AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:21-cv-01852-RGA	12/29/2021	for the District of Delaware

PLAINTIFF	DEFENDANT
EAGLE VIEW TECHNOLOGIES, INC., and PICTOMETRY INTERNATIONAL CORP.,	ROOFR INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 9,183,538 B2	11/10/2015	Pictometry International Corp.
2	US 10,648,800 B2	5/12/2020	Pictometry International Corp.
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☑ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 US 8,170,840 B2	5/1/2012	Eagle View Technologies, Inc.
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
12/467,244	05/15/2009	Chris Pershing	6339.011	66138

Acknowledgement of Loss of Entitlement to Entity Status Discount

The entity status change request below filed through Private PAIR on 06/19/2018 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/marcabrockhaus/
Name:	Marc A. Brockhaus
Registration Number:	40923

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
12/467,244	05/15/2009	Chris Pershing	6339.011	33687

Acknowledgement of Change to Small Entity Status

The entity status change request below filed through Private PAIR on 02/07/2017 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant asserting small entity status. See 37 CFR 1.27.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/marcabrockhaus/
Name:	Marc A. Brockhaus
Registration Number:	40923

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	6339.011

CONFIRMATION NO. 7599

POA ACCEPTANCE LETTER

30589
DUNLAP CODDING, P.C.
PO BOX 16370
OKLAHOMA CITY, OK 73113

OC000000087819664

Date Mailed: 12/13/2016

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/08/2016.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/cnguyen/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

POWER OF ATTORNEY NOTICE

500
SEED INTELLECTUAL PROPERTY LAW GROUP LLP
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

OC000000087819638

Date Mailed: 12/13/2016

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/08/2016.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/cnguyen/

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 30589

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 30589

OR

☐

Firm or Individual Name	DUNLAP CODDING, P.C.		
Address	P.O. Box 16370		
City	Oklahoma City	State OK	Zip 73113
Country	US		
Telephone	405-607-8600	Email	mbrockhaus@dunlapcodding.com

Assignee Name and Address: Eagle View Technologies, Inc.
3700 Monte Villa Pkwy, Ste 200
Bothell, WA 98021

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	November 11, 2014
Name	Richard Jacobs	Telephone	
Title	Assistant Secretary, Eagle View Technologies, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Electronically Filed: 12/08/2016

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.	:	12/467,244
Filed	:	May 15, 2009
Patent No.	:	8,170,840
Issued	:	May 1, 2012
Applicant(s)	:	Chris Pershing
TC/AU	:	2123
Examiner	:	Pierre Louis, Andre
Title	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Docket No.	:	6339.011
Customer No.	:	30589

Mail Stop M - Correspondence
Director of the U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Assertion of Small Entity Status (37 C.F.R. § 1.27(c)(1))

Applicant hereby states that applicant is a small entity and that status as a small entity is asserted for this

[ ] application

[x] patent

12/08/2016
Date

Ann M. Robl

[ ] Inventor(s)

[ ] Assignee(s) of complete interest

[ ] Person authorized to sign on behalf of assignee

[x] Practitioner of record § 34(b)

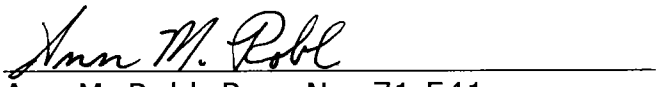
[ ] filed under § 34(a)

Reg. No.:

Customer No.: 30589

Telephone No. (405) 607-8600

Respectfully submitted,



Ann M. Robl, Reg. No. 71,541
DUNLAP, CODDING, P.C.
P.O. Box 16370
Oklahoma City, Oklahoma 73113
Customer No. 30589
Telephone: (405) 607-8600
Facsimile: (405) 607-8686

Attorney for Applicant(s)

Electronic Acknowledgement Receipt

EFS ID:	27738664
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	500
Filer:	Ann M. Robl/Lori Martin
Filer Authorized By:	Ann M. Robl
Attorney Docket Number:	290115.403
Receipt Date:	08-DEC-2016
Filing Date:	15-MAY-2009
Time Stamp:	16:45:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	6339011_Transmittal12082016.pdf	57325 b1def1a729fdd9344e6213508b6680efde14819d	no	1

Warnings:

Information:					
2	Power of Attorney	6339011_POA.pdf	118076 75a46f97d9c078a1dc3e88393665f653d20ac1b5	no	1
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	6339011_AssertionSmallEntity.pdf	41662 1447c9edf00a16ef877a96c261f08abaf251a8c0	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	217063	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: TRAN.LET

Document Description: Transmittal Letter

PTO/SB/21 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission

Application Number	12/467,244
Filing Date	05/15/2009
First Named Inventor	Chris Pershing
Art Unit	2123
Examiner Name	Pierre Louis, Andre
Attorney Docket Number	6339.011

ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☑ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☑ Other Enclosure(s) (please Identify below):
  See Remarks

Remarks

ELECTRONICALLY TRANSMITTED:
1. SB21 Transmittal Form (1 pg);
2. Power of Attorney (1 pg); and
3. Assertion of Small Entity Status (2 pgs).

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	DUNLAP CODDING, P.C.		
Signature	Ann M. Robl		
Printed name	Ann M. Robl		
Date	12/08/2016	Reg. No.	71,541

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	Ann M. Robl		
Typed or printed name	Ann M. Robl	Date	12/08/2016

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and1.14. This collection is estimated to 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Trials@uspto.gov
571-272-7822

Paper 15
Entered: August 16,2016

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

XACTWARE SOLUTIONS, INC.,
Petitioner,

v.

EAGLE VIEW TECHNOLOGIES, INC.,
Patent Owner.

Case IPR2016-00586
Patent 8,170,840 B2

Before HOWARD B. BLANKENSHIP, BRYAN F. MOORE, and STACEY G. WHITE, *Administrative Patent Judges.*

MOORE, *Administrative Patent Judge.*

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

Petitioner, Xactware Solutions, Inc., filed a Second Corrected Petition requesting an *inter partes* review of claims 1, 2, 4, 8–18, 21, and 28 of U.S. Patent No. 8,170,840 B2 (Ex. 1001, "the '840 patent"). Paper 10 ("Pet."). In response, Patent Owner, Eagle View Technologies, Inc., filed a Preliminary Response. Paper 11 ("Prelim. Resp."). We have jurisdiction under 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted "unless . . . the information presented in the petition . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition."

For the reasons set forth below, we do not institute an *inter partes* review of the '840 patent.

A. Related Matter

The '840 patent is involved in the following lawsuit: *Eagle View Techs., Inc. v. Xactware Solutions, Inc.*, No. 2:15–cv–07025 (D. N. J.). Pet. 1.

B. The '840 Patent

The '840 patent relates to a roof estimation system that provides a user interface configured to facilitate roof model generation based on one or more aerial images of a building roof. Ex. 1001, Abstract.

Figure 1 of the '840 patent is reproduced below.

Fig. 1

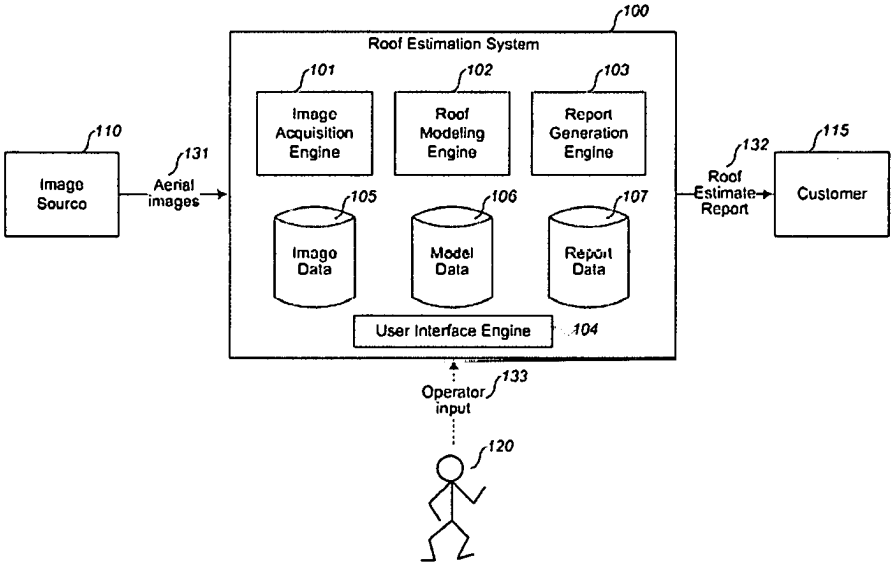


Figure 1 is a block diagram of an example Roof Estimation System ("RES"). Ex. 1001, col. 3, ll. 49–51. RES 100 includes image acquisition engine 101, roof modeling engine 102, report generation engine 103, image data 105, model data 106, and report data 107. *Id.* at col. 3, ll. 52–54. RES 100 is communicatively coupled to image source 110, customer 115, and operator 120. *Id.* at col. 3, ll. 54–56. RES 100 is configured to generate roof estimate report 132 for a specified building, based on aerial images 131 of the building received from the image source 110. *Id.* at col. 3, ll. 60–63.

C. Illustrative Claim

Of the challenged claims, claims 1, 10, and 16 are the only independent claims. Claims 2, 4, 8, and 9 depend either directly or indirectly from claim 1 and claims 11–15 depend either directly or indirectly

from claim 10 and claims 17, 18, 21, and 28 depend either directly or indirectly from claim 16.

Claim 1, reproduced below, is illustrative.

1. A computer-implemented method for generating a roof estimate report, the method comprising:

displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof;

receiving, based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and

modifying a model of the roof based on the received indication of the pitch of the one planar roof section.

Ex. 1001, 23:65–24:13.

D. Prior Art Relied Upon

Petitioner relies upon the following prior art references:

Yuan Hsieh, *Design and Evaluation of a Semi-Automated Site Modeling System*, CMU-CS-95-195, COMPUTER SCIENCE 1–76 (Nov. 1995) ("Hsieh") (Ex. 1004).

Verma et al. ("Verma") US 2006/0061566, published Mar. 23, 2006 (Ex. 1005).

MARTIN BARBER, APPLICAD PRODUCT BULLETIN, KEY FEATURES OF OUR ROOFING SOFTWARE 1–45 (Nov. 2002) ("Applicad") (Ex. 1006).[1]

E. Asserted Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability:

Challenged Claims	Basis	References
1, 2, 4, 8–18, 21, and 28	§ 103(a)	Hsieh and Verma
10, 11, 16, and 18	§ 103(a)	Hsieh, Verma, and Applicad
1, 2, 4, 8–18, 21, and 28	§ 102(b)	Verma
10, 11, 16, and 18	§ 103(a)	Verma and Applicad

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, the Board construes claim terms in an unexpired patent using their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). There is a presumption that a claim term carries its ordinary and customary

[1] Our references are to "Corrected" Exhibit 1006, filed February 10, 2016.

meaning. *CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002). The "ordinary and customary meaning" is that which the term would have to a person of ordinary skill in the art in question. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Only those terms that are in controversy need to be construed, and only to the extent necessary to resolve the controversy. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999). For purposes of this Decision, we determine that no claim terms require express construction.

B. Principles of Law

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

In that regard, an obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 550 U.S. at 418; *see also*

Translogic, 504 F.3d at 1259. A prima facie case of obviousness is established when the prior art itself would appear to have suggested the claimed subject matter to a person of ordinary skill in the art. *In re Rinehart*, 531 F.2d 1048, 1051 (CCPA 1976).

The level of ordinary skill in the art is reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001); *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995); *In re Oelrich*, 579 F.2d 86, 91 (CCPA 1978).

C. Obviousness of Claims over Hsieh and Verma

Petitioner asserts that claims 1, 2, 4, 8–18, 21, and 28 are unpatentable under 35 U.S.C. § 103(a) as obvious over the combination of Hsieh and Verma. Pet. 10. To support its contentions, Petitioner provides detailed explanations as to how the prior art meets each claim limitation. *Id.* at 10–31. Petitioner also relies upon a Declaration of Harold Schuch, who has been retained as a witness by Petitioner for the instant proceeding. Ex. 1007.

Verma is directed to a method and apparatus for automatically generating a 3D computer model from a point cloud created by a laser radar ("LIDAR") system. Ex. 1005, Abstract. LIDAR data collection system 102 scans a scene and produces a point cloud representation of the scene. *Id.* ¶ 24. Each point within the point cloud represents an (x,y) coordinate and a depth from the LIDAR unit. *Id.* The point cloud is processed by the system to extract information about the structure of the roof of a building and that information is further processed to generate a roof model. *Id.* ¶ 10. Figure 2

is reproduced below.

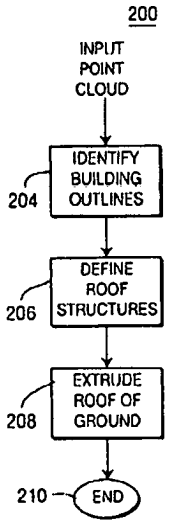


FIG. 2

Figure 2 is a flow diagram of a method for generating a 3D model of a building in an outdoor scene. *Id.* ¶ 14. At step 204, the point cloud is analyzed to identify building outlines. *Id.* at Fig. 2. Verma describes two techniques that may be used to perform this step, (1) conventional edge detection and (2) a two dimensional ("2D") drawing interface that is used manually to draw outlines of roof structures present. *Id.* ¶¶ 34–36. At step 206, the roof structures are defined and two techniques are described that may perform this step. *Id.* ¶¶ 37–39. First, the roof can be defined by one or more planes that are fit to the regions of the point cloud. *Id.* ¶ 37. The planes reveal the outline of the roof structure and that outline is represented by polygons. *Id.* The planes may be rotated or otherwise manipulated into alignment to form complex roof structures such as gable roofs. *Id.* The second technique is described in reference to Figure 3, which is reproduced below.

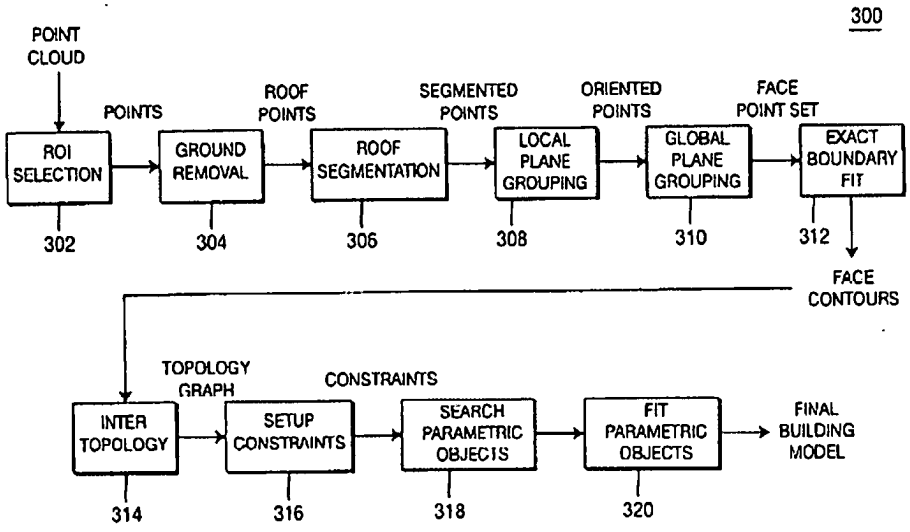


FIG. 3

Figure 3 depicts a method for modeling a roof structure using parametric shapes applied to that point cloud. *Id.* ¶¶ 38, 40. As described in Verma, this technique simplifies the modeling process and mitigates the processing used in the above described technique that utilized rotated planes and attached polygons. *Id.* ¶ 38. The process used in this technique may be automated so that the point cloud is processed in segments and the system may select a region of interest based on the content of the point cloud. *Id.* ¶ 41. At step 304, points related to the ground, objects in the scene that are not part of the building (cars, tree, and other objects), and groups of points that have too few points to be a roof are discarded from the analysis and the remaining points are considered to belong to the roof. *Id.* ¶¶ 42–43. The remaining points then are organized into parametric shapes. At step 320, those shapes may be manipulated to better fit the data. *Id.* ¶¶ 60–63. The shapes are laid over the LIDAR data so that the user can see where the model is not representing the data accurately. *Id.* ¶ 62. "Since the roofs are

composed of prismatic shapes that are specified using very few parameters, the roof shapes can be altered by directly modifying the parameter values of these prismatic shapes. A user interface is provided in the form of handles on the parametric shapes that can be dragged to alter the shape." *Id.* ¶ 62. The parametric shapes also "can be edited intuitively by operations such as push a wall, change the height, change the slope of the gable roof, and the like." *Id.* ¶ 63.

Claim 1 recites "receiving, based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building." Petitioner relies on Verma for its description of handles and operations to meet the limitation to pitch determination marker. Pet. 19–20, Ex. 1005 ¶¶ 37, 62, 63. Verma states that

> A user interface is provided in the form of handles on the parametric shapes that can be dragged to alter the shape. To facilitate adjusting the model, the modeling system provides a simultaneous display of the input LIDAR data and the model such that the model can be edited using the LIDAR data as a reference. With the model (in translucent or outline form) laid over the LIDAR data, a user can quickly understand where the model is not accurately representing the data.

Ex. 1005 ¶ 62. Verma further discloses that "the parametric shapes can be edited intuitively by operations such as push a wall, change the height, change the slope of the gable roof, and the like." *Id.* at ¶ 63.

Patent Owner argues that "Petitioner cites Verma for its description of functionality for editing certain values associated with the parametric shapes

including height and slope, where that functionality is described in terms of "operations" separate and apart from the handles described above." Prelim. Resp. 44. Additionally, Patent Owner argues "[t]hese operations do not include any of the requirements of a 'pitch determination marker,' including that there is no marker, or anything overlaid on the image that can be adjusted to specify pitch." Prelim. Resp. 44.

As noted above, Verma describes two separate techniques for defining roof structures present in that point cloud. Ex. 1005 ¶¶ 37 (attaching polygons to planes and aligning the planes to form complex roof structures) 38–56, 60–63 (fitting parametric shapes to the point cloud and manipulating those shapes to fit the data). Petitioner has not explained how these methods would work together to accomplish the pitch determination marker, nor has Petitioner provided a sufficient rationale for the combination. Petitioner's declarant, Mr. Schuch, describes the two methods and states "[a] person of ordinary skill in the art would have found it obvious to combine the "handle" user interface element and model manipulation tools (e.g., planar rotation functionality) of Verma with the three-dimensional roof generation system of Hsieh." Ex. 1007 ¶ 59. Nonetheless, he does not explain how or why handles and model manipulation tools would be combined and provides only that conclusory rationale for combining them with Hsieh rather than with each other.

Additionally, Petitioner has not explained if and how the "operations" discussed in Verma work with the "handles." Petitioner has not shown that the handles are utilized to accomplish the "change the slope of a gable roof"

operation. Nor does Petitioner argue that one of ordinary skill in the art would have found it obvious to combine the handle feature with the operations of Verma. Thus, Petitioner has not shown that an indication of the pitch of one of the plurality of planar roof sections of the roof of the building is received based on the displayed pitch determination marker.

Petitioner relies on Verma alone to teach receiving, based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building. Pet. 20, 24, 28. Thus, having reviewed the proposed ground of obviousness over Hsieh and Verma against claims 1, 2, 4, 8–18, 21, and 28, and we are not persuaded, on the record before us, that Petitioner has established a reasonable likelihood that Petitioner would prevail in its challenge to claims 1, 2, 4, 8–18, 21, and 28 on this ground.[2]

D. Remaining Grounds Challenging the Claims of the '840 Patent

Each of the remaining grounds in the Petition rely on Verma to teach receiving, based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building. Pet. 20, 24, 28, 35, 36, 41, 44, 47, 50, 52. All challenged claims contain essentially the same limitation in regard to pitch determination marker. Thus, for the reasons stated above, Petitioner has not established a

[2] In view of our determinations, we do not reach Patent Owner's allegation that Petitioner has failed to demonstrate Hsieh is a "printed publication."

reasonable likelihood that Petitioner would prevail in its challenge to any of claims 1, 2, 4, 8–18, 21, and 28 on any of the grounds in the Petition.

III. CONCLUSION

After reviewing the information presented in the Petition and the Preliminary Response, as well as the evidence of record, we determine that Petitioner has not established a reasonable likelihood that it will prevail in showing that claims 1, 2, 4, 8–18, 21, and 28 of the '840 patent are unpatentable.

IV. IV. ORDER

Accordingly, it is

ORDERED that that the Petition is DENIED as to all challenged claims of the '840 patent, and no trial is instituted.

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CHANGE IN ENTITY STATUS

Addressed to: Status & Entity Branch
Office of Finance
Assistant Commissioner for Patents
Washington, D.C. 20231
(703) 308-5077 or (703) 308-6778

From: Seed Intellectual Property Law Group PLLC
Customer Number: **00500**

The entity status has changed to:
(check one)

Small Entity

X Large Entity

in the following listed patent

PATENT NUMBER (if known)	APPLICATION NUMBER
8,170,840	12/467,244

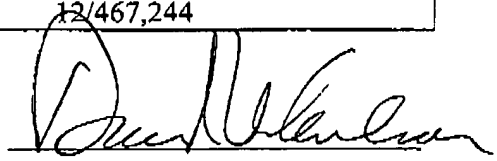
Respectfully Submitted
(check one)

☐ Applicant/Inventor

☒ Attorney or Agent of record

☐ Attorney acting in a representative capacity

☐ Assignee of record: Assignment recorded at Reel __ Frame __



Signature

David V. Carlson (31,153)
Typed or printed name

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Customer's telephone number

09/03/15
Date

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/01/2012	8170840	290115.403	7599

500 7590 04/11/2012

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701 FIFTH AVE
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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 362 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Chris Pershing, Redmond, WA;

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

500 7590 03/28/2012

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
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SEATTLE, WA 98104

EXAMINER	
PIERRE LOUIS, ANDRE	

ART UNIT	PAPER NUMBER
2123	

MAIL DATE	DELIVERY MODE
03/28/2012	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Supplemental Notice of Allowability	Application No. 12/467,244	Applicant(s) PERSHING, CHRIS	
	Examiner ANDRE PIERRE LOUIS	Art Unit 2123	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *IDS filed on11/28/2011*.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-28*.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 11/28/2011
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/A. P./ Examiner, Art Unit 2123	/Kamini S Shah/ Supervisory Patent Examiner, Art Unit 2128

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EXPRESS MAIL No. EV 887976986 US

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.	APPLICATION NO.
290115.403	12/467,244
APPLICANT: Chris Pershing	
FILING DATE: May 15, 2009	GROUP ART UNIT: 2123

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
(Use several sheets if necessary)

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1	5,247,356	09/21/93	Ciampa	358	109	
	2	5,633,995 A	05/27/97	McClain	395	119	
	3	6,323,885 B1	11/27/01	Wiese	345	835	
	4	6,396,491 B2	05/28/02	Watanabe et al.	345	419	
	5	6,496,184 B1	12/17/02	Freeman et al.	345	419	
	6	6,980,690 B1	12/27/05	Taylor et al.	382	154	
	7	7,343,268 B2	03/11/08	Kishikawa	703	1	
	8	7,424,133 B2	09/09/08	Schultz et al.	382	106	
	9	7,873,238 B2	01/18/11	Schultz et al.	382	284	
	10	2003/0014224 A1	01/16/03	Guo et al.	703	1	
	11	2003/0028393 A1	02/06/03	Coultston et al.	705	1	
	12	2003/0115163 A1	06/19/03	Moore et al.	705	500	
	13	2003/0171957 A1	09/11/03	Watrous	705	4	
	14	2003/0233310 A1	12/18/03	Stavrovski	705	37	
	15	2004/0047498 A1	03/11/04	Mulet-Parada et al.	382	128	
	16	2004/0105090 A1	06/03/04	Schultz et al.	356	141.5	
	17	2004/0220906 A1	11/04/04	Gargi et al.	707	3	
	18	2005/0203768 A1	09/15/05	Florance et al.	705	1	
	19	2006/0232605 A1	10/19/06	Imamura	345	619	
	20	2006/0262112 A1	11/23/06	Shimada	345	419	
	21	2006/0265287 A1	11/23/06	Kubo	705	26	
	22	2007/0150366 A1	06/28/07	Yahiro et al.	705	26	
	23	2008/0021683 A1	01/24/08	Rahmes et al.	703	7	
	24	2008/0105045 A1	05/08/08	Woro	73	170.27	
	25	2008/0123994 A1	05/29/08	Schultz et al.	382	284	

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Roofl Exhibit 1002, Page 30

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	26	2008/0204570 A1	08/28/08	Schultz et al.	348	22.1	
	27	2008/0221843 A1	09/11/08	Shenkar et al.	703	1	
	28	2008/0231700 A1	09/28/08	Schultz et al.	348	144	
	29	2008/0310756 A1	12/18/08	Tao et al.	382	285	
	30	2009/0097744 A1	04/16/09	Schultz et al.	382	167	
	31	2009/0132210 A1	05/21/09	Royan et al.	703	1	
	32	2009/0132436 A1	05/21/09	Pershing et al.	705	400	
	33	2009/0141020 A1	06/04/09	Freund et al.	345	419	
	34	2010/0114537 A1	05/06/10	Pershing	703	1	
	35	2011/0187713 A1	08/04/11	Pershing et al.	345	420	

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Roof Exhibit 1002, Page 31

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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
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FOREIGN PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	1	AU 2008230031 B8	11/05/09	AU		
	2	EP 2 251 833 A2	11/17/10	EP		
	3	WO 00/29806 A2	05/25/00	PCT (with English Abstract)		X
	4	WO 2005/124276 A2	12/29/05	PCT (with English Abstract)		X
	5	WO 2006/040775 A2	04/20/06	PCT		
	6	WO 2006/090132 A2	08/31/06	PCT		
	7	WO 2011/094760 A2	08/04/11	PCT		

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Roof Exhibit 1002, Page 32

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	1		Australian Office Action for Australian Application No. 2010201839, dated April 14, 2011, 2 pages.
	2		Autodesk, "Autodesk ImageModeler – Features," retrieved on September 30, 2008, from http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=115639..., 1 page.
	3		Automatic House Reconstruction, retrieved on September 29, 2008, from http://www.vision.ee.ethz.ch/projects/Amobe_I/recons.html, 6 pages.
	4		Baillard et al., "Automatic reconstruction of piecewise planar models from multiple views," CVPR99, Vol. 2, 1999, pp. 559-565. (7 pages)
	5		Bignone et al., "Automatic Extraction of Generic House Roofs from High Resolution Aerial Imagery," *Proc. ECCV*, 1996, 12 pages.
	6		Chevrier et al., "Interactive 3D reconstruction for urban areas – An image based tool," *CAAD Futures*, 2001, 13 pages.
	7		Debevec et al., "Modeling and Rendering Architecture from Photographs: A hybrid geometry- and image-based approach," *SIGGRAPH conference proceedings*, retrieved from www.cs.berkeley.edu/~malik/papers/debevecTM96.pdf., 1996, 10 pages.
	8		Delaney, "Searching for Clients From Above – More Small Businesspeople Use Aerial Mapping Services To Scout Potential Customers," *The Wall Street Journal*, July 31, 2007, retrieved on February 25, 2010, from http://online.wsj.com/public/article/SB118584306224482891.html?mod=yahoo_free, 3 pages.
	9		Faugeras et al., "3-D Reconstruction of Urban Scenes from Sequences of Images," Institut National De Recherche En Informatique Et En Automatique, No. 2572, June 1995, 26 pages.
	10		Henricsson et al., "3-D Building Reconstruction with ARUBA: A Qualitative and Quantitative Evaluation," Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology, 2001, 13 pages.
	11		International Search Report for International Application no. PCT/US11/23408, mailed August 11, 2011, 2 pages.
	12		Lueders, "Infringement Allegations by EagleView Technologies," February 10, 2009. (3 pages)
	13		Mann, "Roof with a view," *Contract Journal 431*(6552):29, November 23, 2005. (2 pages)
	14		Noronha et al., "Detection and Modeling of Buildings from Multiple Aerial Images," *IEEE Transactions on Pattern Analysis and Machine Intelligence 23*(5):501-518, 2001. (32 pages)
	15		Office Action, for U.S. Application No. 12/148,439, mailed August 16, 2010, 47 pages.

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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	16		Office Action, for U.S. Application No. 12/148,439, mailed April 25, 2011, 52 pages.
	17		Office Action, for U.S. Application No. 12/148,439, mailed August 25, 2011, 77 pages.
	18		Office Action, for U.S. Application No. 12/253,092, mailed May 10, 2011, 26 pages.
	19		Office Action for U.S. Application No. 12/467,250, mailed September 7, 2011, 14 pages.
	20		PhotoModeler, "Measuring & Modeling the Real World," retrieved September 30, 2008, from http://www.photomodeler.com/products/photomodeler.htm, 2 pages.
	21		Pictometry.com, "Frequently Asked Questions," retrieved on April 9, 2011, from http://replay.waybackmachine.org/20050801231818/http://www.pictometry.com/faq.asp, 10 pages.
	22		Pictometry.com. "Pictometry Announces Software and Web-based Solution for Engineers, Architects, and Planners," Press Releases, January 22, 2004, 3 pages.
	23		Pictometry, "Electronic Field Study™ Getting Started Guide," Version 2.7, July 2007, 15 pages.
	24		Pictometry, "FAQs," September 22, 2008, retrieved on August 10, 2011, from http://www.web.archive.org/web/20080922013233/http:/www.pictometry.com/about_us/faqs.sht.., 3 pages.
	25		Pictometry Online, "Government," October 7, 2008, retrieved August 10, 2011, from http://web.archive.org/web/20081007111115/http:/www.pictometry.com/government/prod..., 3 pages.
	26		Poullis et al., "Photogrammetric Modeling and Image-Based Rendering for Rapid Virtual Environment Creation," http://handle.dtic.mil/100.2/ADA433420, 1998, 7 pages.
	27		Precigeo.com, "Welcome to precigeo™," "Welcome to precigeoRoof," "Why precigeoRoof," "How precigeoRoof Works," "How precigeoRoof Can Help Me," all retrieved on February 26, 2010, from http://web.archive.org/, pp. 1-5; "Why precigeoRisk Works" and "Welcome to precigeoRisk," retrieved on August 14, 2010, from http://web.archive.org, pp. 6-11. (11 pages total)
	28		Scholze et al., "A Probabilistic Approach to Building Roof Reconstruction Using Semantic Labelling," *Pattern Recognition 2449/2002*, Springer Berlin/Heidelberg, 2002, 8 pages.
	29		Written Opinion, for International Application No. PCT/US11/23408, mailed August 11, 2011, 5 pages.
	30		YouTube, "Pictometry Online Demo," DVD retrieved, February 25, 2010.
	31		Transcription of points of potential interest in the attached Youtube video titled: "Pictometry Online Demo" retrieved February 25, 2010.

EXAMINER	/Andre Pierre Louis/ (03/23/2012)	DATE CONSIDERED	(03/23/2012)

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EXPRESS MAIL No. EV 887976986 US

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
	APPLICANT Chris Pershing	
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	FILING DATE May 15, 2009	GROUP ART UNIT 2123

EXAMINER	/Andre Pierre Louis/ (03/23/2012)	DATE CONSIDERED	(03/23/2012)

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or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

500 7590 02/16/2012

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

TITLE OF INVENTION: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$300	$0	$1170	05/16/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
PIERRE LOUIS, ANDRE	2123	703-001000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Seed IP Law Group PLLC

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Eagle View Technologies, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Redmond, Washington

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual X Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

X Issue Fee

X Publication Fee (No small entity discount permitted)

X Advance Order - # of Copies 2

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

X The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 19-1090 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

X a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Jeremiah J. Baunach/ Date March 27, 2012

Typed or printed name Jeremiah J. Baunach Registration No. 44,527

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal

Application Number:	12467244
Filing Date:	15-May-2009
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Attorney Docket Number:	290115.403

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	870	870
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
Printed copy of patent - no color	8001	2	3	6
		Total in USD ($)		**1176**

Electronic Acknowledgement Receipt

EFS ID:	12407263
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	500
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Filer Authorized By:	Jeremiah J. Baunach
Attorney Docket Number:	290115.403
Receipt Date:	27-MAR-2012
Filing Date:	15-MAY-2009
Time Stamp:	19:13:49
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1176
RAM confirmation Number	6648
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	290115_403_IssueFeeTransmittal.pdf	310251 407ff477e392df4d467bd0da4df45be73ffd63f0	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	33612 3a616d5e90aa163ae15aecb7f58f94e6d10eabb0	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	343863	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

500 7590 02/16/2012

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER
PIERRE LOUIS, ANDRE

ART UNIT	PAPER NUMBER
2123	

DATE MAILED: 02/16/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

TITLE OF INVENTION: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$300	$0	$1170	05/16/2012

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

500 7590 02/16/2012

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

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(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

TITLE OF INVENTION: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$870	$300	$0	$1170	05/16/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
PIERRE LOUIS, ANDRE	2123	703-001000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

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(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

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(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

500 7590 02/16/2012

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER	
PIERRE LOUIS, ANDRE	

ART UNIT	PAPER NUMBER
2123	

DATE MAILED: 02/16/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 362 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 362 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	12/467,244	PERSHING, CHRIS	
	Examiner	Art Unit	
	ANDRE PIERRE LOUIS	2123	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *11/28/2011 and 1/10/2012*.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are *1-28*.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 11/28/2011 and 1/10/2012
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/DWIN M CRAIG/
Primary Examiner, Art Unit 2123

DETAILED ACTION

1. The amendment filed on 11/28/2011 has been received and fully considered.

2. Claims 1-28 are pending and presented for examination.

3. The Terminal Disclaimer (TD) filed on 11/30/2011 has been received and fully considered; it has been approved.

Information disclosure Statement

4. The Information Disclosure Statement (IDS) filed on 11/28/2011 and 1/10/2012 have been received and fully considered; however one or more documents have been lined because they were submitted twice (see the submission of 11/30/2011 and 1/10/2012). The Examiner respectfully notes that one or more NPL have been lined through because they were listed on the IDS form but not received.

Allowable Subject Matter

5. Claims 1-28 are allowed.

5.0 The following is an examiner's statement of reasons for allowance:

5.1 While Pershing teaches a system and method for estimating aerial roof that includes generating a roof estimating report; and Neumann et al. (Other reference previously cited) discloses a system and techniques for implement augmented virtual environment, neither of these references either alone or in combination with the prior of record discloses a computer implemented method for generating a roof estimate report that includes displaying a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof, as specifically shown in the claims, in combination with the remaining elements and features of the

instant invention, it is for these reasons that the applicant's invention defines over the prior art of record.

5.2 Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Andre Pierre-Louis whose telephone number is 571-272-8636. The examiner can normally be reached on Mon-Fri, 8:00AM-4:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul L. Rodriguez can be reached on 571-272-3753. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. P. L/
Examiner, Art Unit 2123

February 14, 2012

/DWIN M CRAIG/
Primary Examiner, Art Unit 2123

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CONFIRMATION NO. 7599

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/467,244	05/15/2009	703	2123	290115.403

APPLICANTS
Chris Pershing, Redmond, WA;

**** CONTINUING DATA ***************************
This appln claims benefit of 61/197,904 10/31/2008

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
05/26/2009

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	☐ Yes ☑ No	/ANDRE PIERRE LOUIS/ Examiner's Signature	☐ Initials	WA	29	28	3

ADDRESS

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104
UNITED STATES

TITLE

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

FILING FEE RECEIVED		
670	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L4	1402	(703/1).CCLS.	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:17
L5	41	(roof with estimat$4) and pitch$2	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:17
L8	8	5 and (aerial with image$s)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:21
L10	5	(roof with estimat$4).ti. and pitch$2	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:22
L11	7	roof and estimat$4 and (pitch$2 with marker$2)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:23
L12	254	roof and estimat$4 and (pitch$2 with determin$4)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:23
L13	2	12 and (aerial with image$2) and (modif$4 with three with dimension$3)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:24
L14	1	12 and (aerial with image$2) and (modif$4 with 3d with dimension$3)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:24
L15	25	5 and modif$4	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:25
L16	5	15 and (aerial with image$2)	US-PGPUB; UPAD	OR	OFF	2012/02/14 10:25

2/14/2012 10:26:08 AM
C:\Users\apierrelouis\Documents\EAST\Workspaces\7244.wsp

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12467244	PERSHING, CHRIS
	Examiner	**Art Unit**
	ANDRE PIERRE LOUIS	2123

ORIGINAL		INTERNATIONAL CLASSIFICATION														
CLASS	SUBCLASS	CLAIMED									NON-CLAIMED					
703	1	G	0	6	F	17 / 50 (2006.01.01)										

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		17												
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	16														

/ANDRE PIERRE LOUIS/ Examiner.Art Unit 2123	2/14/2012	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	28	
/DWIN M CRAIG/ Primary Examiner.Art Unit 2123	02/15/2012	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

OPAP
Receipt date: 11/28/2011
NOV 28 2011
PATENT & TRADEMARK OFFICE

EXPRESS MAIL No. EV 887976986 US

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.	APPLICATION NO.
290115.403	12/467,244
APPLICANT: Chris Pershing	
FILING DATE: May 15, 2009	GROUP ART UNIT: 2123

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
(Use several sheets if necessary)

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1	5,247,356	09/21/93	Ciampa	358	109	
	2	5,633,995 A	05/27/97	McClain	395	119	
	3	6,323,885 B1	11/27/01	Wiese	345	835	
	4	6,396,491 B2	05/28/02	Watanabe et al.	345	419	
	5	6,496,184 B1	12/17/02	Freeman et al.	345	419	
	6	6,980,690 B1	12/27/05	Taylor et al.	382	154	
	7	7,343,268 B2	03/11/08	Kishikawa	703	1	
	8	7,424,133 B2	09/09/08	Schultz et al.	382	106	
	9	7,873,238 B2	01/18/11	Schultz et al.	382	284	
	10	2003/0014224 A1	01/16/03	Guo et al.	703	1	
	11	2003/0028393 A1	02/06/03	Coultston et al.	705	1	
	12	2003/0115163 A1	06/19/03	Moore et al.	705	500	
	13	2003/0171957 A1	09/11/03	Watrous	705	4	
	14	2003/0233310 A1	12/18/03	Stavrovski	705	37	
	15	2004/0047498 A1	03/11/04	Mulet-Parada et al.	382	128	
	16	2004/0105090 A1	06/03/04	Schultz et al.	356	141.5	
	17	2004/0220906 A1	11/04/04	Gargi et al.	707	3	
	18	2005/0203768 A1	09/15/05	Florance et al.	705	1	
	19	2006/0232605 A1	10/19/06	Imamura	345	619	
	20	2006/0262112 A1	11/23/06	Shimada	345	419	
	21	2006/0265287 A1	11/23/06	Kubo	705	26	
	22	2007/0150366 A1	06/28/07	Yahiro et al.	705	26	
	23	2008/0021683 A1	01/24/08	Rahmes et al.	703	7	
	24	2008/0105045 A1	05/08/08	Woro	73	170.27	
	25	2008/0123994 A1	05/29/08	Schultz et al.	382	284	

EXAMINER	DATE CONSIDERED

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

Roof Exhibit 1002, Page 52

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	26	2008/0204570 A1	08/28/08	Schultz et al.	348	22.1	
	27	2008/0221843 A1	09/11/08	Shenkar et al.	703	1	
	28	2008/0231700 A1	09/28/08	Schultz et al.	348	144	
	29	2008/0310756 A1	12/18/08	Tao et al.	382	285	
	30	2009/0097744 A1	04/16/09	Schultz et al.	382	167	
	31	2009/0132210 A1	05/21/09	Royan et al.	703	1	
	32	2009/0132436 A1	05/21/09	Pershing et al.	705	400	
	33	2009/0141020 A1	06/04/09	Freund et al.	345	419	
	34	2010/0114537 A1	05/06/10	Pershing	703	1	
	35	2011/0187713 A1	08/04/11	Pershing et al.	345	420	

EXAMINER	/Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED	(02/14/2012)

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Roof Exhibit 1002, Page 53

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

FOREIGN PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	1	AU 2008230031 B8	11/05/09	AU		
	2	EP 2 251 833 A2	11/17/10	EP		
	3	WO 00/29806 A2	05/25/00	PCT (with English Abstract)		X
	4	WO 2005/124276 A2	12/29/05	PCT (with English Abstract)		X
	5	WO 2006/040775 A2	04/20/06	PCT		
	6	WO 2006/090132 A2	08/31/06	PCT		
	7	WO 2011/094760 A2	08/04/11	PCT		

EXAMINER	/Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED	(02/14/2012)

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Roof Exhibit 1002, Page 54

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	1		Australian Office Action for Australian Application No. 2010201839, dated April 14, 2011, 2 pages.
	2		Autodesk, "Autodesk ImageModeler – Features," retrieved on September 30, 2008, from http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=115639..., 1 page.
	3		Automatic House Reconstruction, retrieved on September 29, 2008, from http://www.vision.ee.ethz.ch/projects/Amobe_I/recons.html, 6 pages.
	4		Baillard et al., "Automatic reconstruction of piecewise planar models from multiple views," CVPR99, Vol. 2, 1999, pp. 559-565. (7 pages)
	5		Bignone et al., "Automatic Extraction of Generic House Roofs from High Resolution Aerial Imagery," *Proc. ECCV*, 1996, 12 pages.
	6		Chevrier et al., "Interactive 3D reconstruction for urban areas – An image based tool," *CAAD Futures*, 2001, 13 pages.
	7		Debevec et al., "Modeling and Rendering Architecture from Photographs: A hybrid geometry- and image-based approach," *SIGGRAPH conference proceedings*, retrieved from www.cs.berkeley.edu/~malik/papers/debevecTM96.pdf., 1996, 10 pages.
	8		Delaney, "Searching for Clients From Above – More Small Businesspeople Use Aerial Mapping Services To Scout Potential Customers," *The Wall Street Journal*, July 31, 2007, retrieved on February 25, 2010, from http://online.wsj.com/public/article/SB118584306224482891.html?mod=yahoo_free, 3 pages.
	9		Faugeras et al., "3-D Reconstruction of Urban Scenes from Sequences of Images," Institut National De Recherche En Informatique Et En Automatique, No. 2572, June 1995, 26 pages.
	10		Henricsson et al., "3-D Building Reconstruction with ARUBA: A Qualitative and Quantitative Evaluation," Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology, 2001, 13 pages.
	11		International Search Report for International Application no. PCT/US11/23408, mailed August 11, 2011, 2 pages.
	12		Lueders, "Infringement Allegations by EagleView Technologies," February 10, 2009. (3 pages)
	13		Mann, "Roof with a view," *Contract Journal 431*(6552):29, November 23, 2005. (2 pages)
	14		Noronha et al., "Detection and Modeling of Buildings from Multiple Aerial Images," *IEEE Transactions on Pattern Analysis and Machine Intelligence 23*(5):501-518, 2001. (32 pages)
	15		Office Action, for U.S. Application No. 12/148,439, mailed August 16, 2010, 47 pages.

EXAMINER /Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED (02/14/2012)

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1922109_1.DOCX Date: October 10, 2011

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANT Chris Pershing	
	FILING DATE May 15, 2009	GROUP ART UNIT 2123

NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	16		Office Action, for U.S. Application No. 12/148,439, mailed April 25, 2011, 52 pages.
	17		Office Action, for U.S. Application No. 12/148,439, mailed August 25, 2011, 77 pages.
	18		Office Action, for U.S. Application No. 12/253,092, mailed May 10, 2011, 26 pages.
	19		Office Action for U.S. Application No. 12/467,250, mailed September 7, 2011, 14 pages.
	20		PhotoModeler, "Measuring & Modeling the Real World," retrieved September 30, 2008, from http://www.photomodeler.com/products/photomodeler.htm, 2 pages.
	21		Pictometry.com, "Frequently Asked Questions," retrieved on April 9, 2011, from http://replay.waybackmachine.org/20050801231818/http://www.pictometry.com/faq.asp, 10 pages.
	22		Pictometry.com. "Pictometry Announces Software and Web-based Solution for Engineers, Architects, and Planners," Press Releases, January 22, 2004, 3 pages.
	23		Pictometry, "Electronic Field Study™ Getting Started Guide," Version 2.7, July 2007, 15 pages.
	24		Pictometry, "FAQs," September 22, 2008, retrieved on August 10, 2011, from http://www.web.archive.org/web/20080922013233/http:/www.pictometry.com/about_us/faqs.sht.., 3 pages.
	25		Pictometry Online, "Government," October 7, 2008, retrieved August 10, 2011, from http://web.archive.org/web/20081007111115/http:/www.pictometry.com/government/prod..., 3 pages.
	26		Poullis et al., "Photogrammetric Modeling and Image-Based Rendering for Rapid Virtual Environment Creation," http://handle.dtic.mil/100.2/ADA433420, 1998, 7 pages.
	27		Precigeo.com, "Welcome to precigeo™," "Welcome to precigeoRoof," "Why precigeoRoof," "How precigeoRoof Works," "How precigeoRoof Can Help Me," all retrieved on February 26, 2010, from http://web.archive.org/, pp. 1-5; "Why precigeoRisk Works" and "Welcome to precigeoRisk," retrieved on August 14, 2010, from http://web.archive.org, pp. 6-11. (11 pages total)
	28		Scholze et al., "A Probabilistic Approach to Building Roof Reconstruction Using Semantic Labelling," *Pattern Recognition 2449/2002*, Springer Berlin/Heidelberg, 2002, 8 pages.
	29		Written Opinion, for International Application No. PCT/US11/23408, mailed August 11, 2011, 5 pages.
	30		YouTube, "Pictometry Online Demo," DVD retrieved, February 25, 2010.
	31		Transcription of points of potential interest in the attached Youtube video titled: "Pictometry Online Demo" retrieved February 25, 2010.

EXAMINER	/Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED	(02/14/2012)

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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
	APPLICANT Chris Pershing	
SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	FILING DATE May 15, 2009	GROUP ART UNIT 2123

EXAMINER	/Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED	(02/14/2012)

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

Roofl Exhibit 1002, Page 57

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12467244	PERSHING, CHRIS
	Examiner	**Art Unit**
	ANDRE PIERRE LOUIS	2123

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/14/2012								
	1	=								
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12467244	PERSHING, CHRIS
	Examiner	**Art Unit**
	ANDRE PIERRE LOUIS	2123

SEARCHED

Class	Subclass	Date	Examiner
703	1	8/23/2011	AP
Above	Search Updated	2/14/2012	AP

SEARCH NOTES

Search Notes	Date	Examiner
Inventor Name Search	8/23/2011	AP
NPL Text Search (Google, IEEE, ACM)_"Aerial Roof estimation" and Pitch determination	8/23/2011	AP
EAST (EAST (US- PGPUB;USPAT;USOCR;EPO;JPO;r ERWENT:IBM TDB-- SEE Search History	8/23/2011	AP
Above Search Updated	2/14/2012	AP

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
USPG_PUB	Interference Text earch_ See Search History	2/14/2012	AP

/A.P./ Examiner.Art Unit 2123	

Receipt date: 01/10/2012

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 290115.403	APPLICATION NO. 12/467,244
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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1	7,424,133 B2	09/09/08	Schultz et al.	382	106	
	2	7,787,659 B2	08/31/10	Schultz et al.	382	106	
	3	7,873,238 B2	01/18/11	Schultz et al.	382	284	
	4	7,991,226 B2	08/02/11	Schultz et al.	382	167	
	5	8,078,436 B2	12/13/11	Pershing et al.	703	2	
	6	2004/0105090 A1	06/03/04	Schultz et al.	356	141.5	
	7	2008/0123994 A1	05/29/08	Schultz et al.	382	284	
	8	2008/0204570 A1	08/28/08	Schultz et al.	348	222.1	
	9	2008/0231700 A1	09/25/08	Schultz et al.	348	144	
	10	2008/0273753 A1	11/06/08	Giuffrida et al.	382	103	
	11	2009/0096884 A1	04/16/09	Schultz et al.	348	222.1	
	12	2009/0097744 A1	04/16/09	Schultz et al.	382	167	
	13	2009/0141020 A1	06/04/09	Freund et al.	345	419	
	14	2010/0034483 A1	02/11/10	Giuffrida et al.	382	284	

FOREIGN PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	1					

NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	1		Notice of Allowance, for U.S. Application No. 12/253,092, mailed October 14, 2011, 30 pages.

EXAMINER	/Andre Pierre Louis/ (02/14/2012)	DATE CONSIDERED	(02/14/2012)

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	3	7,873,238 B2	01/18/11	Schultz et al.	382	284	
	4	7,991,226 B2	08/02/11	Schultz et al.	382	167	
	5	8,078,436 B2	12/13/11	Pershing et al.	703	2	
	6	2004/0105090 A1	06/03/04	Schultz et al.	356	141.5	
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	8	2008/0204570 A1	08/28/08	Schultz et al.	348	222.1	
	9	2008/0231700 A1	09/25/08	Schultz et al.	348	144	
	10	2008/0273753 A1	11/06/08	Giuffrida et al.	382	103	
	11	2009/0096884 A1	04/16/09	Schultz et al.	348	222.1	
	12	2009/0097744 A1	04/16/09	Schultz et al.	382	167	
	13	2009/0141020 A1	06/04/09	Freund et al.	345	419	
	14	2010/0034483 A1	02/11/10	Giuffrida et al.	382	284	

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Electronic Patent Application Fee Transmittal

Application Number:	12467244
Filing Date:	15-May-2009
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Filer:	Jeremiah J. Baunach/Donald Saunderson
Attorney Docket Number:	290115.403

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	11799513
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	500
Filer:	Jeremiah J. Baunach/Donald Saunderson
Filer Authorized By:	Jeremiah J. Baunach
Attorney Docket Number:	290115.403
Receipt Date:	10-JAN-2012
Filing Date:	15-MAY-2009
Time Stamp:	17:18:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	4139
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Transmittal Letter	290115_403_Supplemental_IDS_Transmittal.pdf	52271 f0fffeca9bb0625d35466c80350ace857cca4601	no	2
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	290115_403_Supplemental_IDS_FDA_Form.pdf	48515 6ef9bc18e46f5b28a54204bc5f21f68d91a2fbd4	no	1
Warnings:					
Information:					
3	Non Patent Literature	USAN12253092_Notice_of_Allowance_30pages.pdf	1396511 229d0d09cff010f421d8a9cbe17d1074c8359bd3	no	30
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Form (SB08)	290115_403_Supplemental_IDS_1449.pdf	96697 95975993845 05f44f5addbaa25403312331 10c0b	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
5	Fee Worksheet (SB06)	fee-info.pdf	30364 8eca639a6349c382aa8888df4a3d7832dd5e2c2d	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1624358		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	January 10, 2012

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicant wishes to make known to the U.S. Patent and Trademark Office the references set forth on the attached Supplemental Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicant does not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserves the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method. Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicant's duty to disclose all information he/she is aware of which is believed relevant to the examination of the above-identified application, applicant believes that his/her invention is patentable.

Please acknowledge receipt of this Supplemental Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

Roofr Exhibit 1002, Page 66

A fee of $180 is submitted in accordance with 37 CFR 1.97(c). The Director is authorized to charge any other fees which may be required, or credit any overpayment to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

JJB:djs

Enclosures:
Supplemental Information Disclosure Statement
Cited Reference (1)

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

2060989_1.DOCX

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	January 10, 2012

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicant hereby authorizes the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

2060984_1.DOCX

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	12/467,244	PERSHING, CHRIS	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☒ APPROVED	☐ DISAPPROVED
Date Filed : 11/28/2011	This patent is subject to a Terminal Disclaimer	

Approved/Disapproved by:

Dorethea Lawrence

U.S. Patent and Trademark Office

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	November 30, 2011

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDED SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicant wishes to make known to the U.S. Patent and Trademark Office the references set forth on the Supplemental Information Disclosure Statement submitted via U.S. Express Mail on November 28, 2011. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references have been provided. As to any reference cited, applicant does not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserves the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method.

Applicant submitted the hard copy IDS on November 28, 2011, via U.S. Express Mail, providing a set of additional references for the Examiner's consideration. As discussed in

the phone conference, the published application that the Examiner cited as prior art, 2008/0262789 A1, has one common inventor with the present application and is also now in the middle of prosecution.

While the prior art cited in the prior art reference 2008/0262789 is not believed to be particularly relevant to the current claims, it is cited for the Examiner to fully consider.

Applicant wishes to note that the art provided includes a youtube video that is stored on a DVD. To see the youtube video, the Examiner is invited to put the DVD in his computer and play the video, which has a total length of about 3 minutes. In addition, the Examiner may view the same youtube video on-line by going to the following location: http://www.youtube.com/watch?v=jURSK7o0OD0.

Applicant's attorney has found two locations on the video that the Examiner is particularly directed to: one at 50 seconds and the other at 2:20. To assist the Examiner in his review and ensure full consideration, the spoken words at these two locations is typed and submitted as additional reference on the enclosed IDS. Once again, the Examiner is requested to view the entire YouTube, "Pictometry Online Demo," DVD and to mark the video as being considered on the attached IDS only after he has viewed it.

Applicant does not admit that this youtube video is prior art since the date it was published is not known to applicant. If the actual publication date becomes known, applicant may be able to swear behind the date. However, applicant submits this document for consideration by the Examiner to make clear that the present claims define over this youtube video if it does qualify as prior art.

Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicant's duty to disclose all information he/she is aware of which is believed relevant to the examination of the above-identified application, applicant believes that his/her invention is patentable.

Please acknowledge receipt of the Supplemental Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

Roofr Exhibit 1002, Page 71

The Director is authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-1090.

Respectfully submitted,

Seed Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

JJB:ylc

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1940325_1.DOCX

Electronic Acknowledgement Receipt

EFS ID:	11515936
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	500
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Filer Authorized By:	Jeremiah J. Baunach
Attorney Docket Number:	290115.403
Receipt Date:	30-NOV-2011
Filing Date:	15-MAY-2009
Time Stamp:	18:59:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	290115_403_AmendedSuppIDSTransmittal.pdf	54633 8dd3598643f9081e1937528b64d8682e720ae408	no	3

Warnings:	
Information:	

Total Files Size (in bytes):	54633

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

500 7590 11/28/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER	
PIERRE LOUIS, ANDRE	

ART UNIT	PAPER NUMBER
2123	

MAIL DATE	DELIVERY MODE
11/28/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Applicant-Initiated Interview Summary	Application No.	Applicant(s)	
	12/467,244	PERSHING, CHRIS	
	Examiner	Art Unit	
	ANDRE PIERRE LOUIS	2123	

All participants (applicant, applicant's representative, PTO personnel):

(1) *ANDRE PIERRE LOUIS*.

(2) *Jeremiah J. Baunach (Reg.44,527)*.

(3) *David V. Carlson (Reg.31,153)*.

(4) *Chris Pershing (Inventor)*.

Date of Interview: *22 November 2011*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☒101 ☐112 ☒102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *1-25*.

Identification of prior art discussed: *Chris Pershing*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

During the interview,Chris Pershing gave a brief overview of the claimed invention. Mr. Pershing further discussed the prior art of record, as David V. Carlson pointed out what he believed the prior art fails to teach. We also discussed the 101 rejection and the Double Patenting of record, and Mr. Carlson proposed claims' amendment to substantially overcome the 101 rejection and a Terminal Disclaimer in an effort to overcome the Double Patenting rejection. Mr. Carlson further proposed claims' amendment to substantially overcome the prior art of record; and the Examiner stated that upon receipt of an official amendment to the claims, the Examiner will fully consider the amended claims, to include any limitations not previously presented in the original claims, and update the search.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/Andre Pierre-Louis/ Examiner, Art Unit 2123	/plr/

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	November 28, 2011

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Commissioner for Patents:

In response to the Office Action dated August 26, 2011, please amend the application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks begin on page 8 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A computer-implemented method for generating a roof estimate report, the method comprising:

displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof;

receiving, ~~via~~ based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and

modifying a model of the roof based on the received indication of the pitch of the one planar roof section.

2. (Original) The method of claim 1 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.

3. (Original) The method of claim 1 further comprising:

transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

4. (Original) The method of claim 1 wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building.

5. (Original) The method of claim 1 further comprising:

displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

6. (Original) The method of claim 5 wherein displaying the wireframe rendering occurs in response to the receiving of the indicated pitch.

7. (Original) The method of claim 1 wherein the pitch determination marker includes an adjustable protractor tool having a member that is adjustable to indicate an angle.

8. (Original) The method of claim 1 wherein the pitch determination marker includes an envelope tool having two surfaces that are adjustable to indicate an angle.

9. (Original) The method of claim 1 wherein modifying the model of the roof includes modifying a three-dimensional model of the roof.

10. (Currently Amended) A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

display an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

display a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof;

receive, ~~via~~ based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building;

modify a model of the roof based on the received indication of the pitch of the one planar roof section; and

provide roof measurement information based on the model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

11. (Original) The computing system of claim 10 wherein the roof estimation module is further configured to transmit a roof estimate report based on the provided roof measurement information.

12. (Original) The computing system of claim 10 wherein the pitch determination marker includes at least one of an adjustable protractor tool and an envelope tool.

13. (Original) The computing system of claim 10 wherein the roof estimation module includes an interactive roof modeling user interface.

14. (Original) The computing system of claim 10 wherein the roof estimation module is further configured to display the pitch determination marker as part of an interactive user interface.

15. (Original) The computing system of claim 10 wherein the model of the roof is a three-dimensional model of the roof.

16. (Currently Amended) A non-transitory computer-readable storage medium whose contents enable a computing system to generate a roof estimate report for a building having a roof, by performing a method comprising:

displaying an aerial image of a building having a roof comprising a planar roof section that has a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of the planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof;

receiving, ~~via~~ based on the displayed pitch determination marker, an indication of the pitch of the planar roof section; and

modifying a model of the roof based on the received indication of the pitch of the planar roof section.

17. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.

18. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:

generating a roof estimate report based on the modified model of the roof; and

transmitting the generated roof estimate report.

19. (Currently Amended) The non-transitory computer-readable storage medium of claim 18 wherein the transmitted roof estimate report includes a line drawing of the roof of the house labeled with a measure of the pitch of the planar roof section.

20. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:

determining roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the planar roof section; and

transmitting the determined roof measurement information.

21. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein modifying the model of the roof includes modifying a model of the roof by associating the indicated pitch with a portion of the model of the roof that corresponds to planar roof section of the roof of the building.

22. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:

displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

23. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:

registering, based on operator indicated features, multiple aerial images to a reference grid corresponding to the model.

24. (Currently Amended) The non-transitory computer-readable storage medium of claim 23 wherein registering multiple images includes:

displaying a marker operable to specify a point on the aerial image;

receiving, via the marker, an indication of a point on the aerial image; and

registering, based on the received indication of the point, the aerial image to the reference grid.

25. (Currently Amended) The non-transitory computer-readable storage medium of claim 24 wherein registering the aerial image to the reference grid includes determining a transformation between the aerial image and the reference grid.

26. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:

correcting lean of the aerial image with respect to a vertical axis of a reference grid corresponding to the model.

27. (Currently Amended) The non-transitory computer-readable storage medium of claim 26 wherein correcting misalignment of the aerial image includes:

displaying a lean correction marker operable to indicate a vertical axis of the aerial image;

receiving, via the lean correction marker, an indication of the vertical axis of the aerial image; and

registering, based on the received indication of the vertical axis, the aerial image to the reference grid.

28. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein modifying the model of the roof includes modifying a three-dimensional model of the roof.

REMARKS

Applicant thanks Examiner Louis for his time and consideration during the Examiner interview on November 22, 2011 in which it was agreed the proposed amendments would overcome the rejections based on the art of record. Applicant is submitting this amendment based on the language discussed in the interview and is making other changes to the claims to bring them in line with the comments by the Examiner during the interview.

Claims 1-28 are pending. Claims 1, 10 and 16-28 are being amended. No new matter is being presented by way of this amendment.

The drawings are objected to as failing to comply with 37 CPR 1.84(p)(5) because the Office Action states the drawings include the following reference characters not mentioned in the description: 448, 711, 1188 of Figure 3E.

Applicants respectfully disagree. The numbers 448, 711, 1188 are not reference characters, but are square footage values for the sections of the roof on which they are displayed. This is shown in paragraph 53 of the description, which states, in part, "Figure 3E shows a fifth page 305 of the report and includes a line drawing 305a of the building roof ***showing the square footage of each roof section*** along with ***the total square foot area value***" (emphasis added). Therefore, Applicant respectfully requests the objection be withdrawn.

Claims 1-28 are provisionally rejected on grounds of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-25 of copending Application No. 12/467,250.

Applicant does not acquiesce to the validity of the grounds for the nonstatutory obviousness-type double patenting rejection. However, Applicant submits herewith a terminal disclaimer to overcome the rejection for nonstatutory obviousness-type double patenting in order to advance prosecution. Therefore, Applicant respectfully requests the rejection for nonstatutory obviousness-type double patenting be withdrawn.

Claims 16-28 are rejected under 35 U.S.C. 101 as being directed to non-statutory subject matter.

Claims 16-28 are amended herein to indicate that the computer readable medium of those claims is a "non-transitory" computer readable medium, which is patentable subject

matter. Therefore, Applicant respectfully requests the rejection under 35 U.S.C. 101 be withdrawn.

Claims 1-28 are rejected under 35 U.S.C. 102(e) as being anticipated by Pershing et al. (U.S. Patent Application Publication No. 2008/0262789 A1).

Applicant respectfully traverses the rejection. However, amendments to the claims are made herein as agreed during the Examiner interview on November 22, 2011 in order to advance prosecution of the application.

As a summary of the discussions at the interview, Applicant provides the following explanation and remarks to place them on the official record in writing.

Pershing et al. does not disclose all the elements of independent claims 1, 10 and 16 and their corresponding dependent claims as amended.

For one example, claim 1 as amended recites (emphasis added):

> 1. A computer-implemented method for generating a roof estimate report, the method comprising:
>
> displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;
>
> displaying ***a pitch determination marker*** operable to indicate pitch of a planar roof section, ***wherein the pitch determination marker is overlaid on the aerial image of the building having the roof***;
>
> receiving, based on the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and
>
> modifying a model of the roof based on the received indication of the pitch of the one planar roof section.

The Examiner alleges on page 5 of the Office Action that the element "displaying a pitch determination marker operable to indicate pitch of a planar roof section," is disclosed in the Pershing et al. reference in "fig. 5, para 11-13, 28-31". There is no Figure 5 of Pershing et al., however, Figures 5A through 5F show no such pitch determination marker. Figure 5D shows the value of the pitch angle of each roof section, but this is not a "pitch determination marker," let alone "a pitch determination marker operable to indicate pitch of a planar roof section". Also, there is no description in the specification of Pershing et al. of such a "pitch determination marker".

Furthermore, claim 1 as amended states "wherein the pitch determination marker is overlaid ***on the aerial image of the building having the roof***" (emphasis added). Of Figures 5A through 5F, only Figures 5A and 5B show an aerial image of a roof (the others are plan view line drawings), and there is no maker, let alone a pitch determination marker, on either Figure 5A or Figure 5B, only a camera cross-hair in Figure 5B that is part of the image itself.

Therefore, Pershing et al. does not disclose "displaying a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof," as recited in claim 1 as amended.

Mailed on the same day as this response is being submitted is an IDS having a number of references that were cited in the application which the Examiner cited as prior art, 2008/0262789 A1 to Pershing et al. The Examiner is requested to consider this IDS, including the cover letter explaining the art cited therein.

The Examiner will find a YouTube video titled: Pictometry Online Demo (hereinafter referred to as the Pictometry video) as one art reference which is explained in the IDS cover letter.

This Pictometry youtube video, if it is prior art, does not show carrying out all of the claimed steps of the method and, in particular, the last step of "modifying a model of the roof based on the received indication of the pitch of the one planar roof section."

Thus, while the video does show an operator drawing yellow lines on the aerial image of the roof and from these lines, a pitch is indicated and shown on the screen, it does not show the last step of claims 1 and 16.

For the foregoing reasons, claim 1 is not anticipated by Pershing et al.

Claims 2-9 depend on claim 1, and thus, are also not anticipated by Pershing et al. for the foregoing reasons.

Independent claim 10 is a system claim and recites, in part, "display a pitch determination marker operable to indicate pitch of a planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof…" Pershing

et al. does not disclose this element. Thus, for the foregoing reasons, claim 10 is not anticipated by Pershing et al.

In addition, the Pictometry video does not show the sixth element of claim 10 of "modify a model of the roof based on the received indication of the pitch of the one planar roof section."

Claims 11-15 depend on claim 10, and thus, are also not anticipated by Pershing et al. for the foregoing reasons.

Independent claim 16 is directed to a non-transitory computer readable storage medium and recites, in part, "displaying a pitch determination marker operable to indicate pitch of the planar roof section, wherein the pitch determination marker is overlaid on the aerial image of the building having the roof..." Pershing et al. does not disclose this element. Thus, for the foregoing reasons, claim 16 is not anticipated by Pershing et al.

In addition, the Pictometry video does not show the fourth element of claim 16, which states, "modifying a model of the roof based on the received indication of the pitch of the planar roof section."

Claims 17-28 depend on claim 16, and thus, are also not anticipated by Pershing et al. for the foregoing reasons.

The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090.

All of the claims remaining in the application are now clearly allowable. Favorable consideration and a Notice of Allowance are earnestly solicited.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

JJB:ylc

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Seattle, Washington 98104-7092
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1980534_1.DOC

TERMINAL DISCLAIMER TO OBVIATE A PROVISIONAL DOUBLE PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION	Docket Number 290115.403

In re Application of: Chris Pershing

Application No.: 12/467,244

Filed: May 15, 2009

For: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

The owner*, Eagle View Technologies, Inc. of one-hundred percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending **reference** Application Number 12/467,250, filed on May 15, 2009, as such term is defined in 35 U.S.C. 154 and 173, and as the term of any patent granted on said **reference** application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending **reference** application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the **reference** application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of any patent granted on said **reference** application, "as the term of any patent granted on said **reference** application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending **reference** application," in the event that: any such patent: granted on the pending **reference** application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney or agent of record. Registration No. 44,527

/Jeremiah J. Baunach/	November 28, 2011
Signature	Date
Jeremiah J. Baunach	
Typed or printed name	
206-622-4900	
Telephone Number	

☒ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this statement. See MPEP § 324.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

2042384_1.DOC

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	November 28, 2011

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicant hereby authorizes the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.17 and 1.20 to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

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Phone: (206) 622-4900
Fax: (206) 682-6031

2042778_1.DOCX

Electronic Patent Application Fee Transmittal

Application Number:	12467244
Filing Date:	15-May-2009
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Attorney Docket Number:	290115.403

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Statutory or terminal disclaimer	2814	1	80	80
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**80**

Electronic Acknowledgement Receipt

EFS ID:	11493532
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	500
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Filer Authorized By:	Jeremiah J. Baunach
Attorney Docket Number:	290115.403
Receipt Date:	28-NOV-2011
Filing Date:	15-MAY-2009
Time Stamp:	20:13:13
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$80
RAM confirmation Number	6545
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		1_290115_403_Amendment.pdf	106218 0770f1043e8baa742c08bcbee4b459d763a09959	yes	12

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	7
Applicant Arguments/Remarks Made in an Amendment	8	12

Warnings:					
Information:					
2	Terminal Disclaimer Filed	2_290115_403_TerminalDisclaimer.pdf	83526 89dd74b2e2d17040d3162bd15903c1e4b0888533	no	1
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	3_290115_403_FDA.pdf	45788 19068d1585405f7aea66cef4901f981a37b5f352	no	1
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30262 7aeb0df85a575bd2c25aff70d47032c50a226da4	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	265794		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/467,244	Filing Date 05/15/2009	☐ To be Mailed

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☒		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	11/28/2011	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 28	Minus	** 28	= 0	X $30 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $125 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE	

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/DAWN BREWER/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

11-30-11

1 Fw



EXPRESS MAIL No. EV 887976986 US

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Examiner	:	Andre Pierre Louis
Art Unit	:	2123
Docket No.	:	290115.403
Date	:	November 28, 2011

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicant wishes to make known to the U.S. Patent and Trademark Office the references set forth on the attached Supplemental Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicant does not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserves the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method.

Applicant submits herewith an IDS providing a set of additional references for the Examiner's consideration. As discussed in the phone conference, the published application that the Examiner cited as prior art, 2008/0262789 A1, has one common inventor with the present application and is also now in the middle of prosecution.

11/30/2011 EEKUBAY1 00000019 191090 12467244
01 FC:1806 180.00 DA

While the prior art cited in the prior art reference 2008/0262789 is not believed to be particularly relevant to the current claims, it is cited for the Examiner to fully consider.

Applicant wishes to note that the art provided includes a youtube video that is stored on a DVD. Because the youtube video cannot be sent as a printed document, it is being sent in a separate box that should arrive in a few days. To see the youtube video, the Examiner is invited to put the DVD in his computer and play the video, which has a total length of about 3 minutes. In addition, the Examiner may view the same youtube video on-line by going to the

Applicant's attorney has found two locations on the video that the Examiner is particularly directed to: one at 50 seconds and the other at 2:20. To assist the Examiner in his review and ensure full consideration, the spoken words at these two locations is typed and submitted as additional reference on the enclosed IDS. Once again, the Examiner is requested to view the entire YouTube, "Pictometry Online Demo," DVD and to mark the video as being considered on the attached IDS only after he has viewed it.

Applicant does not admit that this youtube video is prior art since the date it was published is not known to applicant. If the actual publication date becomes known, applicant may be able to swear behind the date. However, applicant submits this document for consideration by the Examiner to make clear that the present claims define over this youtube video if it does qualify as prior art.

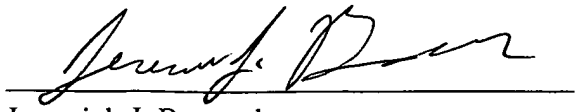
Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicant's duty to disclose all information he/she is aware of which is believed relevant to the examination of the above-identified application, applicant believes that his/her invention is patentable.

Please acknowledge receipt of this Supplemental Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

A fee of $180 is submitted in accordance with 37 CFR 1.97(c). The Director is authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 19-1090.

Respectfully submitted,

Seed Intellectual Property Law Group PLLC



Jeremiah J. Baunach
Registration No. 44,527

JJB:djs

Enclosures:
Check
Postcard
Fee Transmittal Form
Transmittal Form
Supplemental Information Disclosure Statement
Cited References (36 Documents, 1 DVD)

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1940325_1.DOCX

OPAP
IAP11
NOV 28 2011
PATENT & TRADEMARK OFFICE

EXPRESS MAIL No. EV 887976986 US

TRANSMITTAL FORM

(To be used for all correspondence after initial filing)

Application Number	12/467,244
Filing Date	May 15, 2009
First Named Inventor	Chris Pershing
Art Unit	2123
Examiner Name	Andre Pierre Louis
Attorney Docket No.	290115.403

ENCLOSURES (*check all that apply*)

- [X] Fee Transmittal Form
  - [X] Fee Attached
- [ ] Amendment/Response
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [X] Information Disclosure Statement and Transmittal
- [X] Cited References (36 Documents, 1 DVD)
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Response to Missing Parts/Incomplete Application
- [ ] Drawing(s)
- [ ] Request for Corrected Filing Receipt
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation, Change of Correspondence Address
- [ ] Declaration
- [ ] Statement under 37 CFR 3.73(b)
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [X] CD, Number of CD(s) 1
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC *(Appeal Notice, Brief, Reply Brief)*
- [ ] Proprietary Information
- [ ] Status Letter
- [X] Return Receipt Postcard
- [ ] Other Enclosure(s) (*please identify below*):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Seed Intellectual Property Law Group PLLC	Customer Number	00500
Signature			
Printed Name	**Jeremiah J. Baunach**		
Date	**November 28, 2011**	Reg. No.	**44,527**

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below.

Signature			
Typed or printed name	Yvette L. Chriscaden	Date:	11/28/11

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
1940338_1.DOCX

EXPRESS MAIL NO. EV 887976986 US

Fees pursuant to the Consolidated Appropriations Act. 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2009

Complete if Known	
Application Number	12/467,244
Filing Date	May 15, 2009
First Named Inventor	Chris Pershing
Examiner Name	Andre Pierre Louis
Art Unit	2123
Attorney Docket No.	290115.403

OPAP IAP11 NOV 28 2011 PATENT & TRADEMARK OFFICE

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($)**180**

METHOD OF PAYMENT (check all that apply)

☒ **Check** ☐ Credit Card ☐ Money Order ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 19-1090 Deposit Account Name: Seed IP Law Group PLLC

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☐ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☒ Charge any underpayments or credit any overpayments

Warning: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
		Small Entity		Small Entity		Small Entity	
Application Type	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fees Paid ($)
Utility	330	165	540	270	220	110	_____
Design	220	110	100	50	140	70	_____
Provisional	220	110	0	0	0	0	_____

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	52	26
Each independent claim over 3 (including Reissues)	220	110
Multiple dependent claims	390	195

Total Claims		Extra Claims		Fee ($)		Fee Paid ($)
_____	-20 or HP =	_____	X	_____	=	_____

HP = highest number of total claims paid for, if greater than 20.

Multiple Dependent Claims	
Fee ($)	Fee Paid ($)
_____	_____

Indep. Claims		Extra Claims		Fee ($)		Fee Paid ($)
_____	-3 or HP =	_____	X	_____	=	_____

HP = highest number of independent claims paid for, if greater than 3.

3. APPLICATION SIZE FEE

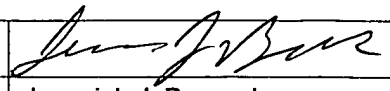
If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)	Fee Paid ($)
_____	-100 =	_____	/50 =	_____ (round **up** to a whole number)	x	_____	_____

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	_____
Other (e.g., late filing surcharge): Information Disclosure Statement	**180**
_____	_____
_____	_____

SUBMITTED BY

Signature		Registration No. (Attorney/Agent)	44,527	Telephone	206-622-4900
Name (Print/Type)	**Jeremiah J. Baunach**			Date	November 28, 2011

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PATENT & TRADEMARK OFFICE

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.	APPLICATION NO.
290115.403	12/467,244
APPLICANT: Chris Pershing	
FILING DATE: May 15, 2009	GROUP ART UNIT: 2123

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
(Use several sheets if necessary)

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1	5,247,356	09/21/93	Ciampa	358	109	
	2	5,633,995 A	05/27/97	McClain	395	119	
	3	6,323,885 B1	11/27/01	Wiese	345	835	
	4	6,396,491 B2	05/28/02	Watanabe et al.	345	419	
	5	6,496,184 B1	12/17/02	Freeman et al.	345	419	
	6	6,980,690 B1	12/27/05	Taylor et al.	382	154	
	7	7,343,268 B2	03/11/08	Kishikawa	703	1	
	8	7,424,133 B2	09/09/08	Schultz et al.	382	106	
	9	7,873,238 B2	01/18/11	Schultz et al.	382	284	
	10	2003/0014224 A1	01/16/03	Guo et al.	703	1	
	11	2003/0028393 A1	02/06/03	Coultston et al.	705	1	
	12	2003/0115163 A1	06/19/03	Moore et al.	705	500	
	13	2003/0171957 A1	09/11/03	Watrous	705	4	
	14	2003/0233310 A1	12/18/03	Stavrovski	705	37	
	15	2004/0047498 A1	03/11/04	Mulet-Parada et al.	382	128	
	16	2004/0105090 A1	06/03/04	Schultz et al.	356	141.5	
	17	2004/0220906 A1	11/04/04	Gargi et al.	707	3	
	18	2005/0203768 A1	09/15/05	Florance et al.	705	1	
	19	2006/0232605 A1	10/19/06	Imamura	345	619	
	20	2006/0262112 A1	11/23/06	Shimada	345	419	
	21	2006/0265287 A1	11/23/06	Kubo	705	26	
	22	2007/0150366 A1	06/28/07	Yahiro et al.	705	26	
	23	2008/0021683 A1	01/24/08	Rahmes et al.	703	7	
	24	2008/0105045 A1	05/08/08	Woro	73	170.27	
	25	2008/0123994 A1	05/29/08	Schultz et al.	382	284	

EXAMINER	DATE CONSIDERED

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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	26	2008/0204570 A1	08/28/08	Schultz et al.	348	22.1	
	27	2008/0221843 A1	09/11/08	Shenkar et al.	703	1	
	28	2008/0231700 A1	09/28/08	Schultz et al.	348	144	
	29	2008/0310756 A1	12/18/08	Tao et al.	382	285	
	30	2009/0097744 A1	04/16/09	Schultz et al.	382	167	
	31	2009/0132210 A1	05/21/09	Royan et al.	703	1	
	32	2009/0132436 A1	05/21/09	Pershing et al.	705	400	
	33	2009/0141020 A1	06/04/09	Freund et al.	345	419	
	34	2010/0114537 A1	05/06/10	Pershing	703	1	
	35	2011/0187713 A1	08/04/11	Pershing et al.	345	420	

EXAMINER	DATE CONSIDERED
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FOREIGN PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	1	AU 2008230031 B8	11/05/09	AU		
	2	EP 2 251 833 A2	11/17/10	EP		
	3	WO 00/29806 A2	05/25/00	PCT (with English Abstract)		X
	4	WO 2005/124276 A2	12/29/05	PCT (with English Abstract)		X
	5	WO 2006/040775 A2	04/20/06	PCT		
	6	WO 2006/090132 A2	08/31/06	PCT		
	7	WO 2011/094760 A2	08/04/11	PCT		

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NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	1		Australian Office Action for Australian Application No. 2010201839, dated April 14, 2011, 2 pages.
	2		Autodesk, "Autodesk ImageModeler – Features," retrieved on September 30, 2008, from http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=115639..., 1 page.
	3		Automatic House Reconstruction, retrieved on September 29, 2008, from http://www.vision.ee.ethz.ch/projects/Amobe_I/recons.html, 6 pages.
	4		Baillard et al., "Automatic reconstruction of piecewise planar models from multiple views," CVPR99, Vol. 2, 1999, pp. 559-565. (7 pages)
	5		Bignone et al., "Automatic Extraction of Generic House Roofs from High Resolution Aerial Imagery," *Proc. ECCV*, 1996, 12 pages.
	6		Chevrier et al., "Interactive 3D reconstruction for urban areas – An image based tool," *CAAD Futures*, 2001, 13 pages.
	7		Debevec et al., "Modeling and Rendering Architecture from Photographs: A hybrid geometry- and image-based approach," *SIGGRAPH conference proceedings*, retrieved from www.cs.berkeley.edu/~malik/papers/debevecTM96.pdf., 1996, 10 pages.
	8		Delaney, "Searching for Clients From Above – More Small Businesspeople Use Aerial Mapping Services To Scout Potential Customers," *The Wall Street Journal*, July 31, 2007, retrieved on February 25, 2010, from http://online.wsj.com/public/article/SB118584306224482891.html?mod=yahoo_free, 3 pages.
	9		Faugeras et al., "3-D Reconstruction of Urban Scenes from Sequences of Images," Institut National De Recherche En Informatique Et En Automatique, No. 2572, June 1995, 26 pages.
	10		Henricsson et al., "3-D Building Reconstruction with ARUBA: A Qualitative and Quantitative Evaluation," Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology, 2001, 13 pages.
	11		International Search Report for International Application no. PCT/US11/23408, mailed August 11, 2011, 2 pages.
	12		Lueders, "Infringement Allegations by EagleView Technologies," February 10, 2009. (3 pages)
	13		Mann, "Roof with a view," *Contract Journal 431*(6552):29, November 23, 2005. (2 pages)
	14		Noronha et al., "Detection and Modeling of Buildings from Multiple Aerial Images," *IEEE Transactions on Pattern Analysis and Machine Intelligence 23*(5):501-518, 2001. (32 pages)
	15		Office Action, for U.S. Application No. 12/148,439, mailed August 16, 2010, 47 pages.

EXAMINER	DATE CONSIDERED
* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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NON-PATENT LITERATURE DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	16		Office Action, for U.S. Application No. 12/148,439, mailed April 25, 2011, 52 pages.
	17		Office Action, for U.S. Application No. 12/148,439, mailed August 25, 2011, 77 pages.
	18		Office Action, for U.S. Application No. 12/253,092, mailed May 10, 2011, 26 pages.
	19		Office Action for U.S. Application No. 12/467,250, mailed September 7, 2011, 14 pages.
	20		PhotoModeler, "Measuring & Modeling the Real World," retrieved September 30, 2008, from http://www.photomodeler.com/products/photomodeler.htm, 2 pages.
	21		Pictometry.com, "Frequently Asked Questions," retrieved on April 9, 2011, from http://replay.waybackmachine.org/20050801231818/http://www.pictometry.com/faq.asp, 10 pages.
	22		Pictometry.com. "Pictometry Announces Software and Web-based Solution for Engineers, Architects, and Planners," Press Releases, January 22, 2004, 3 pages.
	23		Pictometry, "Electronic Field Study™ Getting Started Guide," Version 2.7, July 2007, 15 pages.
	24		Pictometry, "FAQs," September 22, 2008, retrieved on August 10, 2011, from http://www.web.archive.org/web/20080922013233/http:/www.pictometry.com/about_us/faqs.sht.., 3 pages.
	25		Pictometry Online, "Government," October 7, 2008, retrieved August 10, 2011, from http://web.archive.org/web/20081007111115/http:/www.pictometry.com/government/prod..., 3 pages.
	26		Poullis et al., "Photogrammetric Modeling and Image-Based Rendering for Rapid Virtual Environment Creation," http://handle.dtic.mil/100.2/ADA433420, 1998, 7 pages.
	27		Precigeo.com, "Welcome to precigeo™," "Welcome to precigeoRoof," "Why precigeoRoof," "How precigeoRoof Works," "How precigeoRoof Can Help Me," all retrieved on February 26, 2010, from http://web.archive.org/, pp. 1-5; "Why precigeoRisk Works" and "Welcome to precigeoRisk," retrieved on August 14, 2010, from http://web.archive.org, pp. 6-11. (11 pages total)
	28		Scholze et al., "A Probabilistic Approach to Building Roof Reconstruction Using Semantic Labelling," *Pattern Recognition 2449/2002*, Springer Berlin/Heidelberg, 2002, 8 pages.
	29		Written Opinion, for International Application No. PCT/US11/23408, mailed August 11, 2011, 5 pages.
	30		YouTube, "Pictometry Online Demo," DVD retrieved, February 25, 2010.
	31		Transcription of points of potential interest in the attached Youtube video titled: "Pictometry Online Demo" retrieved February 25, 2010.

EXAMINER	DATE CONSIDERED

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(12) STANDARD PATENT (11) Application No. AU 2008230031 B8
(19) AUSTRALIAN PATENT OFFICE

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(54) Title
Aerial roof estimation systems and methods

(51) International Patent Classification(s)
G06F 17/50 (2006.01) ***G06Q 50/00*** (2006.01)

(21) Application No: **2008230031** (22) Date of Filing: **2008.10.21**

(30) Priority Data

(31) Number	(32) Date	(33) Country
12/148,439	**2008.04.17**	**US**
12/253,092	**2008.10.16**	**US**

(43) Publication Date: **2009.11.05**
(43) Publication Journal Date: **2009.11.05**
(44) Accepted Journal Date: **2010.06.10**
(48) Corrigenda Journal Date: **2010.07.15**

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(56) Related Art
US 2003/0014224
WO 2000/029806

2008230031 21 Oct 2008

ABSTRACT OF THE DISCLOSURE

Methods and systems for roof estimation are described. Example embodiments include a roof estimation system, which generates and provides roof estimate reports annotated with indications of the size, geometry, pitch and/or orientation of the roof sections of a building. Generating a roof estimate report may be based on one or more aerial images of a building. In some embodiments, generating a roof estimate report of a specified building roof may include generating a three-dimensional model of the roof, and generating a report that includes one or more views of the three-dimensional model, the views annotated with indications of the dimensions, area, and/or slope of sections of the roof. This abstract is provided to comply with rules requiring an abstract, and it is submitted with the intention that it will not be used to interpret or limit the scope or meaning of the claims.

290115.401C1/ 1258906_1.DOC

2008230031 21 Oct 2008

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

Standard Patent

Applicant(s):

Eagle View Technologies, Inc.

Invention Title:

AERIAL ROOF ESTIMATION SYSTEMS AND METHODS

The following statement is a full description of this invention, including the best method for performing it known to me/us:

2008230031 21 Oct 2008

AERIAL ROOF ESTIMATION SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of co-pending U.S. Patent Application No. 12/148,439, filed on April 17, 2008, which claims the benefit of U.S. Provisional Patent Application No. 60/925,072, filed on April 17, 2007, each of which are incorporated herein by reference in their entireties.

BACKGROUND

1. Field of the Invention:

[0002] This invention relates to systems and methods for estimating construction projects, and more particularly, to such systems and methods that allow estimates involving roofs on buildings to be created remotely.

2. Description of the Related Art:

[0003] The information provided below is not admitted to be part of the present invention, but is provided solely to assist the understanding of the reader.

[0004] Homeowners typically ask several roofing contractors to provide written estimates to repair or replace a roof on a house. Heretofore, the homeowners would make an appointment with each roofing contractor to visit the house to determine the style of roof, take measurements, and to inspect the area around the house for access and cleanup. Using this information, the roofing contractor then prepares a written estimate and then timely delivers it to the homeowner. After receiving several estimates from different rooting contractors, the homeowner then selects one.

[0005] There are factors that impact a roofing contractor's ability to provide a timely written estimate. One factor is the size of the roof contractor's company and the location of the roofing jobs currently underway. Most roof contractors provide roofing services and estimates to building owners over a large

geographical area. Larger roof contractor companies hire one or more trained individuals who travel throughout the entire area providing written estimates. With smaller roofing contractors, the owner or a key trained person is appointed to provide estimates. With both types of companies, roofing estimates are normally scheduled for buildings located in the same area on a particular day. If an estimate is needed suddenly at a distant location, the time for travel and the cost of commuting can be prohibitive. If the roofing contractor is a small company, the removal of the owner or key person on a current job site can be time prohibitive.

[0006] Another factor that may impact the roofing contractor's ability to provide a written estimate is weather and traffic.

[0007] Recently, solar panels have become popular. In order to install solar panels, the roof's slope, geometrical shape, and size as well as its orientation with respect to the sun all must be determined in order to provide an estimate of the number and type of solar panels required. Unfortunately, not all roofs on a building are proper size, geometrical shape, or orientation for use with solar panels.

SUMMARY

[0008] These and other objects are met by the system and method disclosed herein that allows a company that needs the sizes, dimensions, slopes and orientations of the roof sections on a building in order to provide a written estimate. A roof estimation system ("RES") that practices at least some of the techniques described herein may include a roof estimating software program and a location-linked, image file database. During use, the physical address or location information of a building is provided to the program, which then presents aerial images of roof sections on the building at the specific address location. An overhead aircraft, a balloon, or satellite may produce the aerial images. An image analysis and calibration is then performed either manually and/or via a software program that determines the geometry, the slopes, the pitch angles, and the outside dimensions of the roof sections. The images may also include the land

surrounding the roof sections and building which the estimating company can use to factor in additional access or clean-up costs.

[0009] In a first embodiment of the roof estimation system, a roof estimation service is contacted by a potential customer requesting an estimate for repair or replacement of a roof on a building. The roof estimation service uses a local computer with an estimating software program loaded into its working memory to access an image file database located on the computer or on a remote server connected via a wide area network to the local computer. The image file database contains image files of various buildings. When a request for an estimate is received from a potential customer, the roof estimation service enters the customer's address into the software program and aerial images of the building are then presented to the roof estimation service. The roof estimation service then manually measures or uses a roof estimation software program to determine the slopes, dimensions, and other relevant geometric information of the roof sections on the buildings. From these determinations, the overall shape, slopes and square footage of the roof sections are determined and a report is produced. After the report has been prepared, the images are reviewed again for special access and cleanup tasks which can be added to the final estimate before transmission to the potential customer.

[0010] In another embodiment, the roof estimate software program and image file database, operated by a roof estimation service, are both stored on one or more a remote computers and accessed by a roof company, via a wide area network. The roof company uses an assigned user name and password to log onto the Web site and accessed the computer. After logging on, the roof company submits an address of a building, other relevant job related information, and a request for a report from the roof estimation service. The roof estimation service associated with the Web site uses the address information to obtain the images of the roof sections on the building(s) and uses the roof estimation software program and calibration module to determine the relevant geometry, pitch angles, dimensions, and surface areas of the building's roof. The roof estimation service then produces and sends a report to the roof company. The roof company then

uses the report to prepare a final estimate that is then delivered to its potential customer.

[0011] In another embodiment, a roof estimating Web site is created designed to receive requests for roof estimates directly from potential customers in a region. The roof estimation service that operates the Web site is associated with various roof companies that provide roof-related services in the region serviced by the Web site. When a potential customer contacts the Web site and requests an estimate for a roof repair, replacement or installation of equipment, the potential's customer's name, address, and contact information is first submitted on the Web site. The estimation service representative enters the address of the building into the roof estimation software program. The aerial images of the buildings are then obtained and analyzed by the service representative to extract the relevant geometric information about the structures. A report containing the geometric information obtained from the aerial images and other relevant project related information supplied by the potential customer are transmitted to roof companies associated with the estimation service. The roof company reviews the information then prepares an estimate which then can be uploaded to the roof estimating Web site server which then forwards the estimate to the potential customer, or sent from the roof company directly via email, fax or mail to the potential customer.

[0012] In another embodiment, a roof estimation service associated with the roof estimate Web site uses the image file database and roof estimate software to preemptively calculate and store the dimensions, areas, pitch angles, and other relevant geometric information about the buildings and structures located within a geographic region. This pre-calculated information can then be used by any of the previously mentioned embodiments to accelerate the process of obtaining roof estimates within that geographic region.

[0013] It should be understood, that the systems and methods described herein may be used by any individual or company that would find the calculation of the size, geometry, pitch and orientation of the roof of a building from aerial images of the building useful. Such companies may include roofing companies, solar

panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and insurance companies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figure 1 is an illustration showing embodiments of a system and method for roof estimation.

[0015] Figure 2 is an illustration showing another embodiment of a system and method for roof estimation.

[0016] Figure 3 is an illustration showing the top and perspective view of a house for a particular address.

[0017] Figure 4 is an aerial image of the home shown in Figure 3 showing the areas and structures around the home.

[0018] Figures 5A-5F are consecutive pages from a preliminary or final report sent to a potential customer prepared by the roofing company.

[0019] Figure 6 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system.

[0020] Figure 7 is an example block diagram of a computing system for practicing embodiments of a roof estimation system.

[0021] Figure 8 is an example flow diagram of a first example roof estimation routine provided by an example embodiment.

[0022] Figure 9 is an example flow diagram of a second example roof estimation routine provided by an example embodiment.

DETAILED DESCRIPTION

[0023] Referring to the accompanying Figures, there is described a roof estimation system ("RES") 10 and method that allows a roof estimation service 70 to provide a final estimate 102 to a potential customer 90 to install equipment or to repair or replace the roof on a building 92 using aerial images of the building 92, as shown in Figure 1. The roof estimation service 70 may be any service that

provides roof estimates to customers. In one embodiment, the roof estimation service 70 typically provides roof estimates to customers who are roof companies or other entities involved in the construction and/or repair of roofs, such as builders, contractors, etc. In another embodiment, the roof estimation service 70 is a roof company that is directly involved in the construction and/or repair of roofs, and that provides estimates to customers that are property owners, general contractors, etc. The system 10 includes an estimating software program 50 designed to receive an address for the building 92. The software program 50 is linked to an aerial image file database 52 that contains aerial images files 54 of various building 92 in a region. The aerial image files 54 may be taken any available means, such as a manned or unmanned aircraft, a balloon, a satellite, etc. In some embodiments, the aerial image files may include images taken from a ground-based platform, such as a mobile ("street view") photography vehicle, a fixed position (*e.g.*, a tower, nearby building, hilltop, etc.), etc. As shown in Figure 3, the image files 54 typically include at least one a top plan view 65 and a perspective view 66 of the building 92. The roof of the building 92 includes multiple planar roof sections 92a-92d.

[0024] As shown in Figure 4, the image files 54 may also include a wide angle image 67 showing the building 92 and the surrounding areas 93 around the building 92.

[0025] Referring back to Figure 1, in one embodiment, an image analysis and calibration module 56 is linked to the software program 50 that enables the roof estimation service 70 to closely estimate the dimensions and slopes of the roofs of the buildings 92 shown in the views 65, 66. By simply inputting the customer's address into the software program 50, the roof estimation service 70 is able view the customer's roof from the aerial image files 54 using a remote computer 72, determine the dimensions and slopes of the roof sections that make up the roof, and prepare a preliminary report 101 which is then used to prepare a final estimate 102 that is then delivered to the potential customer 90.

[0026] Figure 1 is an illustration showing the system 10 used by a potential customer 90 requesting a roof estimate from a roof estimation service 70 that uses

the system 10 described above. The potential customer 90 may be the building tenant, owner or insurance company. The roof estimation service 70 uses a computer 72 which may connect to a wide area network 60. The customer 90 contacts the roof estimation service 70 via his or her computer 91 and the wide area network 60 or by a telecommunication network 96, and requests a roof estimate 100 for his building 92 located at a public address 93. (in this example, "123 W. 3rd St."). The roof estimation service 70 then processes the request 100 which leads to a final estimate 102 being delivered to the potential customer's computer 91 or via email, fax or postal service to the potential customer 90.

[0027] There are several different ways the system 10 can be setup. Figure 1 shows a first embodiment of the system 10 where the roof estimation service 70 operates a remote computer 72 with a display 74 and a keyboard 75 or similar input means, such as a mouse, joystick, track pad, etc. A roof estimating software program 50 is loaded into the working memory 73 of the remote computer 72. The software program 50 is able to retrieve aerial images of buildings from the database 52 containing aerial images files 54 of buildings located in the region served by the roof estimation service 70. In the first embodiment shown in Figure 1, the remote computer 72 is linked or connected to a database 52 containing aerial images files 54 of the buildings. The software program 50 includes a calibration module 56 that enables the roof estimation service 70 to determine the angles and dimensions of various roof sections shown in the images files 54. After the angles and dimensions are determined, the combined square footage of the building 92 can be determined which is then used to create a preliminary report 101. The roof estimation service 70 then reviews the wide angle image file 67 (see Figure 4) to determine if the building 92 has special access and clean up factors that may impact the final estimate 102. Once the preliminary report 101 or the final estimate 102 is prepared by the roof estimation service 70, one or both can be transmitted to the customer 90 via the wide area network 60, the telecommunication network 96, or by postal service.

[0028] Also shown in Figure1 is an alternative setup of the system 10 wherein a preliminary report 101 is prepared by a separate roof estimating entity

105 which is then forwarded to the roof estimation service 70 who then prepares the final estimate 102 and sends it to the customer 90. The entity 105 includes a computer 106 with a roof estimating software program 50' loaded into the working memory 107. Like the software program 50 loaded into the roof contractor's computer 72 in the previous embodiment the software program 50' is also able to retrieve aerial images of houses from a database 52' containing aerial images files 54' of houses located in the region served by the roof estimation service 70. An optional calibration module 56' may be provided which enables the entity 105 to determine the angles and linear dimensions of various roof sections on the house 92.

[0029] When the system 10 is set up to include the estimating entity 105, the customer 90 may first contact the roof estimation service 70. The roof estimation service 70 may then contact the estimating entity 105 and forward the address of the building 92 thereto. The estimating entity 105 may then prepare the preliminary report 101 that is transmitted to the roof estimation service 70. The roof estimation service 70 may then prepare the final report 102 and send it to the customer 90. In other embodiments, interactions between the customer 90, the roof estimation service 70, and the estimating entity 105 may occur in different ways and/or orders. For example, the customer 90 may contact the estimating entity 105 directly to receive a final report 102, which the customer 90 may then forward to one or more roof companies of their choosing.

[0030] Figure 2 shows a third embodiment of the system 10 where the customer 90 contacts a roof estimating entity 130 who receives a request 100 from the customer 90 via the wide area network 60 or telecommunication network 96. The roof estimating entity 130 prepares a preliminary report 101 which is then transmitted to various roof estimation services 70, 70', 70"associated with the entity 130. Accompanying the preliminary report 101 may be the name and contact telephone number(s) or email address of the customer 90. Each roof estimation service 70, 70', 70" reviews the preliminary report 101 and any associated images sent therewith and then prepares a final estimate 102, 102', 102". The final estimate 102, 102', 102" is then mailed, emailed or faxed to the

customer 90 or back to the estimating entity 130. The estimating entity 130 then sends the final estimate 102, 102', 102" to the customer 90. In this embodiment, the estimating entity 130 includes a computer 135 in which the roof estimating software program 50" is loaded into its working memory 136 loaded and linked to the aerial image database 52"containing image files 54". An optional calibration module 56" may be loaded into the working memory 136 of the computer 135.

[0031] Figures 5A-5F are individual pages that make up a representative report. In Figure 5A, a cover page 103 that lists the address 103a of a building 103c and an overhead aerial image 103b of the building 103c. In Figure 5B, a second page 104 of the report is shown that shows two wide overhead perspective views 104a and 104b of the building 103c at the address with the surrounding areas more clearly shown. Figure 5C is the third page 105 of the report which shows a line drawing 105a of the building showing ridge and valley lines, dimensions and a compass indicator. Fig 5D is an illustration of the fourth page 106 of the report showing a line drawing 106a of the building showing the pitch of each roof section along with a compass indicator. The pitch in this example is given in inches, and it represents the number of vertical inches that the labeled planar roof section drops over 12 inches of horizontal run. The slope can be easily calculated from such a representation using basic trigonometry. The use of a numerical value of inches of rise per foot of run is a well known measure of slope in the roofing industry. A roof builder typically uses this information to assist in the repair and/or construction of a roof. Of course, other measures and/or units of slope may be utilized as well, including percent grade, angle in degrees, etc. Figure 5E is an illustration of the fifth page 107 of the report showing a line drawing 107a of the building showing the square footage of each roof section along with the total square foot area value. Figure 5F is an illustration of a sixth page 108 of the report showing a line drawing 108a of the building where notes or comments may be written.

[0032] Using the above roof estimation system, a detailed description of how the system may be used in one example embodiment is now provided.

[0033] First, a property of interest is identified by a potential customer of the roof estimation service 70. The customer may be a property owner, a roof construction/repair company, a contractor, an insurance company, a solar panel installer, etc. The customer contacts the roof estimation service with the location of the property. Typically, this will be a street address. The roof estimation service 70 may then use a geo-coding provider, operated by the service 70 or some third party, to translate the location information (such as a street address) into a set of coordinates that can be used to query an aerial or satellite image database. Typically, the geo-coding provider will be used to translate the customer supplied street address into a set of longitude-latitude coordinates.

[0034] Next, the longitude-latitude coordinates of the property may be used to query an aerial and/or satellite imagery database in order to retrieve one or more images of the property of interest. It is important to note that horizontal (non-sloping) flat roofs only require a single image of the property. However, few roofs (especially those on residential buildings) are horizontally flat, and often contain one or more pitched sections. In such cases, two or more photographs are typically used in order for the service 70 to identify and measure all relevant sections and features of the roof.

[0035] Once the images of the roof section of the building are obtained, at least one of the images may be calibrated. During calibration, the distance in pixels between two points on the image is converted into a physical length. This calibration information is typically presented as a scale marker on the image itself, or as additional information supplied by the image database provider along with the requested image.

[0036] The image(s) and calibration information returned by the imagery database is entered or imported into measurement software of the service 70.

[0037] Next, a set of reference points may be identified in each of the images. The service's 70 measurement software then uses these reference points and any acceptable algorithm to co-register the images and reconstruct the three-dimensional geometry of the object identified by the reference points. There are a variety of photo-grammetric algorithms that can be utilized to perform this

reconstruction. One such algorithm used by the service 70 uses photographs taken from two or more view points to "triangulate" points of interest on the object in three-dimensional ("3D") space. This triangulation can be visualized as a process of projecting a line originating from the location of the photograph's observation point that passes through a particular reference point in the image. The intersection of these projected lines from the set of observation points to a particular reference point identifies the location of that point in 3D space. Repeating the process for all such reference points allows the software to build a 3D model of the structure.

[0038] The optimal choice of reconstruction algorithm depends on a number of factors such as the spatial relationships between the photographs, the number and locations of the reference points, and any assumptions that are made about the geometry and symmetry of the object being reconstructed. Several such algorithms are described in detail in textbooks, trade journals, and academic publications.

[0039] Once the reconstruction of the building is complete, the results may be reviewed for completeness and correctness. If necessary, an operator of the service's 70 software will make corrections to the reconstructed model.

[0040] Information from the reconstructed model may then be used to generate a report containing information relevant to the customer. The information in the report may include total square footage, square footage and pitch of each section of roof, linear measurements of all roof segments, identification and measurement of ridges and valleys, and different elevation views rendered from the 3D model (top, side, front, etc).

[0041] Using the above description, a method for estimating the size and the repair or replacement costs of a roof may include the following steps:

[0042] a. selecting a roof estimation system that includes a computer with a roof estimation software program loaded into its working memory, said roof estimation software uses aerial image files of buildings in a selected region and a calibration module that allows the size, geometry, and orientation of a roof section to be determined from said aerial image files;

[0043] b. submitting a request for a measurement of a roof of a building at a known location;

[0044] c. submitting the location information of a building with a roof that needs a size determination, a repair estimate, or replacement estimate;

[0045] d. entering the location information of said building and obtaining aerial image files of one or more roof sections used on a roof; and,

[0046] e. using said calibration module to determine the size, geometry and pitch of each said roof section.

[0047] In the above method, the entity requesting the measurement may be a roof construction/repair company, the building tenant, the building owner, an insurance company, etc.

[0048] Figure 6 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system. In particular, Figure 6 shows an example Roof Estimation System ("RES") 600 comprising an image acquisition engine 601, a roof modeling engine 602, a report generation engine 603, image data 605, model data 606, and report data 607. The RES 600 is communicatively coupled to an image source 610, a customer 615, and optionally an operator 620. The RES 600 and its components may be implemented as part of a computing system, as will be further described with reference to Figure 7.

[0049] In the illustrated embodiment, the RES 600 performs some or all of the functions of the whole system described with reference to Figures 1 and 2, and also additional functions as described below. For example, the RES 600 may perform one or more of the functions of the software program 50, the roof estimating entity 105, the aerial image file database 52, and/or the calibration module 56.

[0050] More specifically, in the illustrated embodiment of Figure 6, the RES 600 is configured to generate a roof estimate report 632 for a specified building, based on aerial images 631 of the building received from the image source 610. The image source 610 may be any provider of images of the building for which a roof estimate is being generated. In one embodiment, the image source 610 includes a computing system that provides access to a repository of aerial images

of one or more buildings. The image acquisition engine 601 obtains one or more aerial images of the specified building by, for example, providing an indicator of the location of the specified building (*e.g.*, street address, GPS coordinates, lot number, etc.) to the image source 610. In response, the image source 610 provides to the image acquisition engine 605 the one or more aerial images of the building. The image acquisition engine 601 then stores the received aerial images as image data 605, for further processing by other components of the RES 600. In some embodiments, the aerial images may include images obtain via one or more ground-based platforms, such as a vehicle-mounted camera that obtains street-level images of buildings, a nearby building, a hilltop, etc. In some cases, a vehicle-mounted camera may be mounted in an elevated position, such as a boom.

[0051] Next, the roof modeling engine 602 generates a model of the roof of the specified building. In the illustrated embodiment, the roof modeling engine 602 generates a three-dimensional model, although in other embodiments, a two-dimensional (*e.g.*, top-down roof plan) may be generated instead or in addition. As noted above, a variety of automatic and semi-automatic techniques may be employed to generate a model of the roof of the building. In one embodiment, generating such a model is based at least in part on a correlation between at least two of the aerial images of the building. For example, the roof modeling engine 602 receives an indication of a corresponding feature that is shown in each of the two aerial images. In one embodiment, an operator 620, viewing two or more images of the building, inputs an indication in at least some of the images, the indications identifying which points of the images correspond to each other for model generation purposes.

[0052] The corresponding feature may be, for example, a vertex of the roof of the building, the corner of one of the roof planes of the roof, a point of a gable or hip of the roof, etc. The corresponding feature may also be a linear feature, such as a ridge or valley line between two roof planes of the roof. In one embodiment, the indication of a corresponding feature on the building includes "registration" of a first point in a first aerial image, and a second point in a second aerial image, the

first and second points corresponding the substantially the same point on the roof of the building. Generally, point registration may include the identification of any feature shown in both aerial images. Thus, the feature need not be a point on the roof of the building. Instead, it may be, for example, any point that is visible on both aerial images, such as on a nearby building (*e.g.*, a garage, neighbor's building, etc.), on a nearby structure (*e.g.*, swimming pool, tennis court, etc.), on a nearby natural feature (*e.g.*, a tree, boulder, etc.), etc.

[0053] In some embodiments, the roof modeling engine 602 determines the corresponding feature automatically, such as by employing on one or more image processing techniques used to identify vertexes, edges, or other features of the roof. In other embodiments, the roof modeling engine 602 determines the corresponding feature by receiving, from the human operator 620 as operator input 633, indications of the feature shown in multiple images of the building.

[0054] In addition, generating a 3D model of the roof of a building may include correcting one or more of the aerial images for various imperfections. For example, the vertical axis of a particular aerial image sometimes will not substantially match the actual vertical axis of its scene. This will happen, for example, if the aerial images were taken at different distances from the building, or at a different pitch, roll, or yaw angles of the aircraft from which the images were produced. In such cases, an aerial image may be corrected by providing the operator 620 with a user interface control operable to adjust the scale and/or relative angle of the aerial image to correct for such errors. The correction may be either applied directly to the aerial image, or instead be stored (*e.g.*, as an offset) for use in model generation or other functions of the RES 600.

[0055] Generating a 3D model of the roof of a building further includes the automatic or semi-automatic identification of features of the roof of the building. In one embodiment, one or more user interface controls may be provided, such that the operator 620 may indicate (*e.g.*, draw, paint, etc.) various features of the roof, such as valleys, ridges, hips, vertexes, planes, edges, etc. As these features are indicated by the operator 620, a corresponding 3D model may be updated accordingly to include those features. These features are identified by the

operator based on a visual inspection of the images and by providing inputs that identify various features as valleys, ridges, hips, etc. In some cases, a first and a second image view of the roof (*e.g.*, a north and east view) are simultaneously presented to the operator 620, such that when the operator 620 indicates a feature in the first image view, a projection of that feature is automatically presented in the second image view. By presenting a view of the 3D model, simultaneously projected into multiple image views, the operator 620 is provided with useful visual cues as to the correctness of the 3D model and/or the correspondence between the aerial images.

[0056] In addition, generating a 3D model of the roof of a building may include determining the pitch of one or more of the sections of the roof. In some embodiments, one or more user interface controls are provided, such that the operator 620 may accurately determine the pitch of each of the one or more roof sections. An accurate determination of the roof pitch may be employed (by a human or the RES 600) to better determine an accurate cost estimate, as roof sections having a low pitch are typically less costly surfaces to repair and/or replace.

[0057] The generated 3D model typically includes a plurality of planar roof sections that each correspond to one of the planar sections of the roof of the building. Each of the planar roof sections in the model has a number of associated dimensions and/or attributes, among them slope, area, and length of each edge of the roof section. Other information may include, whether a roof section edge is in a valley or on a ridge of the roof, the orientation of the roof section, and other information relevant to roof builder (*e.g.*, roof and/or roof section perimeter dimensions and/or outlines). Once a 3D model has been generated to the satisfaction of the roof modeling engine 602 and/or the operator 620, the generated 3D model is stored as model data 606 for further processing by the RES 600. In one embodiment, the generated 3D model is then stored in a quality assurance queue, from which it is reviewed and possibly corrected by a quality control operator.

[0058] The report generation engine 603 generates a final roof estimate report based on a 3D model stored as model data 606, and then stores the generated report as report data 607. Such a report typically includes one or more plan (top-down) views of the 3D model, annotated with numerical values for the slope, area, and/or lengths of the edges of at least some of the plurality of planar roof sections of the 3D model of the roof. For example, the example report of Figures 5A-5E includes multiple plan views of a generated 3D model of the house 103c. In particular, Figure 5C shows a first plan view of the 3D model, annotated with dimensions of the edges of each roof section. Figure 5D shows a second plan view of the same 3D model, annotated with the slope of each roof section. Figure 5E shows a third plan view of the same 3D model, annotated with the area of each roof section.

[0059] In some embodiments, generating a report includes labeling one or more views of the 3D model with annotations that are readable to a human user. Some 3D models include a large number of small roof details, such as dormers or other sections, such that applying uniformly sized, oriented, and positioned labels to roof section views results in a visually cluttered diagram. Accordingly, various techniques may be employed to generate a readable report, including automatically determining an optimal or near-optimal label font size, label position, and/or label orientation, such that the resulting report may be easily read and understood by the customer 615.

[0060] In addition, in some embodiments, generating a report includes automatically determining a cost estimate, based on specified costs, such as those of materials, labor, transportation, etc. For example, the customer 615 provides indications of material and labor costs to the RES 600. In response, the report generation engine 603 generates a roof estimate report that includes a cost estimate, based on the costs provided by the customer 615 and the attributes of the particular roof, such as area, pitch, etc.

[0061] In one embodiment, the generated report is then provided to a customer. The generated report can be represented, for example, as an electronic file (*e.g.*, a PDF file) or a paper document. In the illustrated example, roof estimate

report 632 is transmitted to the customer 615. The customer 615 may be or include any human, organization, or computing system that is the recipient of the roof estimate report 632. The customer 615 may be a property owner, a property manager, a roof construction/repair company, a general contractor, an insurance company, a solar power panel installer, etc. Reports may be transmitted electronically, such as via a network (*e.g.*, as an email, Web page, etc.) or by some shipping mechanism, such as the postal service, a courier service, etc.

[0062] In some embodiments, one or more of the 3D models stored as model data 606 are provided directly to the customer, without first being transformed into a report. For example, a 3D model may be exported as a data file, in any acceptable format, that may be consumed or otherwise utilized by some other computing system, such as computer-aided design ("CAD") tool, drawing program, etc.

[0063] Figure 7 is an example block diagram of a computing system for practicing embodiments of a roof estimation system. Figure 7 shows a computing system 700 that may be utilized to implement a Roof Estimation System ("RES") 710. One or more general purpose or special purpose computing systems may be used to implement the RES 710. More specifically, the computing system 700 may comprise one or more distinct computing systems present at distributed locations. In addition, each block shown may represent one or more such blocks as appropriate to a specific embodiment or may be combined with other blocks. Moreover, the various blocks of the RES 710 may physically reside on one or more machines, which use standard inter-process communication mechanisms (*e.g.*, TCP/IP) to communicate with each other. Further, the RES 710 may be implemented in software, hardware, firmware, or in some combination to achieve the capabilities described herein.

[0064] In the embodiment shown, computing system 700 comprises a computer memory ("memory") 701, a display 702, one or more Central Processing Units ("CPU") 703, Input/Output devices 704 (*e.g.*, keyboard, mouse, CRT or LCD display, and the like), other computer-readable media 705, and network connections 706. The RES 710 is shown residing in memory 701. In other

embodiments, some portion of the contents, some of, or all of the components of the RES 710 may be stored on and/or transmitted over the other computer-readable media 705. The components of the RES 710 preferably execute on one or more CPUs 703 and generate roof estimate reports, as described herein. Other code or programs 730 (*e.g.*, a Web server, a database management system, and the like) and potentially other data repositories, such as data repository 720, also reside in the memory 710, and preferably execute on one or more CPUs 703. Not all of the components in Figure 7 are required for each implementation. For example, some embodiments embedded in other software do not provide means for user input, for display, for a customer computing system, or other components.

[0065] In a typical embodiment, the RES 710 includes an image acquisition engine 711, a roof modeling engine 712, a report generation engine 713, an interface engine 714, and a roof estimation system data repository 716. Other and/or different modules may be implemented. In addition, the RES 710 interacts via a network 750 with an image source computing system 755, an operator computing system 765, and/or a customer computing system 760.

[0066] The image acquisition engine 711 performs at least some of the functions of the image acquisition engine 601 described with reference to Figure 6. In particular, the image acquisition engine 711 interacts with the image source computing system 755 to obtain one or more images of a building, and stores those images in the RES data repository 716 for processing by other components of the RES 710. In some embodiments, the image acquisition engine 711 may act as an image cache manager, such that it preferentially provides images to other components of the RES 710 from the RES data repository 716, while obtaining images from the image source computing system 755 when they are not already present in the RES data repository 716.

[0067] The roof modeling engine 712 performs at least some of the functions of the roof modeling engine 602 described with reference to Figure 6. In particular, the roof modeling engine 712 generates a 3D model based on one or more images of a building that are obtained from the RES data repository 716. As noted, 3D model generation may be performed semi-automatically, based on at

least some inputs received from the computing system 765. In addition, at least some aspects of the 3D model generation may be performed automatically, based on image processing and/or image understanding techniques. After the roof modeling engine 712 generates a 3D model, it stores the generated model in the RES data repository 716 for further processing by other components of the RES 710.

[0068] The report generation engine 713 performs at least some of the functions of the report generation engine 603 described with reference to Figure 6. In particular, the report generation engine 713 generates roof reports based on 3D models stored in the RES data repository 716. Generating a roof report may include preparing one or more views of a given 3D model of a roof, annotating those views with indications of various characteristics of the model, such as dimensions of sections or other features (*e.g.*, ridges, valleys, etc.) of the roof, slopes of sections of the roof, areas of sections of the roof, etc.

[0069] The interface engine 714 provides a view and a controller that facilitate user interaction with the RES 710 and its various components. For example, the interface engine 714 provides an interactive graphical user interface that can be used by a human user operating the operator computing system 765 to interact with, for example, the roof modeling engine 612, to perform functions related to the generation of 3D models, such as point registration, feature indication, pitch estimation, etc. In other embodiments, the interface engine 714 provides access directly to a customer operating the customer computing system 760, such that the customer may place an order for a roof estimate report for an indicated building location. In at least some embodiments, access to the functionality of the interface engine 714 is provided via a Web server, possibly executing as one of the other programs 730.

[0070] In some embodiments, the interface engine 714 provides programmatic access to one or more functions of the RES 710. For example, the interface engine 714 provides a programmatic interface (*e.g.*, as a Web service, static or dynamic library, etc.) to one or more roof estimation functions of the RES 710 that may be invoked by one of the other programs 730 or some other module.

In this manner, the interface engine 714 facilitates the development of third-party software, such as user interfaces, plug-ins, adapters (*e.g.*, for integrating functions of the RES 710 into desktop applications, Web-based applications, embedded applications, etc.), and the like. In addition, the interface engine 714 may be in at least some embodiments invoked or otherwise accessed via remote entities, such as the operator computing system 765, the image source computing system 755, and/or the customer computing system 760, to access various roof estimation functionality of the RES 710.

[0071] The RES data repository 716 stores information related the roof estimation functions performed by the RES 710. Such information may include image data 605, model data 606, and/or report data 607 described with reference to Figure 6. In addition, the RES data repository 716 may include information about customers, operators, or other individuals or entities associated with the RES 710.

[0072] In an example embodiment, components/modules of the RES 710 are implemented using standard programming techniques. For example, the RES 710 may be implemented as a "native" executable running on the CPU 703, along with one or more static or dynamic libraries. In other embodiments, the RES 710 is implemented as instructions processed by virtual machine that executes as one of the other programs 730. In general, a range of programming languages known in the art may be employed for implementing such example embodiments, including representative implementations of various programming language paradigms, including but not limited to, object-oriented (*e.g.*, Java, C++, C#, Visual Basic.NET, Smalltalk, and the like), functional (*e.g.*, ML, Lisp, Scheme, and the like), procedural (*e.g.*, C, Pascal, Ada, Modula, and the like), scripting (*e.g.*, Perl, Ruby, Python, JavaScript, VBScript, and the like), declarative (*e.g.*, SQL, Prolog, and the like).

[0073] The embodiments described above may also use well-known synchronous or asynchronous client-server computing techniques. However, the various components may be implemented using more monolithic programming techniques as well, for example, as an executable running on a single CPU

computer system, or alternatively decomposed using a variety of structuring techniques known in the art, including but not limited to, multiprogramming, multithreading, client-server, or peer-to-peer, running on one or more computer systems each having one or more CPUs. Some embodiments execute concurrently and asynchronously, and communicate using message passing techniques. Equivalent synchronous embodiments are also supported by an RES implementation. Also, other functions could be implemented and/or performed by each component/module, and in different orders, and by different components/modules, yet still achieve the functions of the RES.

[0074] In addition, programming interfaces to the data stored as part of the RES 710, such as in the RES data repository 716, can be available by standard mechanisms such as through C, C++, C#, and Java APIs; libraries for accessing files, databases, or other data repositories; through scripting languages such as XML; or through Web servers, FTP servers, or other types of servers providing access to stored data. For example, the RES data repository 716 may be implemented as one or more database systems, file systems, memory buffers, or any other technique for storing such information, or any combination of the above, including implementations using distributed computing techniques.

[0075] Also, the example RES 710 can be implemented in a distributed environment comprising multiple, even heterogeneous, computer systems and networks. For example, in one embodiment, the image acquisition engine 711, the roof modeling engine 712, the report generation engine 713, the interface engine 714, and the data repository 716 are all located in physically different computer systems. In another embodiment, various modules of the RES 710 are hosted each on a separate server machine and are remotely located from the tables which are stored in the data repository 716. Also, one or more of the modules may themselves be distributed, pooled or otherwise grouped, such as for load balancing, reliability or security reasons. Different configurations and locations of programs and data are contemplated for use with techniques of described herein. A variety of distributed computing techniques are appropriate for implementing the components of the illustrated embodiments in a distributed manner including but

not limited to TCP/IP sockets, RPC, RMI, HTTP, Web Services (XML-RPC, JAX-RPC, SOAP, and the like).

[0076] Furthermore, in some embodiments, some or all of the components of the RES are implemented or provided in other manners, such as at least partially in firmware and/or hardware, including, but not limited to one or more application-specific integrated circuits (ASICs), standard integrated circuits, controllers (*e.g.*, by executing appropriate instructions, and including microcontrollers and/or embedded controllers), field-programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), and the like Some or all of the system components and/or data structures may also be stored (*e.g.*, as software instructions or structured data) on a computer-readable medium, such as a hard disk, a memory, a network, or a portable media article to be read by an appropriate drive or via an appropriate connection. The system components and data structures may also be stored as data signals (*e.g.*, by being encoded as part of a carrier wave or included as part of an analog or digital propagated signal) on a variety of computer-readable transmission mediums, which are then transmitted, including across wireless-based and wired/cable-based mediums, and may take a variety of forms (*e.g.*, as part of a single or multiplexed analog signal, or as multiple discrete digital packets or frames). Such computer program products may also take other forms in other embodiments. Accordingly, embodiments of this disclosure may be practiced with other computer system configurations.

[0077] Figure 8 is an example flow diagram of a first example roof estimation routine provided by an example embodiment. The illustrated routine 800 may be provided by, for example, execution of the roof estimation system 710 described with respect to Figure 7. The illustrated routine 800 generates a 3D model of a roof of a building, based on two or more aerial images of the building, and further prepares and transmits a roof estimate report based on the 3D model.

[0078] More specifically, the routine begins at step 801 where it receives a first and a second aerial image of a building, each of the aerial images providing a different view of the roof of the building. The aerial images may be received from, for example, the image source computing system 755 and/or from the RES data

repository 716 described with reference to Figure 7. As discussed above, aerial images may be originally created by cameras mounted on airplanes, balloons, satellites, etc. In some embodiments, images obtained from ground-based platforms (*e.g.*, vehicle-mounted cameras) may be used instead or in addition.

[0079] In step 802, the routine correlates the first aerial image with the second aerial image. In some embodiments, correlating the aerial images may include registering pairs of points on the first and second aerial images, each pair of points corresponding to substantially the same point on the roof depicted in each of the images. Correlating the aerial images may be based at least in part on input received from a human operator and/or automatic image processing techniques.

[0080] In step 803, the routine generates, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof. The three-dimensional model of the roof may include a plurality of planar roof sections that each have a corresponding slope, area, and perimeter. Generating the three-dimensional model may be based at least in part indications of features of the roof, such as valleys, ridges, edges, planes, etc. Generating the three-dimensional model may also be based at least in part on input received from a human operator (*e.g.*, indications of roof ridges and valleys) and/or automatic image processing techniques.

[0081] In step 804, the routine prepares (*e.g.*, generates, determines, produces, etc.) and transmits a roof estimate report that includes one or more annotated top-down views of the three-dimensional model. In some embodiments, the annotations include numerical values indicating the slope, area, and lengths of the edges of the perimeter of at least some of the plurality of planar roof sections of the three-dimensional model of the roof. The roof estimate report may be an electronic file that includes images of the building and/or its roof, as well as line drawings of one or more views of the three-dimensional model of the building roof. Preparing the report may include annotating the report with labels that are sized and oriented in a manner that preserves and/or enhances readability of the report. For example, labels on a particular line drawing may be sized based at least in part

on the size of the feature (*e.g.*, roof ridge line) that they are associated with, such that smaller features are annotated with smaller labels so as to preserve readability of the line drawing by preventing or reducing the occurrence of labels that overlap with other portions (*e.g.*, lines, labels, etc.) of the line drawing. The roof estimate report may be transmitted to various destinations, such as directly to a customer or computing system associated with that customer, a data repository, and/or a quality assurance queue for inspection and/or improvement by a human operator.

[0082] After step 804, the routine ends. In other embodiments, the routine may instead return to step 801, to generate another roof estimate report for another building. Note that the illustrated routine may be performed interactively, such as based at least in part on one or more inputs received from a human operator, or in batch mode, such as for performing automatic, bulk generation of roof estimate reports.

[0083] Figure 9 is an example flow diagram of a second example roof estimation routine provided by an example embodiment. The illustrated routine 900 may be provided by, for example, execution of the roof estimation system 710 described with respect to Figure 7. The illustrated routine 900 generates a roof estimate report based on a single aerial image and additional information received from a user, such as information about the pitch of various roof sections.

[0084] In step 901, the routine receives a substantially top-down aerial image of a building having a roof. Such an aerial image may be obtained from, for example, a satellite or aircraft.

[0085] In step 902, the routine generates a preliminary model of the roof based on the received aerial image. The preliminary roof model may be a two-dimensional ("flat") model that includes information about the perimeter of the roof and at least some of its corresponding planar roof sections. Such a preliminary roof model may include estimates of various dimensions of the roof, such as edge lengths and/or section areas. In some cases, the preliminary roof model does not include information related to the pitch of various roof sections.

[0086] In step 903, the routine modifies the preliminary model based on additional information about the roof received from a user. For example, the preliminary model may be presented to a user (*e.g.*, a customer, an operator, etc.), by displaying a representation of the model, such as a line drawing. In response, the user provides the routine with pitch information and/or feature identification (*e.g.*, of ridges and/or valleys), etc. Such user-supplied information is then incorporated into the preliminary roof model to obtain a modified (refined) roof model. In some cases, the user supplies the additional information via a Web-base interface that provides access to the routine.

[0087] In step 904, the routine prepares and transmits a roof estimate report that includes one or more annotated views of the modified model. As discussed above, the annotations may include numerical values indicating the slope, area, and lengths of the edges of the perimeter of at least some of the roof sections of the roof. After step 904, the routine ends.

[0088] The routines 800 and 900 may be used in conjunction to advantageously offer customers roof estimate reports at differing price points. For example, routine 800 can be utilized as part of a "premium" service that offers a customer with a more accurate roof estimate report for minimal effort on the customer's part. Routine 900 can be utilized as part of an "economy" service that offers a customer a less accurate roof estimate report at a lower price, but that may be further refined with additional effort from the customer.

[0089] From the foregoing it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the present disclosure. For example, the methods, systems, and techniques for generating and providing roof estimate reports discussed herein are applicable to other architectures other than the illustrated architecture or a particular roof estimation system implementation. Also, the methods and systems discussed herein are applicable to differing network protocols, communication media (optical, wireless, cable, etc.) and devices (such as wireless handsets, electronic organizers, personal digital assistants, portable email machines, game machines,

pagers, navigation devices such as GPS receivers, etc.). Further, the methods and systems discussed herein may be utilized by and/or applied to other contexts or purposes, such as by or for solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and/or insurance companies.

[0090] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

[0091] A reference herein to a prior art document is not an admission that the document forms part of the common general knowledge in the art in Australia.

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CLAIMS

1. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

receive a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building;

correlate the first aerial image with the second aerial image;

generate, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

generate and transmit a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical values that indicate the corresponding slope, area, and length of edges of at least some of the plurality of planar roof sections.

2. The computing system of claim 1 wherein the roof estimation module is further configured to correlate the first and second aerial images by receiving an indication of one or more corresponding points on the building shown in each of the first and second aerial images.

3. The computing system of claim 1 wherein the roof estimation module is further configured to generate the three-dimensional model by receiving an indication of at least one of a ridgeline of the roof, a valley of the roof, an edge of the roof, a hip of the roof, and a gable of the roof.

4. The computing system of claim 1 wherein the roof estimation module is further configured to receive the first and second aerial image from an image source computing system.

5. The computing system of claim 1 wherein the roof estimation module is further configured to generate the roof estimate report by generating an electronic file that includes an image of the building along with line drawings of the one or more top plan views of the three-dimensional model.

6. A computer-implemented method for generating a roof estimate, the method comprising:

receiving a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building;

correlating the first aerial image with the second aerial image;

generating, based at least in part on the correlation between the first and second aerial images, a three-dimensional model of the roof that includes a plurality of planar roof sections that each have a corresponding slope, area, and edges; and

transmitting a roof estimate report that includes one or more top plan views of the three-dimensional model annotated with numerical indications of at least one of the slope, area, and lengths of the edges of the plurality of planar roof sections.

7. The method of claim 6 wherein identifying the building includes receiving a street address of the building.

8. The method of claim 6 wherein correlating the first and second aerial images includes receiving an indication of one or more corresponding points shown in each of the first and second aerial images.

9. The method of claim 8 wherein receiving the indication of the corresponding point includes receiving the indication from a user.

10. The method of claim 6 wherein generating the three-dimensional model includes receiving an indication of at least one of a ridgeline of the roof, a valley of the roof, an edge of the roof, a hip of the roof, and a gable of the roof.

11. The method of claim 6, further comprising generating the roof estimate report, the roof estimate report being a data file that includes an image of the building along with line drawings of the one or more top plan views of the three-dimensional model.

12. The method of claim 6 wherein transmitting the roof estimate report includes transmitting a data file that includes the one or more top plan views of the three-dimensional model.

13. The method of claim 1 wherein transmitting the roof estimate report includes initiating printing of the one or more top plan views of the three-dimensional model.

14. A computer-readable medium whose contents enable a computing system to generate a roof estimate report for a building having a roof, by performing a method comprising:

receiving one or more images of the building;

generating, based on the one or more images of the building, a model of the roof that includes a plurality of planar roof sections that each have a corresponding area and edges; and

transmitting a roof estimate report that includes one or more views of the model, the report being annotated with numerical indications of the area and lengths of the edges of at least some of the plurality of planar roof sections.

15. The computer-readable medium of claim 14 wherein generating the model includes generating a three-dimensional model based on a correlation between two of the one or more images.

16. The computer-readable medium of claim 14 wherein the method further comprises generating the roof estimate report, the roof estimate report including annotated line drawings of each of the one or more views of the model.

17. The computer-readable medium of claim 16 wherein generating the roof estimate report includes labeling the one more views with labels that indicate the area and/or dimensions of the perimeter of at least some of the plurality of planar roof sections, the labels each having a size that is based at least in part on the area and/or the dimensions of the perimeter of the at least some planar roof sections.

18. The computer-readable medium of claim 14 wherein the one or more images of the building are images obtained from at least one of an aircraft, satellite, and ground-based platform, and wherein the one or more views of the model are top-down line drawing views of the model.

19. The computer-readable medium of claim 14 wherein generating the model of the roof includes automatically identifying at least some features of the roof for inclusion in the model.

20. The computer-readable medium of claim 14 wherein the contents are instructions that when executed cause the computing system to perform the method.

21. The computer-readable medium of claim 14 wherein the method further comprises transmitting to a remote computing system a computer-readable data file that includes a representation of the model.

22. The computer-readable medium of claim 14 wherein generating the model of the roof includes generating a two-dimensional model of the roof based on a single image that provides a substantially top-down view of the roof.

23. The computer-readable medium of claim 22 further comprising:

presenting the model to a customer; and

modifying the model of the roof based on input received from the customer, the input indicating a slope corresponding to one of the plurality of planar roof sections, wherein transmitting the roof estimate report includes generating a roof estimate report based on the modified model.

23. The computer-readable medium of claim 22 further comprising:

modifying the model of the roof based on input received from a customer, the input identifying a ridge or valley of the roof, wherein transmitting the roof estimate report includes generating a roof estimate report based on the modified model.

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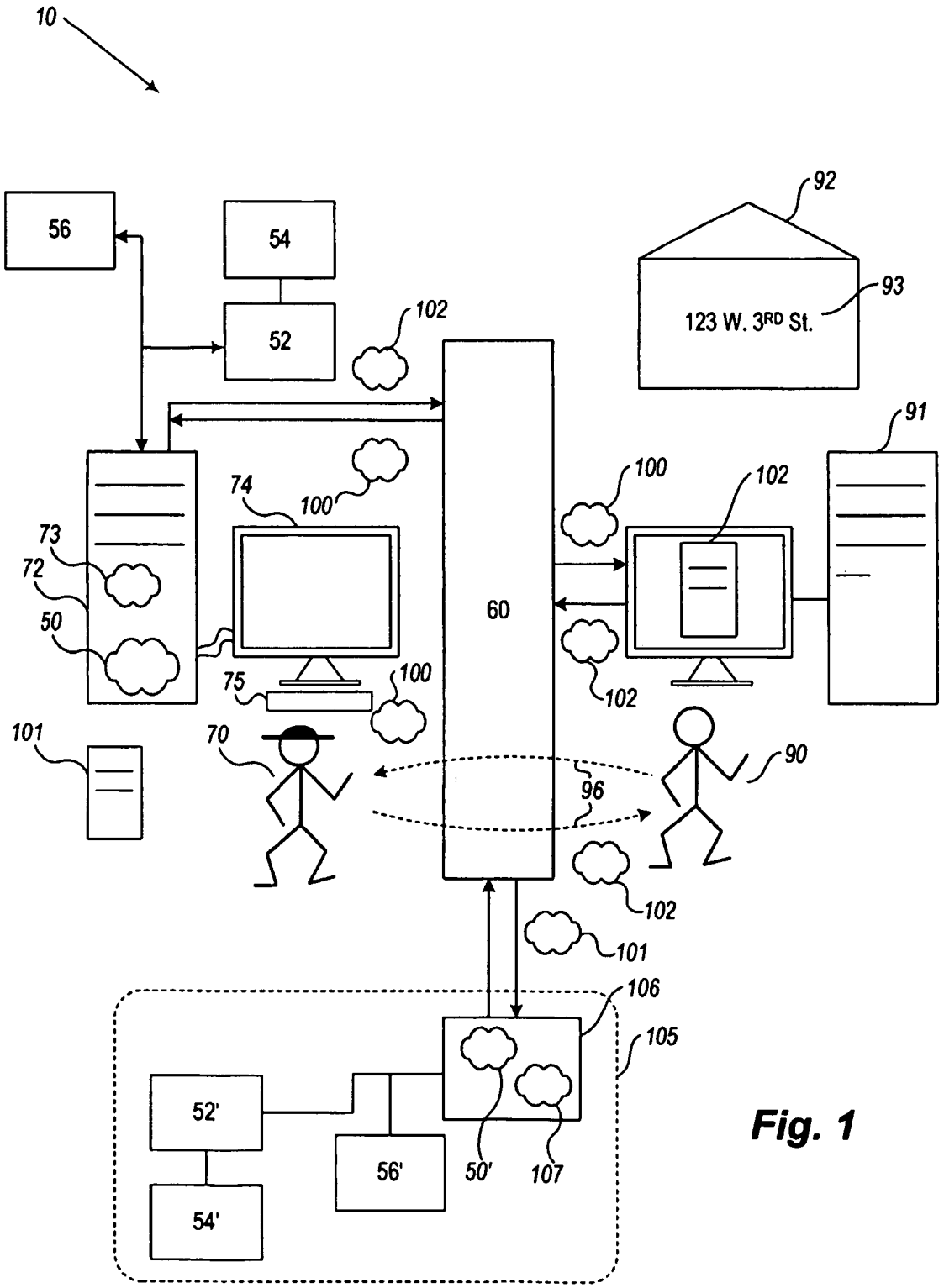


Fig. 1

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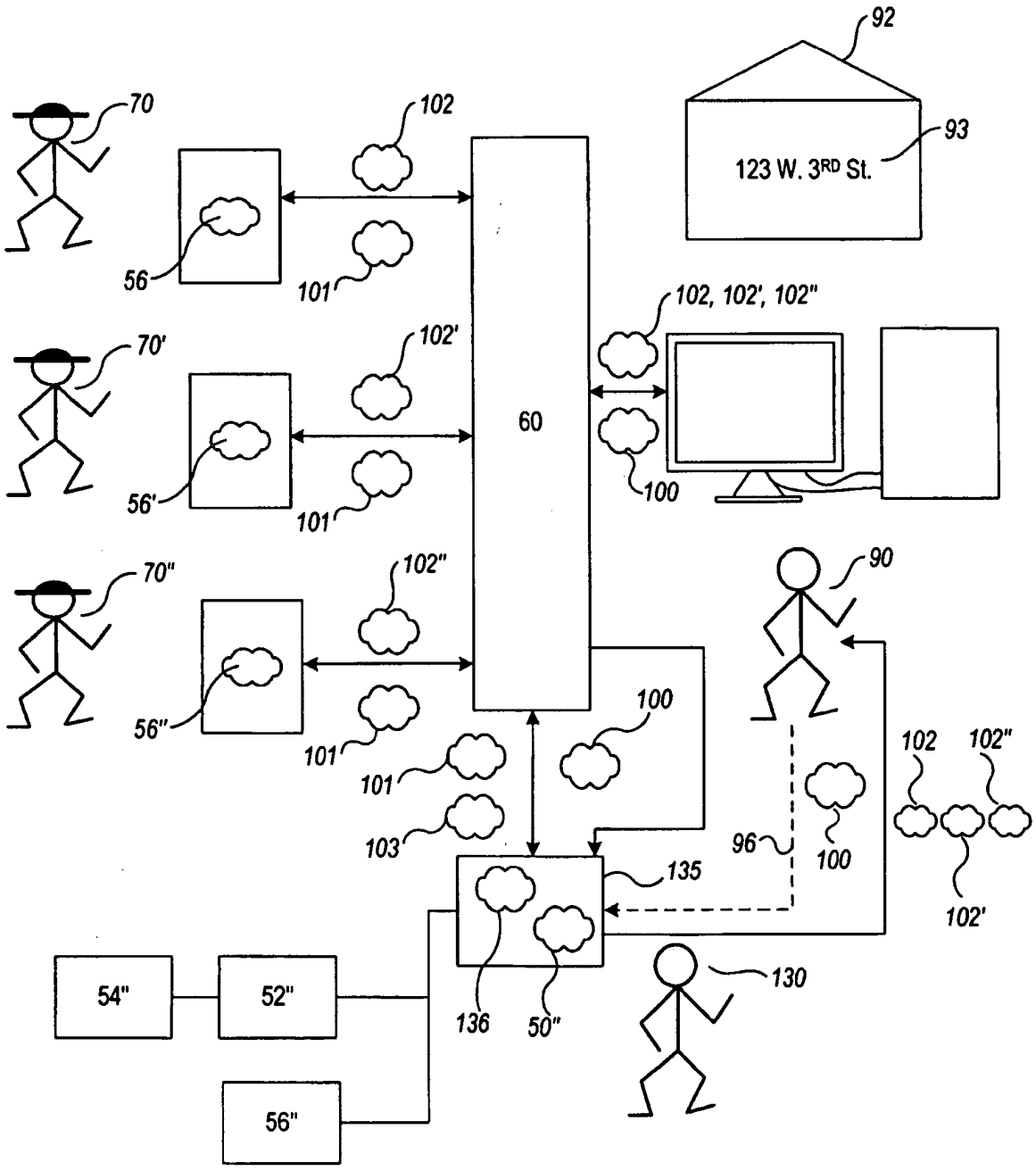


Fig. 2

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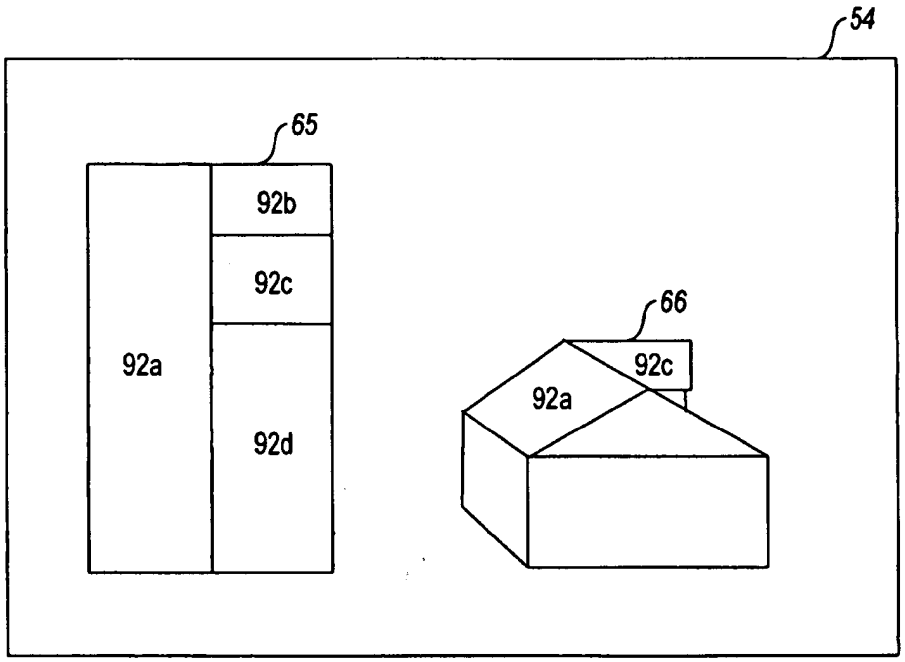


Fig. 3

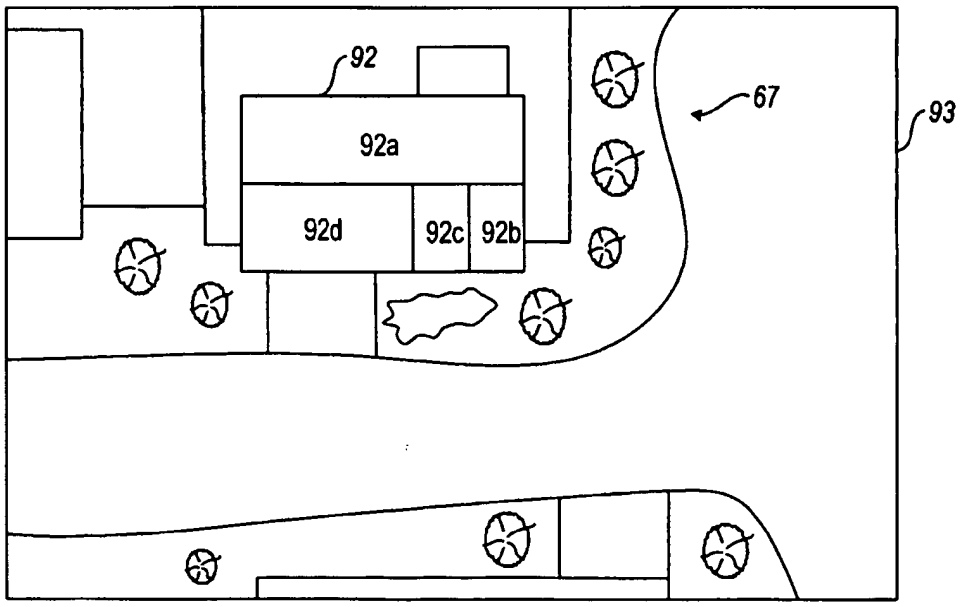


Fig. 4

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1234 Main Street, Redmond, WA

Order: 2468

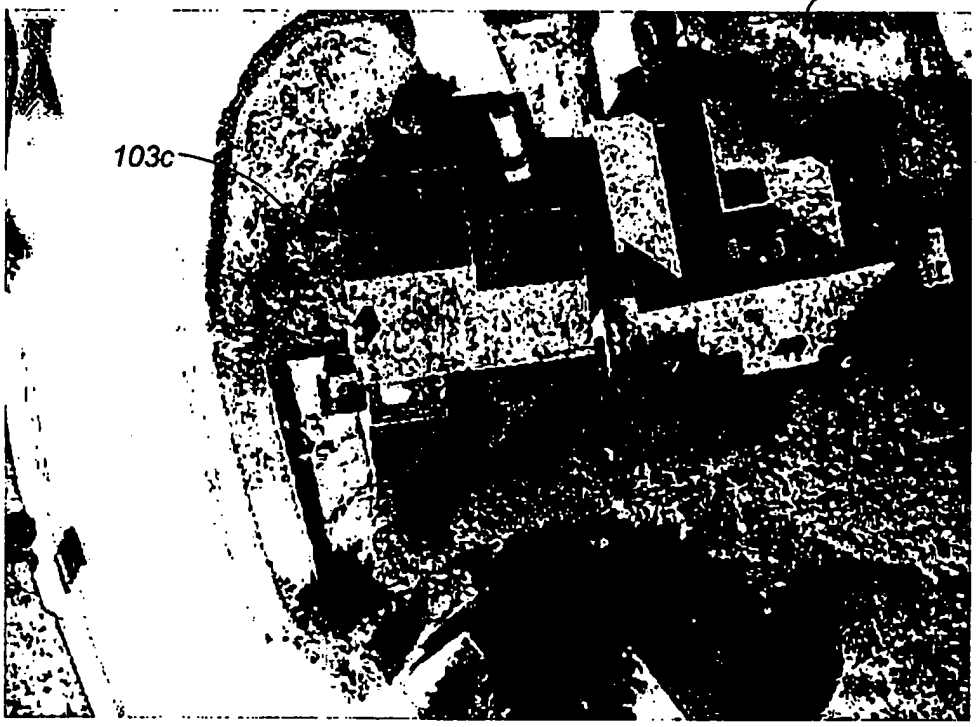
<Customer Name Here>

4/16/2008

103a

1234 Main Street, Redmond, WA

103b



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Fig. 5A

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1234 Main Street, Redmond, WA

Images:



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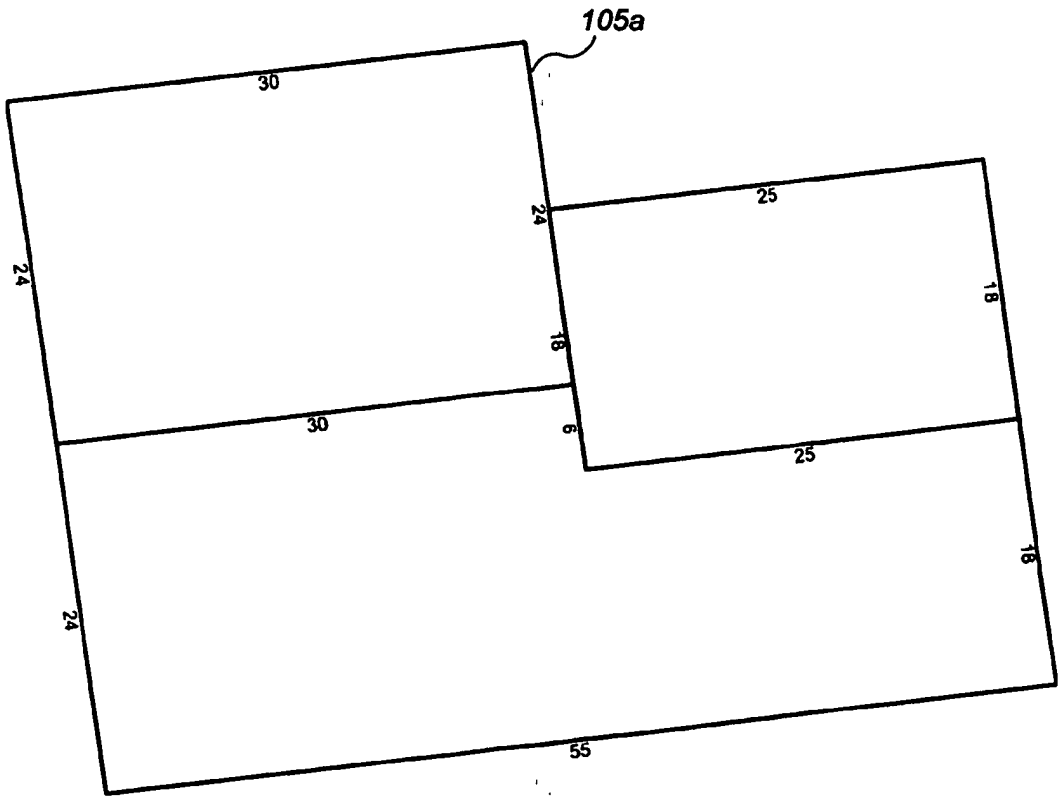
Fig. 5B

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1234 Main Street, Redmond, WA

Length Diagram:

All measurements are rounded to the nearest foot
Ridge Length = 55 ft [Red Lines]
Valley Length = 0 ft [Blue lines]



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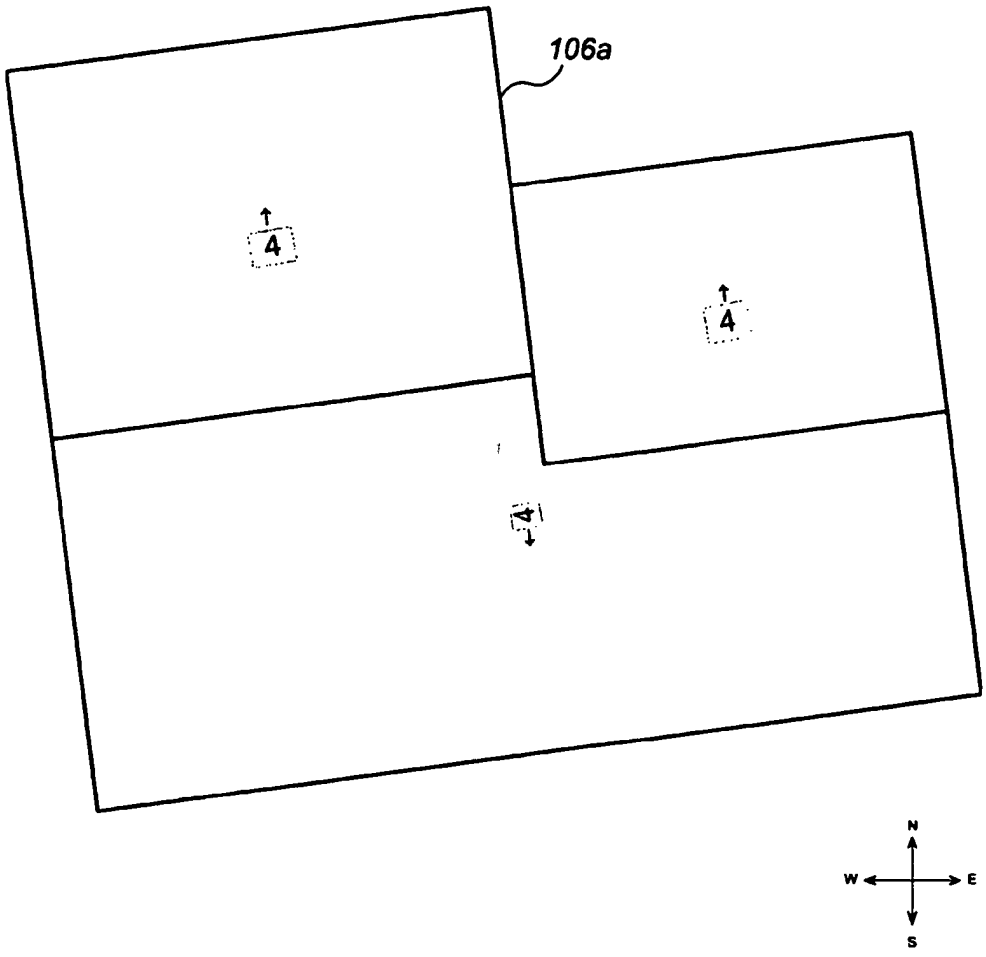
105

Fig. 5C

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1234 Main Street, Redmond, WA

Pitch Diagram:
Pitch units are inches per foot.



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Fig. 5D

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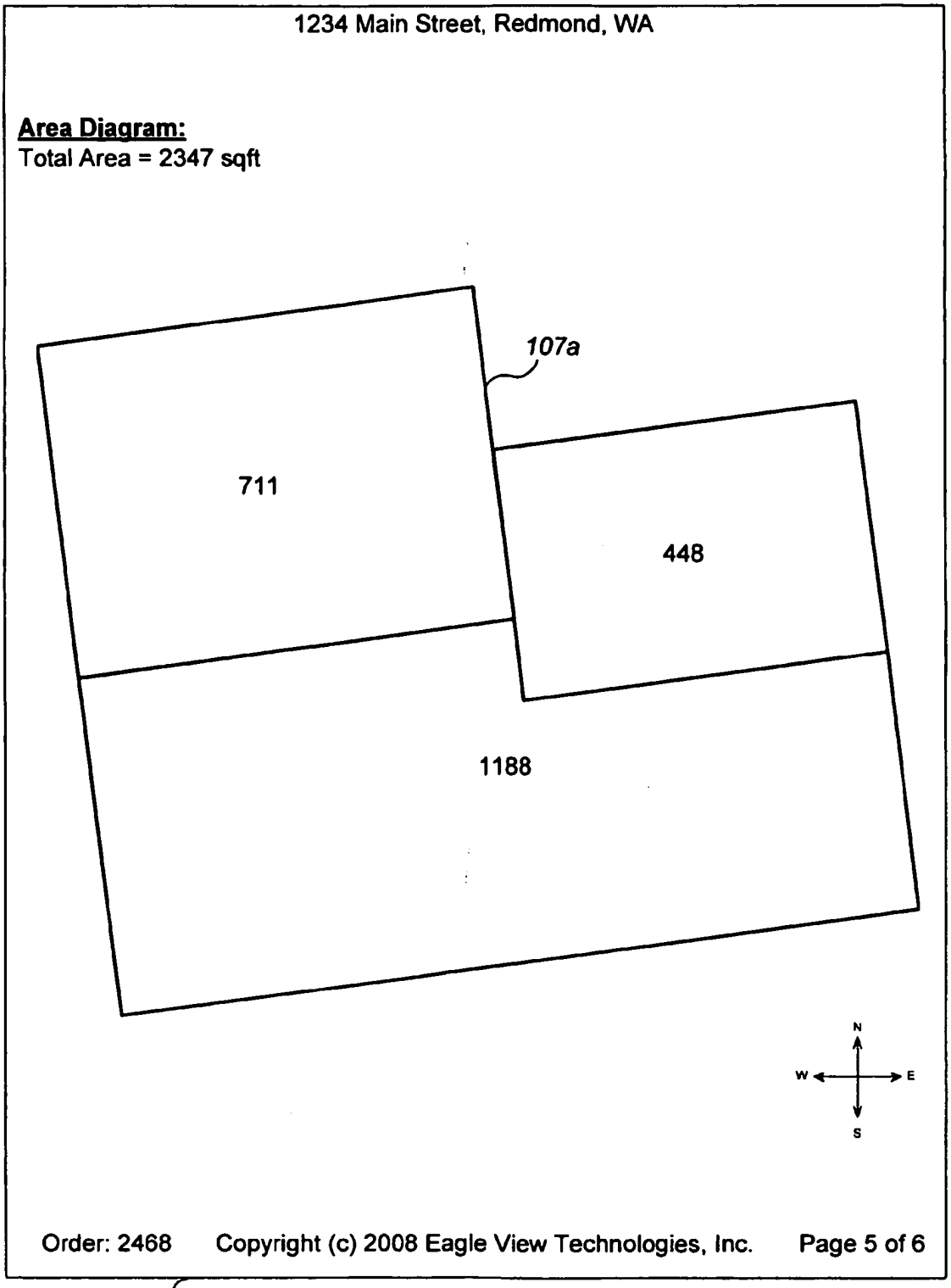


Fig. 5E

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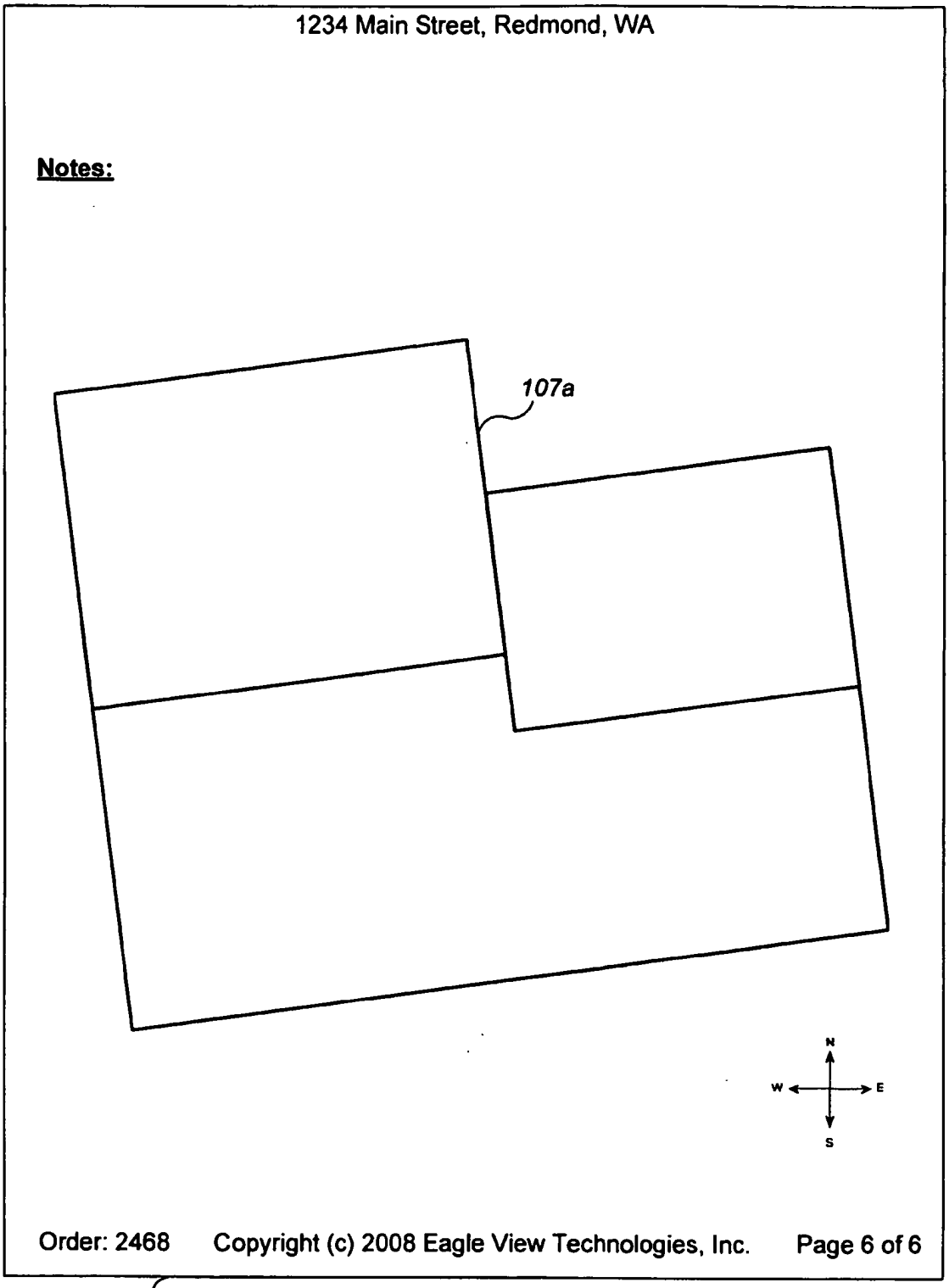
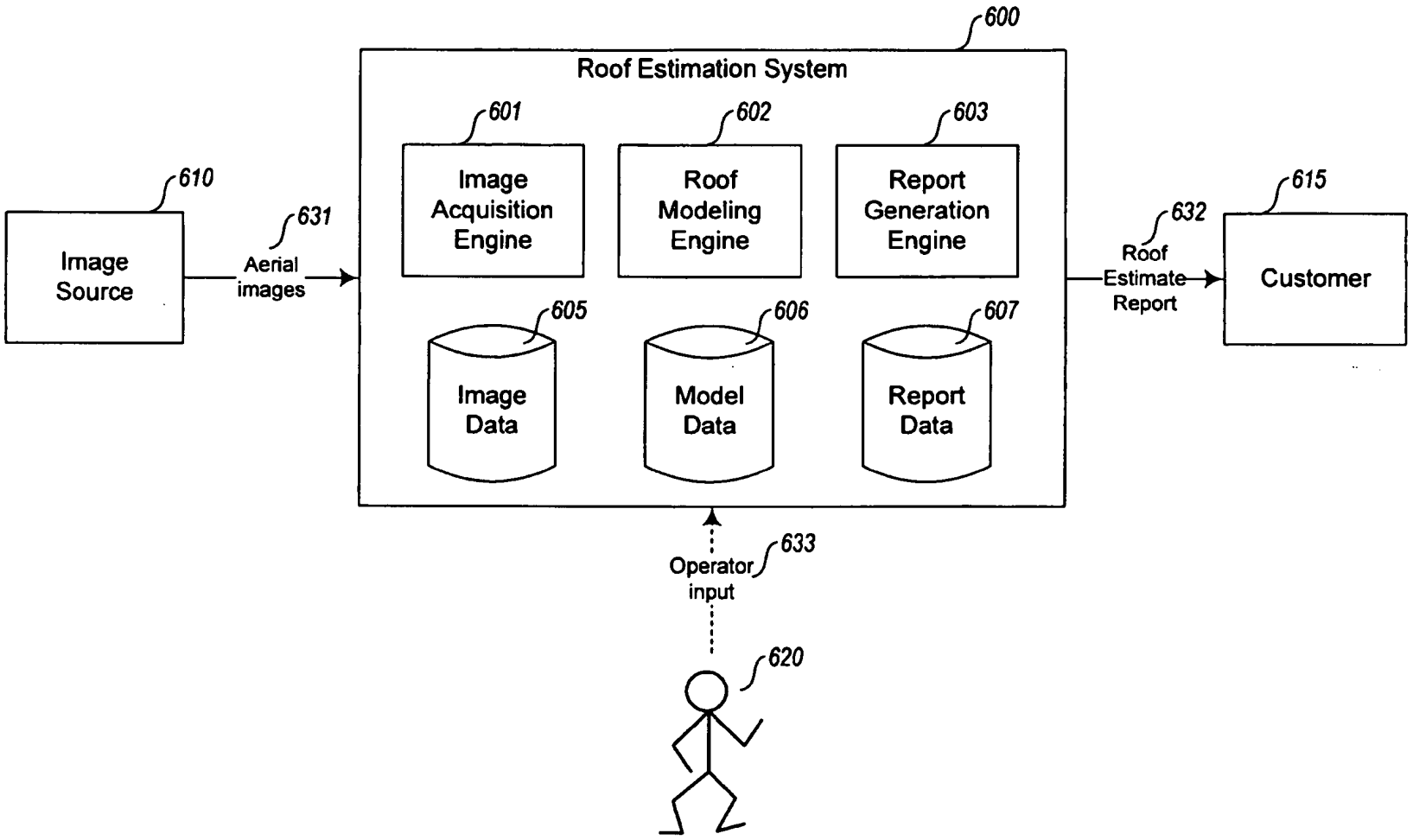


Fig. 5F

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Fig. 6



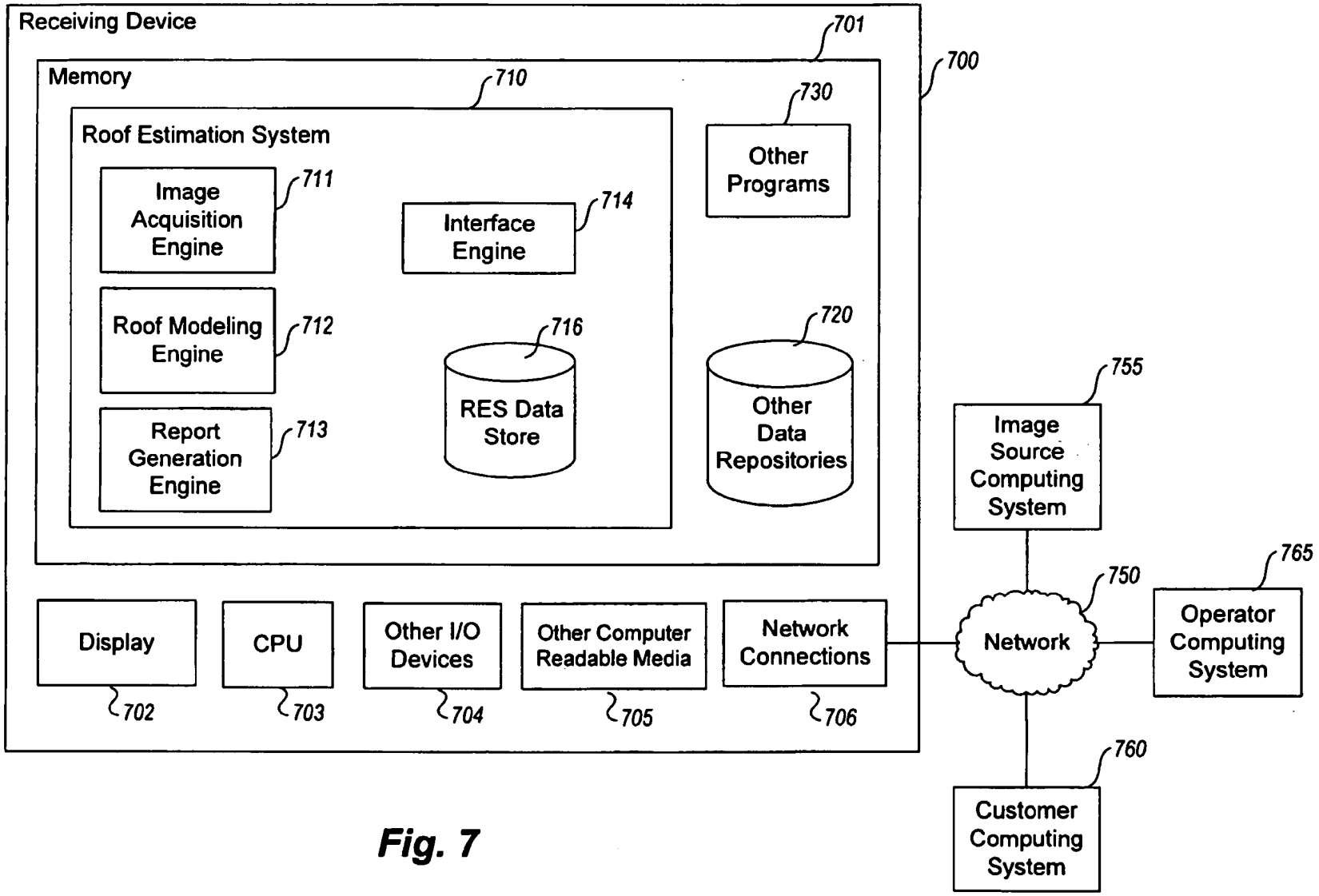

Receiving Device
701
700
Memory
710
730
Roof Estimation System
Image Acquisition Engine
711
Interface Engine
714
Other Programs
Roof Modeling Engine
712
716
720
RES Data Store
Other Data Repositories
Report Generation Engine
713
755
Image Source Computing System
765
750
Network
Operator Computing System
Display
CPU
Other I/O Devices
Other Computer Readable Media
Network Connections
702
703
704
705
706
760
Customer Computing System

Fig. 7

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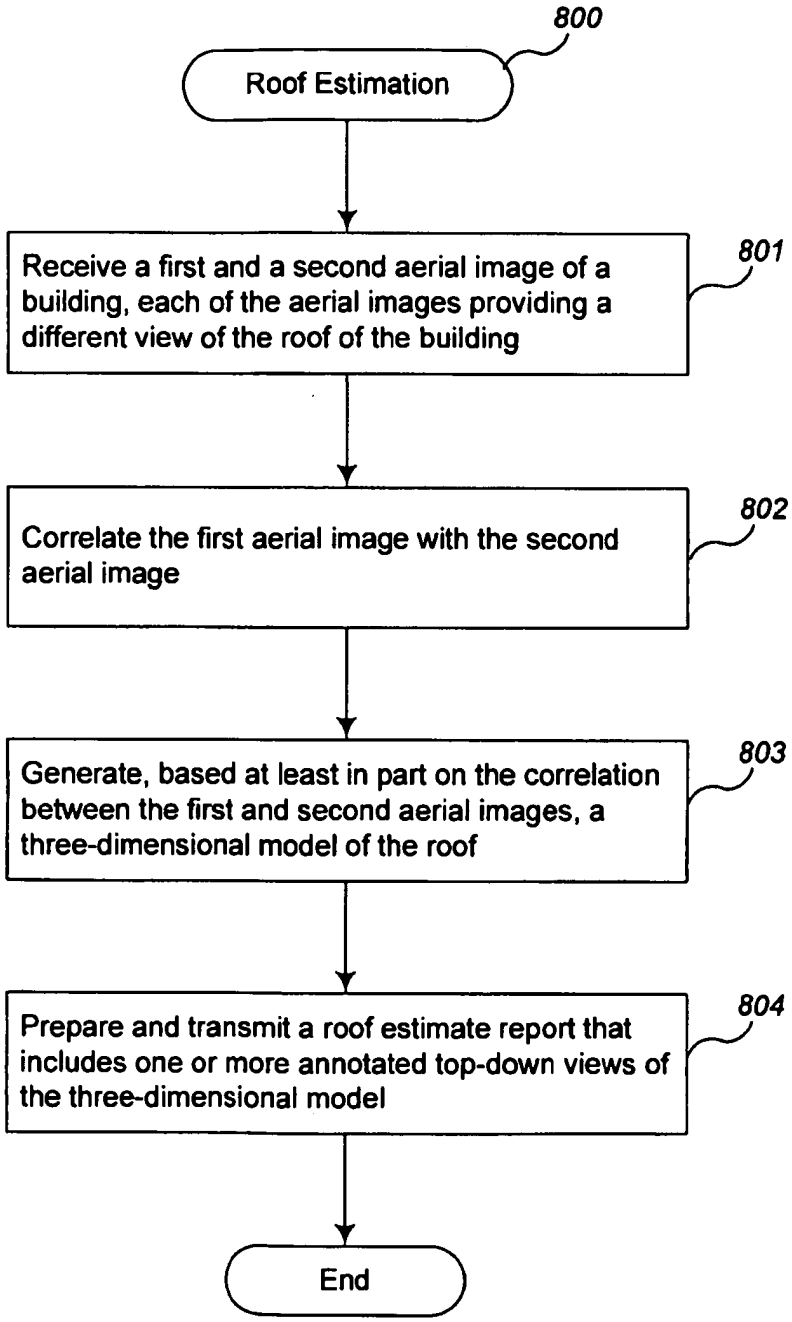


Fig. 8

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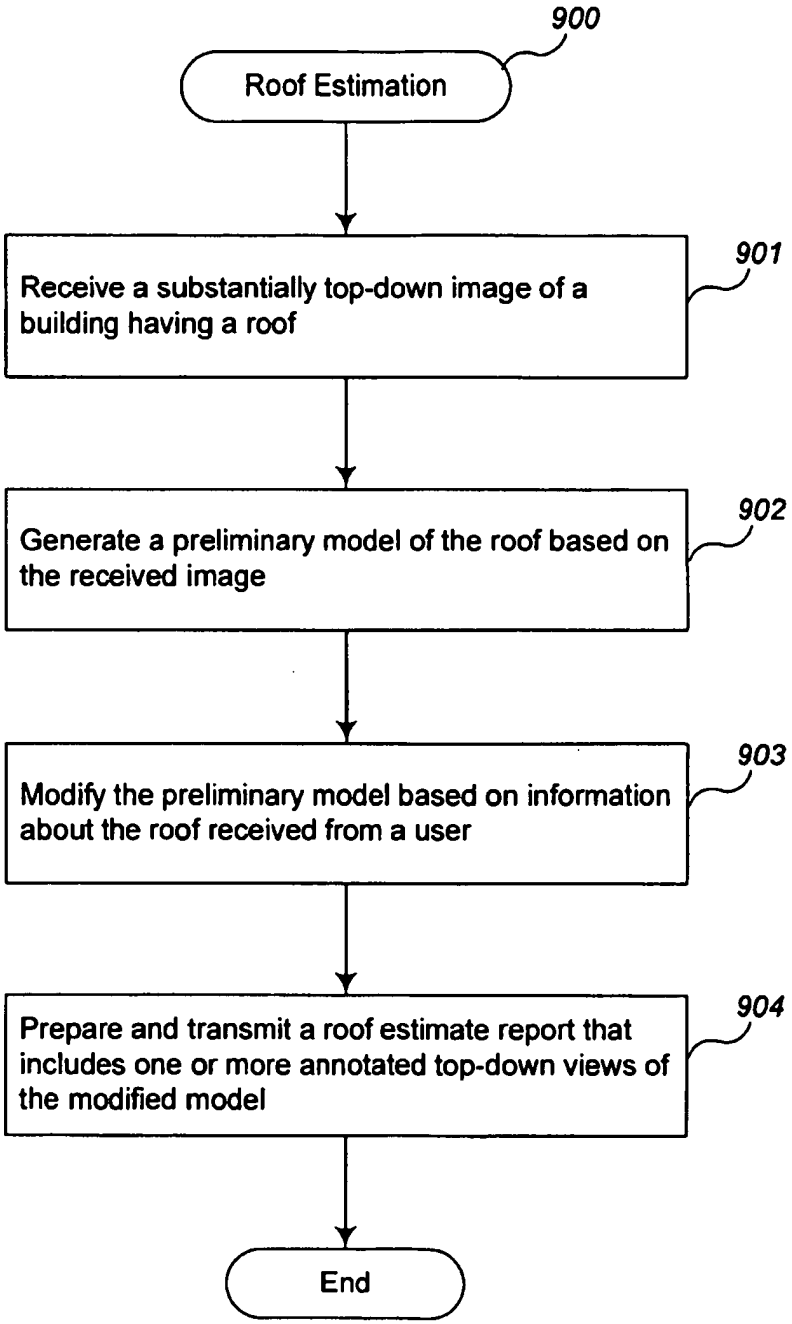


Fig. 9

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 251 833 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.11.2010 Bulletin 2010/46

(51) Int Cl.:
G06T 17/40 *(2006.01)* ***G06T 17/50*** *(2006.01)*

(21) Application number: **10162199.3**

(22) Date of filing: **06.05.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
BA ME RS

(30) Priority: **15.05.2009 US 467244**

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(54) Pitch determination systems and methods for aerial roof estimation

(57) User interface systems and methods for roof estimation are described. Example embodiments include a roof estimation system that provides a user interface configured to facilitate roof model generation based on one or more aerial images of a building roof. In one embodiment, roof model generation includes image registration, image lean correction, roof section pitch determination, wire frame model construction, and/or roof model review. The described user interface provides user interface controls that may be manipulated by an operator to perform at least some of the functions of roof model generation. In one embodiment, the user interface provides user interface controls that facilitate the determination of pitch of one or more sections of a building roof. This abstract is provided to comply with rules requiring an abstract, and it is submitted with the intention that it will not be used to interpret or limit the scope or meaning of the claims.

EP 2 251 833 A2

Printed by Jouve, 75001 PARIS (FR)

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Non-Provisional Application No. 12/467,244; entitled "PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION" filed May 15, 2009 which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention:

[0002] This invention relates to systems and methods for estimating construction projects, and more particularly, to such systems and methods for determining roof measurement information based on one or more aerial images of a roof of a building.

2. Description of the Related Art:

[0003] The information provided below is not admitted to be part of the present invention, but is provided solely to assist the understanding of the reader.

[0004] Homeowners typically ask several roofing contractors to provide written estimates to repair or replace a roof on a house. Heretofore, the homeowners would make an appointment with each roofing contractor to visit the house to determine the style of roof, take measurements, and to inspect the area around the house for access and cleanup. Using this information, the roofing contractor then prepares a written estimate and then timely delivers it to the homeowner. After receiving several estimates from different rooting contractors, the homeowner then selects one.

[0005] There are factors that impact a roofing contractor's ability to provide a timely written estimate. One factor is the size of the roof contractor's company and the location of the roofing jobs currently underway. Most roof contractors provide roofing services and estimates to building owners over a large geographical area. Larger roof contractor companies hire one or more trained individuals who travel throughout the entire area providing written estimates. With smaller roofing contractors, the owner or a key trained person is appointed to provide estimates. With both types of companies, roofing estimates are normally scheduled for buildings located in the same area on a particular day. If an estimate is needed suddenly at a distant location, the time for travel and the cost of commuting can be prohibitive. If the roofing contractor is a small company, the removal of the owner or key person on a current job site can be time prohibitive.

[0006] Another factor that may impact the roofing contractor's ability to provide a written estimate is weather and traffic.

[0007] Recently, solar panels have become popular. In order to install solar panels, the roof's slope, geometrical shape, and size as well as its orientation with respect to the sun all must be determined in order to provide an estimate of the number and type of solar panels required. Unfortunately, not all roofs on a building are proper size, geometrical shape, or orientation for use with solar panels.

SUMMARY

[0008] These and other objects are met by the systems and methods disclosed herein that determine and provide roof measurement information about the sizes, dimensions, slopes and orientations of the roof sections of a building roof. Roof measurement information may be used to generate a roof estimate report that provides and graphically shows this information. A roof estimation system that practices at least some of the techniques described herein may include an image acquisition engine, a roof modeling engine, and a report generation engine. The roof estimation system is configured to generate a model of a roof of a building, based on one or more aerial images. In addition, the roof estimation system is configured to determine roof measurement information and generate a roof estimate report based on the generated model and/or the determined roof measurement information.

[0009] In some embodiments, the roof estimation system includes a user interface engine which provides access to at least some of the functions of the roof estimation system. In one embodiment, the user interface engine provides interactive user interface components operable by an operator to perform various functions related to generating a model of a roof of a building, including image registration, lean correction, pitch determination, feature identification, and model review and/or correction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system.

[0011] Figures 2A-2B illustrate aerial images of a building at a particular address.

[0012] Figures 3A-3F illustrate individual pages of an example roof estimate report generated by an example embodiment of a roof estimation system.

[0013] Figures 4A-4F are screen displays illustrating image registration and image lean correction in an example embodiment. (Also shows lean correction.)

[0014] Figures 5A-5D are screen displays illustrating pitch determination in an example embodiment.

[0015] Figures 6A-6D are screen displays illustrating model construction and concurrent display of operator specified roof features in an example embodiment.

[0016] Figures 7A-7C are screen displays illustrating roof model review in an example embodiment.

[0017] Figure 8 is an example block diagram of a com-

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puting system for practicing embodiments of a roof estimation system.

[0018] Figure 9 is an example flow diagram of an image registration routine provided by an example embodiment.

[0019] Figure 10 is an example flow diagram of a pitch determination routine provided by an example embodiment.

[0020] Figure 11 is an example flow diagram of concurrent feature display routine provided by an example embodiment.

DETAILED DESCRIPTION

[0021] Embodiments described herein provide enhanced computer-and network-based methods, techniques, and systems for estimating construction projects based on one or more images of a structure. Example embodiments provide a Roof Estimation System ("RES") that is operable to provide a roof estimate report for a specified building, based on one or more aerial images of the building. In one embodiment, a customer of the RES specifies the building by providing an address of the building. The RES then obtains one or more aerial images showing at least portions of the roof of the building. Next, the RES generates a model of the roof of the building, which is then utilized to determine roof measurement information. The roof measurement information may include measurements such as lengths of the edges of sections of the roof, pitches of sections of the roof, areas of sections of the roof, etc. The model of the roof and/or the roof measurement information is then used to generate a roof estimate report. The roof estimate report includes one or more line drawings of the roof of the building, which are annotated with information about the roof, such as lengths of the edges of sections of the roof, pitches of sections of the roof, areas of sections of the roof, etc.

[0022] Some embodiments of the roof estimation system include an interactive user interface configured to provide access to one or more of the functions of the roof estimation system. In one embodiment, the roof estimation system includes user interface controls that facilitate image registration, image lean correction, roof model generation, pitch determination, and roof model review. Image registration includes aligning, based at least in part on operator inputs, one or more images of a building roof to a set of reference points within a single three-dimensional ("3D") grid that is shared between the one or more images. Roof model generation includes generating a 3D model of a roof, based at least in part on operator inputs specifying various features and/or dimensional attributes of the roof. Roof model generation may further include the determination of the pitches of various planar sections of a roof. Roof model review includes display of a model of a roof, possibly in conjunction with one or more images of the roof, so that an operator may review the model for accuracy and possibly make adjustments and/or corrections to the roof model. In other embodiments, all or some of the functions of the roof estimation system may be performed automatically. For example, image registration may include automatically identifying building features for the placement of reference markers. Further, roof model generation may include automatically recognizing features, dimensional attributes, and/or pitches of various planar roof sections of the roof.

[0023] The described user interface is also configured to concurrently display roof features onto multiple images of a roof. For example, in the context of roof model generation, an operator may indicate a roof feature, such as an edge or a corner of a section of the roof, in a first image of the roof. As the roof estimation system receives the indication of the roof feature, the user interface concurrently displays that feature in one or more other images of the roof, so that the operator may obtain feedback regarding the accuracy of the roof model, the image registration, etc.

[0024] In the following, Figures 1-3 provide an overview of the operation of an example roof estimation system. Figures 4-7 provide additional details related an example interactive user interface provided by one embodiment of the roof estimation system. Figures 8-11 provide details related to roof estimation system implementation techniques.

1. Roof Estimation System Overview

[0025] Figure 1 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system. In particular, Figure 1 shows an example Roof Estimation System ("RES") 100 comprising an image acquisition engine 101, a roof modeling engine 102, a report generation engine 103, image data 105, model data 106, and report data 107. The RES 100 is communicatively coupled to an image source 110, a customer 115, and optionally an operator 120. The RES 100 and its components may be implemented as part of a computing system, as will be further described with reference to Figure 8.

[0026] More specifically, in the illustrated embodiment of Figure 1, the RES 100 is configured to generate a roof estimate report 132 for a specified building, based on aerial images 131 of the building received from the image source 110. The image source 110 may be any provider of images of the building for which a roof estimate is being generated. In one embodiment, the image source 110 includes a computing system that provides access to a repository of aerial images of one or more buildings. In addition, the aerial images 131 may include images obtained via manned or unmanned aircraft (*e.g.*, airplane, helicopter, blimp, drone, etc.), satellite, etc. Furthermore, the aerial images 131 may include images obtain via one or more ground-based platforms, such as a vehicle-mounted camera that obtains street-level images of buildings, a nearby building, a hilltop, etc. In some cases, a vehicle-mounted camera may be mounted in an elevated position, such as a boom. Example aerial images

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are described further with reference to Figures 2A-2B.

[0027] The image acquisition engine 101 obtains one or more aerial images of the specified building by, for example, providing an indicator of the location of the specified building (*e.g.*, street address, GPS coordinates, lot number, etc.) to the image source 110. In response, the image source 110 provides to the image acquisition engine 101 the one or more aerial images of the building. The image acquisition engine 101 then stores the received aerial images as image data 105, for further processing by other components of the RES 100. Obtaining aerial images of a specified building may include various forms of geo-coding, performed by the image acquisition engine 101 and/or the image source 110. In one embodiment, the image source geo-codes a provided street address into latitude and longitude coordinates, which are then used to look up (*e.g.*, query a database) aerial images of the provided street address.

[0028] Next, the roof modeling engine 102 generates a model of the roof of the specified building. In the illustrated embodiment, the roof modeling engine 102 generates a three-dimensional ("3D") model, although in other embodiments, a two-dimensional (*e.g.*, top-down roof plan) may be generated instead or in addition. Generating a model of the roof may generally include image calibration, in which the distance between two pixels on a given image is converted into a physical length. Image calibration may be performed automatically, such as based on meta-information provided along with the aerial images 131.

[0029] A variety of automatic and semi-automatic techniques may be employed to generate a model of the roof of the building. In one embodiment, generating such a model is based at least in part on a correlation between at least two of the aerial images of the building. For example, the roof modeling engine 102 receives an indication of a corresponding feature that is shown in each of the two aerial images. In one embodiment, an operator 120, viewing two or more images of the building, inputs an indication in at least some of the images, the indications identifying which points of the images correspond to each other for model generation purposes.

[0030] The corresponding feature may be, for example, a vertex of the roof of the building, the corner of one of the roof planes of the roof, a point of a gable or hip of the roof, etc. The corresponding feature may also be a linear feature, such as a ridge or valley line between two roof planes of the roof. In one embodiment, the indication of a corresponding feature on the building includes "registration" of a first point in a first aerial image, and a second point in a second aerial image, the first and second points corresponding the substantially the same point on the roof of the building. Generally, point registration may include the identification of any feature shown in both aerial images. Thus, the feature need not be a point on the roof of the building. Instead, it may be, for example, any point that is visible on both aerial images, such as on a nearby building (*e.g.*, a garage, neighbor's building, etc.), on a nearby structure (*e.g.*, swimming pool, tennis court, etc.), on a nearby natural feature (*e.g.*, a tree, boulder, etc.), etc.

[0031] In some embodiments, the roof modeling engine 102 determines the corresponding feature automatically, such as by employing on one or more image processing techniques used to identify vertexes, edges, or other features of the roof. In other embodiments, the roof modeling engine 102 determines the corresponding feature by receiving, from the human operator 120 as operator input 133, indications of the feature shown in multiple images of the building.

[0032] In one example embodiment, the RES 100 generates a model of the roof of the building in the following manner. First, a set of reference points are be identified in each of the images. These reference points are identified by the operator 120 utilizing a suitable input device, such as a mouse or joystick. The roof modeling engine 102 then uses these reference points and any acceptable algorithm to co-register the images and reconstruct the three-dimensional geometry of the object identified by the reference points. There are a variety of photogrammetric algorithms that can be utilized to perform this reconstruction. One such algorithm used by the RES 100 uses photographs taken from two or more view points to "triangulate" points of interest on the object in three-dimensional ("3D") space. This triangulation can be visualized as a process of projecting a line originating from the location of the photograph's observation point that passes through a particular reference point in the image. The intersection of these projected lines from the set of observation points to a particular reference point identifies the location of that point in 3D space. Repeating the process for all such reference points allows the software to determine a 3D volume suitable for building a 3D model of the structure. The choice of reconstruction algorithm depends on a number of factors such as the spatial relationships between the photographs, the number and locations of the reference points, and any assumptions that are made about the geometry and symmetry of the object being reconstructed. Several such algorithms are described in detail in textbooks, trade journals, and academic publications.

[0033] In addition, generating a model of the roof of a building may include correcting one or more of the aerial images for various imperfections. For example, the vertical axis of a particular aerial image sometimes will not substantially match the actual vertical axis of its scene. This will happen, for example, if the aerial images were taken at different distances from the building, or at a different pitch, roll, or yaw angles of the aircraft from which the images were produced. In such cases, an aerial image may be corrected by providing the operator 120 with a user interface control operable to adjust the scale and/or relative angle of the aerial image to correct for such errors. The correction may be either applied directly to the aerial image, or instead be stored (*e.g.*, as an offset) for use in model generation or other functions of the RES

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100.

[0034] Generating a model of the roof of a building further includes the automatic or semi-automatic identification of features of the roof of the building. In one embodiment, one or more user interface controls may be provided, such that the operator 120 may indicate (*e.g.*, draw, paint, etc.) various features of the roof, such as valleys, ridges, hips, vertexes, planes, edges, etc. As these features are indicated by the operator 120, a corresponding three-dimensional ("3D") model may be updated accordingly to include those features. These features are identified by the operator based on a visual inspection of the images and by providing inputs that identify various features as valleys, ridges, hips, etc. In some cases, a first and a second image view of the roof (*e.g.*, a north and east view) are simultaneously presented to the operator 120, such that when the operator 120 indicates a feature in the first image view, a projection of that feature is automatically presented in the second image view. By presenting a view of the 3D model, simultaneously projected into multiple image views, the operator 120 is provided with useful visual cues as to the correctness of the 3D model and/or the correspondence between the aerial images.

[0035] In addition, generating a model of the roof of a building may include determining the pitch of one or more of the sections of the roof. In some embodiments, one or more user interface controls are provided, such that the operator 120 may accurately determine the pitch of each of the one or more roof sections. An accurate determination of the roof pitch may be employed (by a human or the RES 100) to better determine an accurate cost estimate, as roof sections having a low pitch are typically less costly surfaces to repair and/or replace.

[0036] The generated model typically includes a plurality of planar roof sections that each correspond to one of the planar sections of the roof of the building. Each of the planar roof sections in the model has a number of associated dimensions and/or attributes, among them slope, area, and length of each edge of the roof section. Other information may include any information relevant to a roof builder or other entity having an interest in construction of, or installation upon, the roof. For example, the other information may include identification of valleys, ridges, rakes, eaves, or hip ridges of the roof and/or its sections; roof and/or roof section perimeter dimensions and/or outlines; measurements of step heights between different roof levels (*e.g.*, terraces); bearing and/or orientation of each roof section; light exposure and/or shadowing patterns due to chimneys, other structures, trees, latitude, etc.; roofing material; etc? Once a 3D model has been generated to the satisfaction of the roof modeling engine 102 and/or the operator 120, the generated 3D model is stored as model data 106 for further processing by the RES 100. In one embodiment, the generated 3D model is then stored in a quality assurance queue, from which it is reviewed and possibly corrected by a quality control operator.

[0037] The report generation engine 103 generates a final roof estimate report based on a model stored as model data 106, and then stores the generated report as report data 107. Such a report typically includes one or more plan (top-down) views of the model, annotated with numerical values for the slope, area, and/or lengths of the edges of at least some of the plurality of planar roof sections of the model of the roof. The report may also include information about total area of the roof, identification and measurement of ridges and/or valleys of the roof, and/or different elevation views rendered from the 3D model (top, side, front, etc). An example report is illustrated and discussed with respect to Figures 3A-3E, below.

[0038] In some embodiments, generating a report includes labeling one or more views of the model with annotations that are readable to a human user. Some models include a large number of small roof details, such as dormers or other sections, such that applying uniformly sized, oriented, and positioned labels to roof section views results in a visually cluttered diagram. Accordingly, various techniques may be employed to generate a readable report, including automatically determining an optimal or near-optimal label font size, label position, and/or label orientation, such that the resulting report may be easily read and understood by the customer 115.

[0039] In addition, in some embodiments, generating a report includes automatically determining a cost estimate, based on specified costs, such as those of materials, labor, transportation, etc. For example, the customer 115 provides indications of material and labor costs to the RES 100. In response, the report generation engine 103 generates a roof estimate report that includes a cost estimate, based on the costs provided by the customer 115 and the attributes of the particular roof, such as area, pitch, etc.

[0040] In one embodiment, the generated report is then provided to a customer. The generated report can be represented, for example, as an electronic file (*e.g.*, a PDF file) or a paper document. In the illustrated example, roof estimate report 132 is transmitted to the customer 115. The customer 115 may be or include any human, organization, or computing system that is the recipient of the roof estimate report 132. For example, the customer 115 may be a property owner, a property manager, a roof construction/repair company, a general contractor, an insurance company, a solar power panel installer, a climate control (*e.g.*, heating, ventilation, and/or air conditioning) system installer, a roof gutter installer, an awning installer, etc. Reports may be transmitted electronically, such as via a network (*e.g.*, as an email, Web page, etc.) or by some shipping mechanism, such as the postal service, a courier service, etc.

[0041] In some embodiments, one or more of the models stored as model data 106 are provided directly to the customer or other computing system, without first being transformed into a report. For example, a model and/or roof measurement information based thereon may be ex-

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ported and/or transmitted as a data file, in any suitable format, that may be consumed or otherwise utilized by some other computing system, such as a computer-aided design ("CAD") tool, a drawing program, a labor and material estimation software, a project management/estimation software, etc.

[0042] The RES 100 may be operated by various types of entities. In one embodiment, the RES 100 is operated by a roof estimation service that provides roof estimate reports to customers, such as roofing contractors, in exchange for payment. In another embodiment, the RES 100 is operated by a roof construction/repair company, to generate roof estimate reports that are used internally and/or provided to customers, such as property owners.

[0043] In addition, the RES 100 may be operated in various ways. In one embodiment, the RES 100 executes as a desktop computer application that is operated by the operator 120. In another embodiment, the RES 100 executes as a network-accessible service, such as by a Web server, that may be operated remotely by the operator 120 and/or the customer 115. Additional details regarding the implementation of an example roof estimation system are provided with respect to Figure 8, below.

[0044] Figures 2A-2B illustrate aerial images of a building at a particular address. In the illustrated example, the aerial images are represented as stylized line drawings for clarity of explanation. As noted above, such aerial images may be acquired in various ways. In one embodiment, an aircraft, such as an airplane or helicopter is utilized to take photographs while flying over one or more properties. Such aircraft may be manned or unmanned. In another embodiment, a ground-based vehicle, such as a car or truck, is utilized to take photographs (*e.g.*, "street view" photographs) while driving past one or more properties. In such an embodiment, a camera may be mounted on a boom or other elevating member, such that images of building roofs may be obtained. In another embodiment, photographs may be taken from a fixed position, such as a tall building, hilltop, tower, etc.

[0045] In particular, Figure 2A shows a top plan (top-down) aerial image 210 of a building 200. The roof of the building 200 includes multiple planar roof sections 200a-200d. Figure 2A also shows a second aerial image 211 providing a perspective (oblique) view of the building 200. The roof sections 200a and 200c are also visible in image 211.

[0046] Figure 2B shows a top-down, wide angle image 212 of the building 200. The image 212 includes details of the surrounding areas 220 of the building 220. Information about the surrounding areas 220 of the building 220 are in some embodiments used to determine additional cost factors related to a roof estimate. For example, the cleanup of, or access to, a worksite at building 220 may be complicated by various factors, including a substantial amount of landscaping; steeply sloped building sites; proximity to environmentally sensitive areas; etc. In such cases, the roof estimation system may automatically increase a cost factor in a corresponding roof estimate report.

[0047] In some embodiments, an aerial image has corresponding meta-information. Such meta-information may include details about the type of camera used (*e.g.*, focal length, exposure, etc.), the position of the camera (*e.g.*, GPS coordinates of the aircraft at the time the image was captured), the orientation of the camera (*e.g.*, the angle of the camera), the time and/or date the image was captured, etc.

[0048] Figures 3A-3F illustrate individual pages of an example roof estimate report generated by an example embodiment of a roof estimation system. As discussed with respect to Figure 1, a roof estimate report is generated by the roof estimation system based on one or more aerial images of a building. The roof estimate report may be based on a computer model (*e.g.*, a 3D model) of the roof, and includes one or more views of the model. In this example, the various views of the model are presented as annotated line drawings, which provide information about the roof, such as the roof section areas, roof section edge lengths, roof section pitches, etc. The roof estimate report may be in an electronic format (*e.g.*, a PDF file) and/or paper format (*e.g.*, a printed report). In some embodiments, the roof estimate report may be in a format that may be consumed by a computer-aided design program.

[0049] Figure 3A shows a cover page 301 of the report and includes the address 301 a of a building 301 c and an overhead aerial image 301 b of the building 301 c.

[0050] Figure 3B shows a second page 302 of the report and includes two wide perspective (oblique) views 302a and 302b of the building 301 c at the address with the surrounding areas more clearly shown.

[0051] Figure 3C shows a third page 303 of the report and includes a line drawing 303a of the building roof showing ridge lines 303b and 303c, and a compass indicator 303d. In addition, a building roof having valleys would result in a line drawing including one or more valley lines. The ridge and/or valley lines may be called out in particular colors. For example, ridge lines 303b and 303c may be illustrated in red, while valley lines may be illustrated in blue. The line drawing 303a is also annotated with the dimensions of the planar sections of the building roof. In this case, the dimensions are the lengths of the edges of the planar roof sections.

[0052] Fig 3D shows a fourth page 304 of the report and includes a line drawing 304a of the building roof showing the pitch of each roof section along with a compass indicator. The pitch in this example is given in inches, and it represents the number of vertical inches that the labeled planar roof section drops over 12 inches of horizontal run. The slope can be easily calculated from such a representation using basic trigonometry. The use of a numerical value of inches of rise per foot of run is a well known measure of slope in the roofing industry. A roof builder typically uses this information to assist in the repair and/or construction of a roof. Of course, other measures and/or units of slope may be utilized as well,

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including percent grade, angle in degrees, etc.

[0053] Figure 3E shows a fifth page 305 of the report and includes a line drawing 305a of the building roof showing the square footage of each roof section along with the total square foot area value. Of course, other units of area may be used as well, such as square meters or the number of "squares" of roofing material required for covering each roof section.

[0054] Figure 3F shows a fifth page 306 of the report and includes a line drawing 306a of the building roof where notes or comments may be written. The line drawing 306a includes a label for each roof section (shown here as "A", "B", "C"), such that comments may be conveniently related to specific roof sections.

[0055] In other embodiments, more or less information may be provided, or the illustrated information may be arranged in different ways. For example, the report may be provided in electronic form, such as a PDF file or a computer aided design software format. In some embodiments, the report may be "active" or editable, such that the user of the report may make changes to the report, based on on-site observations.

2. Roof Estimation System User Interface

[0056] Figures 4A-4F, 5A-5D, 6A-6D, and 7A-7C describe an example interactive user interface provided by one embodiment of the roof estimation system. As noted, the RES 100 described with reference to Figure 1 includes a user interface engine 104 that is configured to provide access to one or more functions of the RES 100, including image registration (described with respect to Figures 4A-4F), roof pitch determination (described with respect to Figures 5A-5D), roof model construction (described with reference to Figures 6A-6D), and roof model review (described with respect to Figures 7A-7C).

A. Image Registration

[0057] Figures 4A-4F are screen displays illustrating image registration and image lean correction in an example embodiment. In particular, Figure 4A shows a user interface screen 400 that is utilized by an operator to generate a three dimensional model of a roof of a building. The user interface screen 400 shows a roof modeling project in an initial state, after the operator has specified an address of a building and after images of the building have been obtained and loaded into the roof estimation system.

[0058] The user interface screen 400 includes a control panel 401 and five images 402-406 of a building roof 407. The control panel 401 includes user selectable controls (*e.g.*, buttons, check boxes, menus, etc.) for various roof modeling tasks, such as setting reference points for the images, setting the vertical (Z) axis for the images, switching between different images, saving the model, and the like. Each of the images 402-406 provides a different view of the building roof 407. In particular, images 402-406 respectively provide substantially top-down, south, north, west, and east views of the building roof 407. Each image 402-406 includes four marker controls (also called "reference points" or "registration markers") that are used by the operator to set reference points in the image for purposes of image registration. The registration markers will be described further with respect to an enlargement of image portion 408 described with respect to Figures 4B-4C, below.

[0059] Figures 4B-4C show an enlarged view of image portion 408 during the process of image registration for image 402, which provides a top-down view of the building roof 407. As shown in Figure 4B, image portion 408 includes the building roof 407 and registration markers 410-413. The markers 410-413 are interactive user interface controls that can be directly manipulated (*e.g.*, moved, rotated, etc.) by the operator in order to specify points to use for purposes of image registration. In particular, image registration includes determining a transformation between each of one or more images and a uniform 3D reference grid. The uniform 3D reference grid is used as a coordinate system for a 3D model of the roof. By registering multiple images to the reference grid, an operator may indicate a roof feature on an image (such as a roof edge), which may then be translated from the coordinate system of the image to the coordinate system of the reference grid, for purposes of including of the indicated feature in the 3D model.

[0060] Marker 410 is an origin marker control, and includes arms 410a-410c. Arms 410a and 410b are horizontal arms that are utilized to specify the X and Y axes (*e.g.*, the horizontal plane) of the reference grid. Arm 410c is a vertical arm that may be utilized to specify the Z axis (*e.g.*, the vertical axis) of the reference grid. The use of the vertical arm to specify the Z axis will be further described with respect to Figure 4E, below.

[0061] Typically, markers 410-413 are color coded, such that they may be distinguished from one another. For example, marker 411-413 may be respectively colored red, blue, and green. Origin marker 410 has a different appearance than markers 411-413, so may be of any color. In other embodiments, markers 411-413 may be distinguished in other ways, such as by utilizing different sized dashed lines, different line thicknesses, etc. In still other embodiments, markers are not distinguished any way from each other, such as by being of uniform shape, color, etc.

[0062] Figure 4C shows image portion 408 with markers 410-413 after they have been placed by an operator. Typically, registration markers are placed at four spatially distributed corners of the roof. As shown in Figure 4C, the operator has placed markers 410-413 at four different corners of the building roof 407. In particular, the operator first placed the origin marker 410 at the lower left corner of the building roof 407, and has adjusted (*e.g.*, rotated) the arms 410a and 410b to align with the major horizontal axes of the roof. By adjusting the arms 410a and 410b of the origin marker 410, the rotational orientation of

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markers 411-413 is automatically adjusted by the roof estimation system. Next, the operator places markers 411-413 on some other corners of the roof. In general, the operator can place registration marker over any roof feature, but roof comers are typically utilized because they are more easily identified by the operator. After the operator is satisfied with the placement of markers 410-413, the operator typically registers a next image of the building roof 407, as will be described next.

[0063] Figures 4D-4F illustrate image registration for image 404, which provides a north view of the building roof 407. In particular, Figure 4D shows the user interface screen 400 described with reference to Figure 4A. Here, image 402 has been minimized, while image 404 has been enlarged so that the operator may register that image by placing markers on image 404, as will be described below with respect to an enlarged view of image portion 418.

[0064] Figure 4E shows an enlarged view of image portion 418 during the process of image registration for image 404. Image portion 418 includes the building roof 407 and registration markers 420-423. Markers 420-423 respectively correspond to markers 410-413 described above. In particular, marker 420 is an origin marker control that includes arms 420a-420c. Arms 420a and 420b are horizontal arms that are utilized to specify the X and Y axes of the reference grid. Arm 420c is a vertical arm that may be utilized to specify the Z axis of the reference grid.

[0065] In the example of Figure 4E, the operator has moved each of markers 420-423 to a corner of the roof 407. Note that the markers 420-423 are moved to roof corners that correspond to those selected by the operator with markers 410-413, as described with reference to Figure 4C. In particular, origin marker 420 has been moved to the comer of the roof 407 selected with origin marker 410 in image 408; marker 421 has been moved to the corner selected with marker 411 in image 408; marker 422 has been moved to the corner selected with marker 412 in image 408; and marker 423 has been moved to the comer selected with marker 413 in image 408. In addition, markers 420-423 have been rotated, by operator rotation of the origin marker 420, to align with the major axes of the roof 407.

[0066] As noted, the operator can utilize the origin marker 420 to specify the vertical axis of the reference grid. In particular, the operator can adjust (*e.g.*, by dragging with a mouse or other pointing device) arm 420c of marker 420 to specify the vertical (Z) axis of the image. In some cases, aerial images may include some amount of lean, due to the orientation of the aircraft during image capture. For example, pitch, yaw, or roll of an aircraft during the course of image capture may result in images that are misaligned with respect to the vertical axis of the building and its roof. Typically, an operator may adjust arm 420c to line up with a feature of a building or roof that is known to be substantially vertical, such as a wall of a house or a chimney. Then, based on the angle of arm 420c with respect to the vertical axis of the image, the roof estimation system can determine a correction between the reference grid and the image.

[0067] Figure 4F shows an enlarged view of image portion 418 after registration of image 404. Once the operator has placed and adjusted markers 420-423, the operator may direct (*e.g.*, by clicking a button) the roof estimation system to register the image to the reference grid, based on the positions and orientations of markers 420-423. Once the roof estimation system registers the image, it provides the operator with feedback so that the operator may determine the correctness or accuracy of the registration.

[0068] In the example of Figure 4F, the operator has directed the roof estimation system to register image 404, and the roof estimation system has updated image portion 418 with registration indicators 430-433. Registration indicators 430-433 provide the operator with feedback so that the operator may judge the accuracy of the registration of image 404.

[0069] Registration indicator 430 is an origin registration indicator that includes two arms 430a-430b and three reference grid indicators 430c-430e, shown as dashed lines. The reference grid indicators 430c-430e show the vertical axis (430c) and the two horizontal axes (430d and 430e) of the reference grid determined based on the placement and orientation of the markers 420-423. Arms 430a and 430b correspond to the placement of arms 420a-420c of origin marker 420. If the arms 430a and 430b do not substantially align with the corresponding reference grid indicators 430e and 430d, then the determined reference grid is out of alignment with the specified axes of the house. Typically, an operator will return to the view of Figure 4E to make adjustments to origin marker, such as adjusting one or more of the vertical or horizontal axes, in order to refine the registration of the image. Although the arms 430a-430b and the reference grid indicators 430c-430e are here illustrated as solid and dashed lines, in other embodiments they may be color coded. For example, arms 430a-430b may be red, while reference grid indicators 430c-430e may be blue.

[0070] Registration indicators 431-433 provide the operator with information regarding the accuracy of the placement of markers 421-423. In particular, each registration indicator 431-433 includes a solid crosshairs and a reference indicator, shown for example as a dashed line 432a. The crosshair of a registration indicator corresponds to the placement of a marker. For example, the crosshairs of registration indicator 431 corresponds to the placement of marker 421 in Figure 4E. If the reference indicator intersects the center (or substantially near the center) of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is accurate. On the other hand, if the reference indicator does not intersect the center of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is inaccurate. Typically, such an inaccuracy arises when the placement

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of markers in the top view of the roof does not agree with (correspond to) the placement of corresponding markers in another view of the roof. In such cases, the operator can return to the view of Figure 4C or 4E to adjust the position of one or more markers.

[0071] After registering image 404, the operator will proceed to register additional images of the building roof 407 utilizing a process similar to that described above. In this example, the operator will register images 403, 405, and 406. Although the operator is here described as registering a total of five images, in other cases more or fewer images may be registered.

B. Roof Model Construction

[0072] Figures 5A-5D and 6A-6C generally illustrate aspects of the process of roof model generation based on multiple registered images. In particular, these figures illustrate the construction of a roof model by an operator. Model generation/construction may include identification of roofFeatures shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. Each identified roof feature is incorporated by the roof estimation system into a 3D model of the roof, based on a translation between an image in which the feature is identified and the reference grid, as determined by the process described with reference to Figures 4A-4F, above.

[0073] Figures 5A-5D are screen displays illustrating pitch determination in an example embodiment. In particular, Figure 5A shows the user interface screen 400 after images 402-406 have been registered. In this example, the operator is using a pitch determination control (also called a "pitch determination marker" or "pitch determination tool") to specify the pitch of a planar roof section of the building roof 407 visible in image 406. The pitch determination control will be further described in Figure 5B, below, with respect to an enlargement of image portion 508.

[0074] Figure 5B shows an enlarged view of image portion 508 during the process of pitch determination for image 406, which provides an east perspective view of the building roof 407. As shown in Figure 5B, the image portion 508 includes the building roof 407 and a pitch determination marker 510 (also called a "protractor tool"). The pitch determination marker 510 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407.

[0075] The pitch determination marker 510 includes arms 510a-510d. Arms 510a-510c are axes, which are automatically aligned, based on the registration of image 406, with the major (X, Y, and Z) axes of the building roof. Arm 510d is a "protractor" arm that is adjustable by the operator to specify roof pitch.

[0076] The marker 510 is typically first moved by the operator to a convenient location on the building roof 407, usually corner of a planar section of the roof 407. Next, the operator adjusts arm 510d so that is substantially aligns with the sloped edge of the planar roof section. Then, the roof estimation system determines the pitch of the roof section, based on the configuration of the marker 510 with respect to the image and the reference grid.

[0077] After specifying the pitch of a planar roof section, the operator will typically specify other information about the planar roof section, such as its outline, as will be described with reference to Figures 6A-6D. Note that as the operator provides additional information about the geometry of the roof 407, the roof estimation system may automatically determine the pitch and/or other features of at least some of the other planar roof sections, based on the provided geometric information and/or assumptions about roof symmetry or other standard architectural practices.

[0078] Figure 5C shows a second type of pitch determination marker being used in the context of image 403 which provides a south perspective viewof the building roof 407. The illustrated pitch determination marker may be used in addition to, or instead of, the pitch determination marker 510 described with respect to Figures 5A-5B, above. In particular, Figure 5C shows a pitch determination marker 520 (also called an "envelope tool") that includes surfaces 520a and 520b. The pitch determination marker 520 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407. In particular, the pitch determination marker 520 may be moved and/or adjusted so that it appears to lie substantially atop two adjacent planar sections of roof 407.

[0079] Figure 5D shows the pitch determination marker 520 after the operator has used it to specify the pitch of two sections of roof 407. Here, the operator has moved the marker 520 to a position in which the spine of the marker 520 is substantially aligned with the ridge line of roof 407. Then, the operator has adjusted the angle of the surfaces 520a and 520b so that they appear to lie substantially atop corresponding sections of roof 407. Then, the roof estimation system determines the pitch of the roof sections, based on the configuration of the marker 520 with respect to the image and the reference grid. Also illustrated are pitch indicators 521 and 522. Pitch indicator 521 corresponds to the measured pitch of surface 520a, and pitch indicator 522 corresponds to the measured pitch of surface 520b. As the operator adjusts the angle of surfaces 520a and/or 520b, the corresponding pitch indicators 521-522 are automatically updated to reflect the determined pitch. In this example, the pitch of both surfaces is given as 4 inches of rise per foot of run.

[0080] The envelope pitch determination marker 520 may be adjusted in other ways, to specify pitches for types of roofs other than the gabled roof shown in image 403. For example, when measuring pitch of roof sections that form a roof hip, point 520c may be manipulated by the operator, such as by dragging it to the left or right, to adjust the shape of the surfaces 520a and 520b, so that

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the surfaces align with the edges formed by the intersection of the sections that form the roof hip.

[0081] Figures 6A-6D are screen displays illustrating model construction and concurrent display of operator specified roof features in an example embodiment. In particular, Figures 6A-6D illustrate the construction of a three dimensional wire frame model of a building roof, based on the specification of roof features by an operator. In addition, Figures 6A-6D illustrate the concurrent display of operator specified roof features in multiple views of a building roof.

[0082] Figure 6A shows the user interface screen 400 after images 402-406 have been registered, and after roof pitches have been determined. In this example, the operator is specifying sections of roof 407, visible in image 406, that are to be added to a 3D wire frame model of the roof 407 maintained by the roof estimation system. The specification of roof sections will be further described with reference to enlarged portion 608 of image 406 in Figure 6B, below. In addition, as the operator specifies roof sections in image 406, the roof estimation system concurrently displays the specified roof sections in each of the other images 402-405. The concurrent display of operator specified roof features will be further described with reference to enlarged portion 609 of image 402 in Figure 6C, below.

[0083] Figure 6B is an enlarged view of image portion 608 during the process of wire frame model construction in the context of image 406, which provides an east perspective view of the building roof 407. As shown in Figure 6B, the image portion 608 includes the building roof 407, drawing tool 610, and wire frame 611. The drawing tool 610 (also called a "drawing marker" or a "drawing control") is an interactive user interface control that can be directly manipulated by the operator in order to specify roof features, such as edges, ridges, valleys, comers, etc. In the illustrated embodiment, the operator uses the drawing tool 610 to trace or outline planar sections of the roof 407, leading to the generation of wire frame 611. The drawing tool 610 may be used to establish a series of connected line segments that result in a closed polygon representing a planar roof section. As the operator specifies a planar roof section in this manner, the roof estimation system determines, based on the image and the reference grid, the geometry of the planar roof section, and includes (adds) the specified planar roof section in a 3D model that corresponds to roof 407.

[0084] Figure 6C is an enlarged view of image portion 609 illustrating the concurrent display of operator specified roof features, in the context of image 402, which provides a top plan view of the building roof 407. As the operator specifies roof sections as described with respect to Figure 6B, the roof estimation system concurrently displays the specified roof features in one or more of the other images displayed by the user interface screen 400. More specifically, image portion 609 includes building roof 407 and wire frame 612. Wire frame 612 corresponds to wire frame 611 constructed by the operator with reference to Figure 6B, except that wire frame 612 is automatically displayed as a projection from the 3D model into the top-down view of image 402. Changes that the operator makes to wire frame 611 are concurrently displayed by the roof estimation system as wire frame 612 in image portion 609. For example, if a new planar roof section is added by the operator to wire frame 611, the new planar roof section is automatically displayed in wire frame 612. By concurrently displaying operator identified features in multiple views of building roof 407, the operator obtains feedback regarding the correctness and/or accuracy of the 3D model or other aspects of the model generation process, such as image registration and pitch determination.

[0085] Generally, the roof estimation system can be configured to concurrently display any operator-identified features, such as comers, ridges, valleys, planar sections, and the like, in multiple views of a building.

[0086] Furthermore, the concurrently displayed wire frame 612 is an interactive user interface element, in that the operator can make changes to the wire frame 612, which are then concurrently displayed in wire frame 611. Wire frames similar to those described above are also projected by the roof estimation system into images 403, 404, and 405 displayed by the user interface screen 400. In this manner, the operator can switch between various images of the building roof 407, making refinements to the 3D model by adjusting the wire frame in whichever image is more convenient and/or provides a more suitable perspective/view of the model.

[0087] Figure 6D shows the user interface screen 400 during construction of a 3D model of the building roof 407. In particular, the user interface 400 includes a shaded wire frame 613 representation of the 3D model constructed as described above. In this view, the operator can review the wire frame 613 in isolation from any images to determine whether the wire frame 613 accurately represents the building roof 407. The wire frame 613 is an interactive user interface component, in that it can be directly manipulated (*e.g.*, moved, rotated, resized, etc.). In some embodiments, manipulating the wire frame 613, such as by changing its shape, results in corresponding changes in the underlying 3D model.

C. Roof Model Review

[0088] Figures 7A-7C are screen displays illustrating roof model review in an example embodiment. In particular, Figures 7A-7C illustrate various techniques to facilitate the review of a roof model by an operator. Reviewing the roof model may include reviewing roof section pitches (*e.g.*, to determine whether they conform to the building roof and/or standard construction practices), reviewing the shape and/or location of the roof model (*e.g.*, to determine whether it substantially conforms to the building roof), etc.

[0089] Figure 7A shows the user interface screen 400 after the operator has constructed a model of the roof

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407 using one or more of the images 402-406. In this example, a wire frame has been projected onto (superimposed upon) image 402 and annotated with roof section pitches, as will be described further with respect to enlarged portion 708 of image 402 in Figure 7B, below.

[0090] Figure 7B is an enlarged view of image portion 708 during the process of roof model review in the context of image 402, which provides a substantially top plan view of the building roof 407. As shown in Figure 7B, the image portion 708 includes a wire frame 710 and labels 711 a-711 c that indicate pitches of corresponding sections of roof 407. The wire frame 710 and the illustrated pitches are determined by the roof estimation system based on the pitch determination described with respect to Figures 5A-5D, above, and the operator's specification of the wire frame model described with respect to Figures 6A-6D, above.

[0091] The wire frame 710 includes multiple vertexes connected by line segments. Each vertex includes a handle, such as handle 710a. The handles may be directly manipulated (individually or in groups) by the operator to make adjustments/modifications to the wire frame 710. For example, when an operator drags handle 710a to a new location, the ends of the two line segments connected to handle 710a will also move to the new location.

[0092] Figure 7C is an alternative view of the 3D model of roof 407 during the process of roof model review. In Figure 7C, the user interface screen 400 includes a wire frame 720 representation of the 3D model of the roof 407. The wire frame 720 consists of multiple line segments corresponding to edges of planar roof sections. Each line segment is annotated with a label, such as label 723, indicating the determined length of the corresponding roof section edge. Furthermore, some of the line segments indicate that they correspond to a particular roof feature. For example, line segments 721 and 722 may be colored (*e.g.*, red) so as to indicate that they correspond to roof ridges. Other line segments may be differently colored (*e.g.*, blue) so as to indicate a correspondence to roof valleys or other features. In addition, the wire frame 720 may be directly manipulated by the operator in order to make adjustments to the underlying model of the roof 407. For example, the operator could increase or decrease the length of line segment 721, resulting in a change in the corresponding feature of the 3D model of roof 407.

[0093] Note that although the operator is shown, in Figures 5-7 above, operating upon a total of five images, in other cases, fewer images may be used. For example, in some cases fewer images may be available, or some images may provide obstructed views of the building roof, such as due to tree cover, neighboring buildings, etc.

3. Implementation Techniques

[0094] Figure 8 is an example block diagram of a computing system for practicing embodiments of a roof estimation system. Figure 8 shows a computing system 800 that may be utilized to implement a Roof Estimation System ("RES") 810. One or more general purpose or special purpose computing systems may be used to implement the RES 810. More specifically, the computing system 800 may comprise one or more distinct computing systems present at distributed locations. In addition, each block shown may represent one or more such blocks as appropriate to a specific embodiment or may be combined with other blocks. Moreover, the various blocks of the RES 810 may physically reside on one or more machines, which use standard inter-process communication mechanisms (*e.g.*, TCP/IP) to communicate with each other. Further, the RES 810 may be implemented in software, hardware, firmware, or in some combination to achieve the capabilities described herein.

[0095] In the embodiment shown, computing system 800 comprises a computer memory ("memory") 801, a display 802, one or more Central Processing Units ("CPU") 803, Input/Output devices 804 (*e.g.*, keyboard, mouse, joystick, track pad, CRT or LCD display, and the like), other computer-readable media 805, and network connections 806. The RES 810 is shown residing in memory 801. In other embodiments, some portion of the contents, some of, or all of the components of the RES 810 may be stored on and/or transmitted over the other computer-readable media 805. The components of the RES 810 preferably execute on one or more CPUs 803 and generate roof estimate reports, as described herein. Other code or programs 830 (*e.g.*, a Web server, a database management system, and the like) and potentially other data repositories, such as data repository 820, also reside in the memory 801, and preferably execute on one or more CPUs 803. Not all of the components in Figure 8 are required for each implementation. For example, some embodiments embedded in other software do not provide means for user input, for display, for a customer computing system, or other components.

[0096] In a typical embodiment, the RES 810 includes an image acquisition engine 811, a roof modeling engine 812, a report generation engine 813, an interface engine 814, and a roof estimation system data repository 816. Other and/or different modules may be implemented. In addition, the RES 810 interacts via a network 850 with an image source computing system 855, an operator computing system 865, and/or a customer computing system 860.

[0097] The image acquisition engine 811 performs at least some of the functions of the image acquisition engine 101 described with reference to Figure 1. In particular, the image acquisition engine 811 interacts with the image source computing system 855 to obtain one or more images of a building, and stores those images in the RES data repository 816 for processing by other components of the RES 810. In some embodiments, the image acquisition engine 811 may act as an image cache manager, such that it preferentially provides images to other components of the RES 810 from the RES data repository 816, while obtaining images from the image

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source computing system 855 when they are not already present in the RES data repository 816. In other embodiments, images may be obtained in an "on demand" manner, such that they are provided, either by the image acquisition engine 811 or the image source computing system 855, directly to modules of the RES 810 and/or the operator computing system 865, without intervening storage in the RES data repository 816.

[0098] The roof modeling engine 812 performs at least some of the functions of the roof modeling engine 102 described with reference to Figure 1. In particular, the roof modeling engine 812 generates a model based on one or more images of a building that are obtained from the RES data repository 816 or directly from the image source computing system 855. As noted, model generation may be performed semi-automatically, based on at least some inputs received from the computing system 865. In addition, at least some aspects of the model generation may be performed automatically, based on image processing and/or image understanding techniques. After the roof modeling engine 812 generates a model, it stores the generated model in the RES data repository 816 for further processing by other components of the RES 810.

[0099] The report generation engine 813 performs at least some of the functions of the report generation engine 103 described with reference to Figure 1. In particular, the report generation engine 813 generates roof reports based on models stored in the RES data repository 816. Generating a roof report may include preparing one or more views of a given 3D model of a roof, annotating those views with indications of various characteristics of the model, such as dimensions of sections or other features (*e.g.*, ridges, valleys, etc.) of the roof, slopes of sections of the roof, areas of sections of the roof, etc. In some embodiments, the report generation engine 813 facilitates transmission of roof measurement information that may or may not be incorporated into a roof estimate report. For example, the roof generation engine 813 may transmit roof measurement information based on, or derived from, models stored in the RES data repository 816. Such roof measurement information may be provided to, for example, third-party systems that generate roof estimate reports based on the provided information.

[0100] The interface engine 814 provides a view and a controller that facilitate user interaction with the RES 810 and its various components. For example, the interface engine 814 implements a user interface engine 104 described with reference to Figure 1. Thus, the interface engine 814 provides an interactive graphical user interface that can be used by a human user operating the operator computing system 865 to interact with, for example, the roof modeling engine 812, to perform functions related to the generation of models, such as point registration, feature indication, pitch estimation, etc. In other embodiments, the interface engine 814 provides access directly to a customer operating the customer computing system 860, such that the customer may place an order for a roof estimate report for an indicated building location. In at least some embodiments, access to the functionality of the interface engine 814 is provided via a Web server, possibly executing as one of the other programs 830.

[0101] In some embodiments, the interface engine 814 provides programmatic access to one or more functions of the RES 810. For example, the interface engine 814 provides a programmatic interface (*e.g.*, as a Web service, static or dynamic library, etc.) to one or more roof estimation functions of the RES 810 that may be invoked by one of the other programs 830 or some other module. In this manner, the interface engine 814 facilitates the development of third-party software, such as user interfaces, plug-ins, adapters (*e.g.*, for integrating functions of the RES 810 into desktop applications, Web-based applications, embedded applications, etc.), and the like. In addition, the interface engine 814 may be in at least some embodiments invoked or otherwise accessed via remote entities, such as the operator computing system 865, the image source computing system 855, and/or the customer computing system 860, to access various roof estimation functionality of the RES 810.

[0102] The RES data repository 816 stores information related the roof estimation functions performed by the RES 810. Such information may include image data 105, model data 106, and/or report data 107 described with reference to Figure 1. In addition, the RES data repository 816 may include information about customers, operators, or other individuals or entities associated with the RES 810.

[0103] In an example embodiment, components/modules of the RES 810 are implemented using standard programming techniques. For example, the RES 810 may be implemented as a "native" executable running on the CPU 803, along with one or more static or dynamic libraries. In other embodiments, the RES 810 is implemented as instructions processed by virtual machine that executes as one of the other programs 830. In general, a range of programming languages known in the art may be employed for implementing such example embodiments, including representative implementations of various programming language paradigms, including but not limited to, object-oriented (*e.g.*, Java, C++, C#, Matlab, Visual Basic.NET, Smalltalk, and the like), functional (*e.g.*, ML, Lisp, Scheme, and the like), procedural (*e.g.*, C, Pascal, Ada, Modula, and the like), scripting (*e.g.*, Perl, Ruby, Python, JavaScript, VBScript, and the like), declarative (*e.g.*, SQL, Prolog, and the like).

[0104] The embodiments described above may also use well-known synchronous or asynchronous client-server computing techniques. However, the various components may be implemented using more monolithic programming techniques as well, for example, as an executable running on a single CPU computer system, or alternatively decomposed using a variety of structuring techniques known in the art, including but not limited to, multiprogramming, multithreading, client-server, or peer-

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to-peer, running on one or more computer systems each having one or more CPUs. Some embodiments execute concurrently and asynchronously, and communicate using message passing techniques. Equivalent synchronous embodiments are also supported by an RES implementation. Also, other functions could be implemented and/or performed by each component/module, and in different orders, and by different components/modules, yet still achieve the functions of the RES.

[0105] In addition, programming interfaces to the data stored as part of the RES 810, such as in the RES data repository 816, can be available by standard mechanisms such as through C, C++, C#, and Java APIs; libraries for accessing files, databases, or other data repositories; through scripting languages such as XML; or through Web servers, FTP servers, or other types of servers providing access to stored data. For example, the RES data repository 816 may be implemented as one or more database systems, file systems, memory buffers, or any other technique for storing such information, or any combination of the above, including implementations using distributed computing techniques.

[0106] Also, the example RES 810 can be implemented in a distributed environment comprising multiple, even heterogeneous, computer systems and networks. For example, in one embodiment, the image acquisition engine 811, the roof modeling engine 812, the report generation engine 813, the interface engine 814, and the data repository 816 are all located in physically different computer systems. In another embodiment, various modules of the RES 810 are hosted each on a separate server machine and are remotely located from the tables which are stored in the data repository 816. Also, one or more of the modules may themselves be distributed, pooled or otherwise grouped, such as for load balancing, reliability or security reasons. Different configurations and locations of programs and data are contemplated for use with techniques of described herein. A variety of distributed computing techniques are appropriate for implementing the components of the illustrated embodiments in a distributed manner including but not limited to TCP/IP sockets, RPC, RMI, HTTP, Web Services (XML-RPC, JAX-RPC, SOAP, and the like).

[0107] Furthermore, in some embodiments, some or all of the components of the RES are implemented or provided in other manners, such as at least partially in firmware and/or hardware, including, but not limited to one or more application-specific integrated circuits (ASICs), standard integrated circuits, controllers (*e.g.*, by executing appropriate instructions, and including microcontrollers and/or embedded controllers), field-programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), and the like Someorall of the system components and/or data structures may also be stored (*e.g.*, as software instructions or structured data) on a computer-readable medium, such as a hard disk, a memory, a network, or a portable media article to be read by an appropriate drive or via an appropriate connection. The system components and data structures may also be stored as data signals (*e.g.*, by being encoded as part of a carrier wave or included as part of an analog or digital propagated signal) on a variety of computer-readable transmission mediums, which are then transmitted, including across wireless-based and wired/cable-based mediums, and may take a variety of forms (*e.g.*, as part of a single or multiplexed analog signal, or as multiple discrete digital packets or frames). Such computer program products may also take other forms in other embodiments. Accordingly, embodiments of this disclosure may be practiced with other computer system configurations.

[0108] Figure 9 is an example flow diagram of an image registration routine provided by an example embodiment. The illustrated routine 900 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 900 facilitates image registration based upon operator indicated registration points and/or image lean corrections.

[0109] More specifically, the routine begins in step 901, where it displays, on a user interface screen, an aerial image of a building having a roof. As part of the user interface screen, the routine also displays user interface controls such as markers that may be used by an operator for purposes of image registration and/or lean correction, as described with reference to Figure 4A, above.

[0110] In step 902, the routine receives, via one or more registration markers, indications of one or more points on the aerial image. The registration markers are manipulated by the operator to specify points on the aerial image, as described with reference to Figures 4A-4E. Typically, the points are visually identifiable features, such as corners of the roof of the building. For example, if the roof has four corners (*e.g.*, a northwest, southwest, northeast, and southwest corner) the operator may place one registration marker on each of the four corners as shown in the aerial image. Then, the positions (*e.g.*, coordinates on the aerial image) of the markers are transmitted to the routine for use in registering the aerial image, as described below.

[0111] In step 903, the routine receives, via a lean correction marker, an indication of the vertical axis of the building roof. In at least some cases, the aerial image of the building is out of alignment with respect to the vertical axis of the building. This may be caused, for example, by pitch, roll, and/or yaw experienced by the aircraft during the process of photographing the building. To correct for such misalignment, the lean correction marker is manipulated by the operator to indicate a vertical axis of the building. Typically, the operator aligns the lean correction marker with known, substantially vertical feature of the building, such as a chimney, wall corner, etc., as described with reference to Figure 4E, above. After the operator has aligned the lean correction marker, the position (*e.g.*, angle of the marker, coordinates of the endpoints of the marker, etc.) of the lean correction marker

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is transmitted to the routine for use in registering the aerial image, as described below.

[0112] Particular benefits may be obtained from lean correction performed in the context of an overhead, or "top down," view. An "overhead lean" occurs when the camera is not directly overhead with respect to the building when the photo is taken. In some cases, leans in excess of 5 degrees have been observed in "top down" photos. Furthermore, unlike oblique, perspective views, a top-down lean is typically less likely to include a convenient visual marker that provides sufficient angle to assess the lean direction and magnitude, such as the edge of the building or a tall chimney. An overhead lean affects the perceived location of the roof lines in a top down view. This effect is amplified as the pitch of the roof increases and/or as the vertical separation between disconnected roof sections increases. Without lean correction, superimposing a wire frame over the visible ridgelines (and other features of a building that reside at different elevations) may produce asymmetries in otherwise symmetric structures. Further, an absence of lean correction may introduce errors in pitch estimation, as the wire frame may not appear consistent between top and oblique view points. More specifically, without top view lean correction, the positions for the roof lines in an otherwise correct (*i.e.*, accurate with respect to the actual geometry of the roof) wire frame will typically not line up on the visible roof lines in the overhead reference photo. This often leads the user (or software) to either introduce errors by incorrectly drawing the wire frame to the image lines or perform a subjective determination of where and how to shift the wire frame lines off the image lines to produce a correct model. Top view lean correction allows the roof estimation system to trace to, or substantially to, the actual roof lines seen in the top image while still producing an accurate wire frame model.

[0113] Image misalignment may be specified in other ways. For example, in other embodiments, the operator may instead rotate the image to a position in which the building appears to be in a substantially vertical position. Then, the angle of rotation of the image may be transmitted to the routine for use in registering the aerial image.

[0114] In step 904, the routine registers, based on the received indications of the points and/or the received indication of the vertical axis, the aerial image to a reference grid. Registering the image to a reference grid may include determining a transformation between the reference grid and the image, based on the indicated points and/or the indicated vertical axis. Determining such a transformation may be based on other information as well, such as meta-information associated with the aerial image. In some embodiments, the aerial image has corresponding meta-information that includes image capture conditions, such as camera type, focal length, time of day, camera position (*e.g.*, latitude, longitude, and/or elevation), etc.

[0115] In step 905, the routine determines whether there are additional aerial images to be registered, and if so, returns to step 901, else proceeds to step 906. During execution of the loop of steps 901-905, the operator typically indicates, for each registration marker, the same feature (*e.g.*, corner) of the roof as shown in each of multiple images, such that the routine can register the multiple images to a single, uniform reference grid. Upon completion of the registration process, the routine has determined a uniform coordinate system for the multiple aerial images, for use during other phases of model construction, such as pitch determination or feature identification.

[0116] In step 906, the routine generates a three-dimensional model based at least in part on the aerial image(s) and the reference grid. As discussed above with reference to Figures 5A-5D and 6A-6D, model generation includes identification of roof features shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. In other embodiments, the routine performs other functions with the registered images, such as storing them for later use (*e.g.*, by an automated model generation module), transmitting them to another computing (*e.g.*, for use in a third-party design application), etc. Afterstep 906, the routine ends.

[0117] Note that in at least some embodiments, aspects of the routine 900 may be performed in an automated manner. For example, operations discussed above as being performed by an operator, such as the determination of the location of image registration points of step 902 and/or the indication of lean of step 903, may be performed by automated image processing techniques.

[0118] Figure 10 is an example flow diagram of a pitch determination routine provided by an example embodiment. The illustrated routine 1000 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1000 facilitates the determination of the pitch of a section of a roof, by displaying a pitch determination marker and modifying a 3D model of a roof based on an indication of roof pitch received via the pitch determination marker.

[0119] More specifically, the routine begins at step 1001 where it displays an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch. The aerial image is displayed in the context of a user interface screen, such as is described with reference to Figures 4A-6C, above. The aerial images may be received from, for example, the image source computing system 855 and/or from the RES data repository 816 described with reference to Figure 8. As discussed above, aerial images may be originally created by cameras mounted on airplanes, balloons, satellites, etc. In some embodiments, images obtained from ground-based platforms (*e.g.*, vehicle-mounted cameras) may be used instead or in addition.

[0120] In step 1002, the routine displays a pitch deter-

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mination marker operable to indicate pitch of a planar roof section. The pitch determination marker may be, for example, a pitch determination marker 510 ("protractor tool") or 520 ("envelope tool"), such as are respectively described with respect to Figures 5B and 5C, above. The routine displays the pitch determination marker by, for example, presenting it on a user interface screen displayed on a computer monitor or other display device. The pitch determination marker is a direct manipulation user interface control, in that an operator may manipulate it (*e.g.*, adjust an angle, change its shape, alter its position, etc.) in order to indicate pitch of a planar roof section. Additional details regarding pitch determination controls are provided with respect to Figures 5A-5D, above.

[0121] In step 1003, the routine receives, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building. Receiving an indication of the pitch includes receiving an indication (*e.g.*, via an event, callback, etc.) that the marker has been manipulated by the operator, and then determining an angle based on the shape and/or position of the marker. In some embodiments, such an indication may be received on an event driven basis, such as every time the marker is manipulated in some manner. In other embodiments, the routine may poll the marker from time to time to determine its current state. In addition, the operator may explicitly indicate that the current state of the marker is to be transmitted to the routine, such as by pressing a button or other indication.

[0122] In step 1004, the routine modifies a three-dimensional model of the roof based on the received indication of the pitch of the one planar roof section. Modifying the 3D model of the roof includes associating the indicated pitch with a portion of the model corresponding to the one planar roof section. For example, the 3D model may include one or more data structures representing planar roof sections, and the indicated pitch may be included as part of the data structure representing the one planar roof section. In some embodiments, the 3D model may not at this point include representations of the planar roof sections, such as because the operator has not yet specified them. In such a case, the routine may store the indicated pitch in association with the location and orientation at which the pitch was specified by the operator, as determined from the aerial image. Then, at a later time, when the operator specifies a roof section that has the same orientation as the stored pitch and that includes or is near the stored location, the roof estimation system can store the indicated pitch in association with the specified roof section.

[0123] After step 1004, the routine ends. In other embodiments, the routine may instead return to step 1001, to determine the pitch for another planar roof section (of the same or different roof).

[0124] Figure 11 is an example flow diagram of concurrent feature display routine provided by an example embodiment. The illustrated routine 1100 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1100 concurrently displays operator indicated features in multiple aerial images of a building roof.

[0125] More specifically, the routine begins in step 1101, where it displays a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building. The aerial images are displayed in the context of a user interface screen, such as is described with reference to Figures 6A-6C, above.

[0126] In step 1102, the routine receives an indication of a feature of the building shown in the first aerial image. The indication is typically received via a user interface control, such as a drawing tool or marker, upon its manipulation by an operator. For example, the operator may manipulate a drawing tool in order to specify one or more features of the building roof, such as a corner on the roof, an edge of the roof, an outline of a section of the roof, etc. In one embodiment, the operator utilizes a drawing tool to indicate roof section corner points and roof section edges connecting those corner points. Additional details regarding feature indication are provided with respect to Figures 6A-6C, above.

[0127] In step 1103, the routine modifies a three-dimensional model of the roof based on the received indication of the feature of the building. Modifying the 3D model may include adding or updating the indicated feature to a wire frame model of the roof. For example, if the indicated feature is a roof section corner point, the corner point will be added to the 3D model, along with the location (*e.g.*, the X, Y, and Z position of the point) of the point. The location of the point is automatically determined based on a translation of the position of the point in the image to a point in the uniform reference grid associated with the image. If the indicated feature is a roof section edge, the edge will be added to the 3D model, such as by associating the edge with two points corresponding to the end points of the edge. Higher-level features can also be indicated. For example, a planar roof section may be indicated by "closing" a sequence of two or more connected line segments, to create a closed polygon that represents the outline or perimeter of the planar roof section.

[0128] In step 1104, the routine concurrently displays a projection of the feature from the modified three-dimensional model onto the first and second aerial images. In one embodiment, displaying the feature from the modified three-dimensional model includes projecting the three-dimensional model onto both the first and second aerial images. For example, if the first image (for which the indicated feature was received) provides a west view of the building, and the second image provides an east view of the building, the routine will concurrently display a projection of the indicated feature from the 3D model onto both the first and second images. The projection of the indicated feature into the second image is based at least in part on a translation from the position of the fea-

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ture in the reference grid to a position in the second image. In addition, the concurrent display onto two or more images occurs at substantially the same time (within a short time interval, at times that are substantially coincident) as the indication of the feature of the building in step 1102, giving the operator the illusion that as they are indicating a feature in the first image, the feature is being simultaneously projected into the second image.

[0129] After step 1104, the routine ends. In other embodiments, the routine may instead return to step 1101, to perform an interactive loop of steps 1101-1104 with the operator, so that the routine can concurrently display multiple features as they are indicated by the operator. Note that in such an embodiment, each iteration of the loop of steps 1101-1104 may be performed at near real-time speeds, so as to provide a fluid, interactive model generation experience for the operator enabling the operator to drag, draw, or otherwise indicate/manipulate features in a first image and view the results of their work concurrently projected into a second image.

[0130] All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet, including but not limited to U.S. Non-Provisional Patent Application No. 12/467,244, entitled "PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION," filed May 15, 2009, are incorporated herein by reference, in their entireties.

[0131] From the foregoing it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the present disclosure. For example, the methods, systems, and techniques for generating and providing roof estimate reports discussed herein are applicable to other architectures other than the illustrated architecture or a particular roof estimation system implementation. Also, the methods and systems discussed herein are applicable to differing network protocols, communication media (optical, wireless, cable, etc.) and devices (such as wireless handsets, electronic organizers, personal digital assistants, portable email machines, game machines, pagers, navigation devices such as GPS receivers, etc.). Further, the methods and systems discussed herein may be utilized by and/or applied to other contexts or purposes, such as by or for solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and/or insurance companies.

Claims

1. A computer-implemented method for generating a roof estimate report, the method comprising:

displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of a planar roof section;

receiving, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and

modifying a model of the roof based on the received indication of the pitch of the one planar roof section.

2. The method of claim 1 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.

3. The method of claim 1 or 2 further comprising:

transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

4. The method of any of claims 1 to 3 wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building.

5. The method of any of claims 1 to 4 further comprising:

displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

6. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

display an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

display a pitch determination marker operable to indicate pitch of a planar roof section;

receive, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building;

modify a model of the roof based on the received indication of the pitch of the one planar roof section; and

provide roof measurement information

Roofr Exhibit 1002, Page 171

based on the model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

7. The computing system of claim 6 wherein the roof estimation module is further configured to transmit a roof estimate report based on the provided roof measurement information.

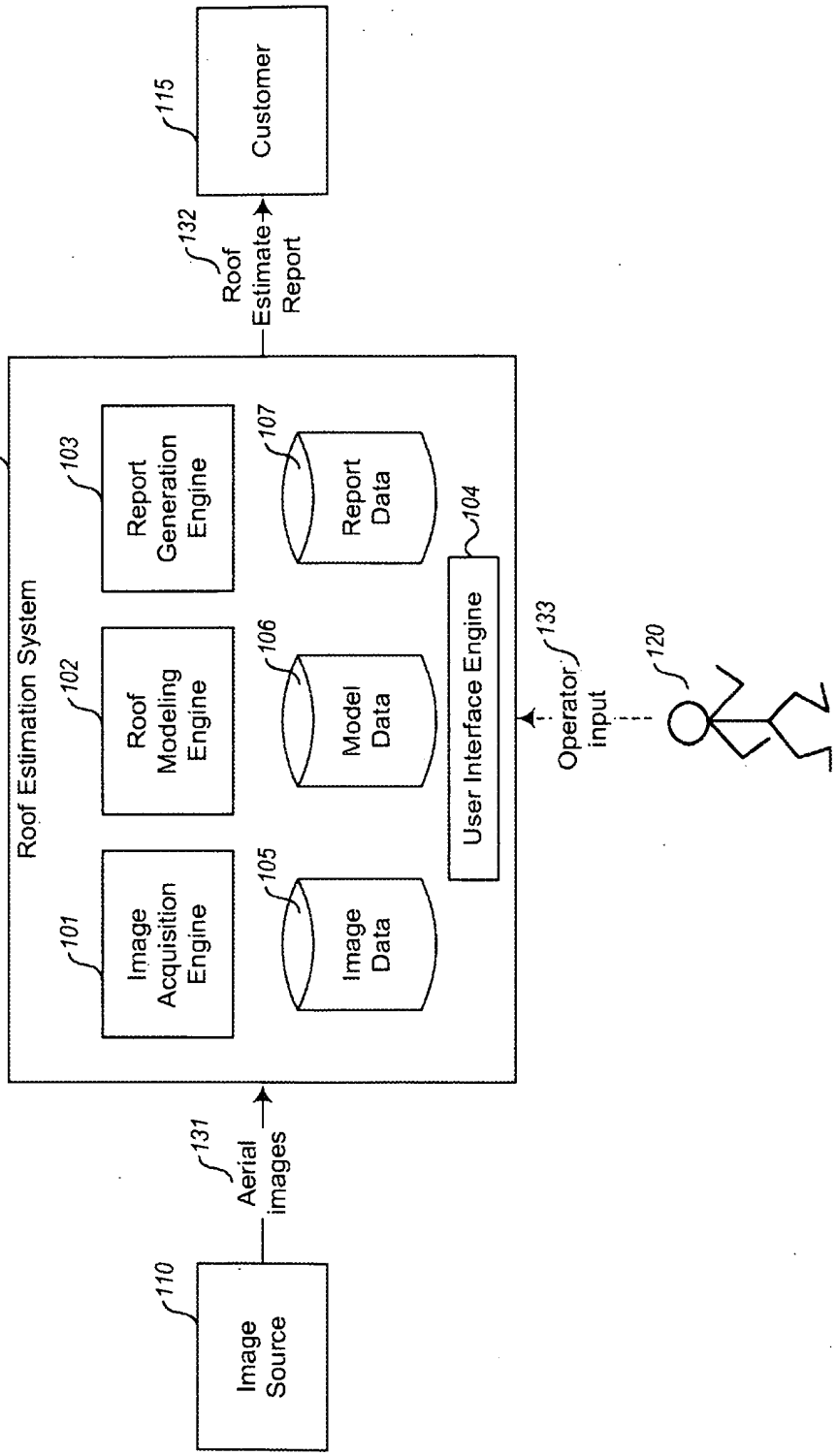
8. The computing system of claim 6 or **7** wherein the pitch determination marker includes at least one of an adjustable protractor tool and an envelope tool.

9. The computing system of any of claims 6 to 8 wherein the roof estimation module includes an interactive roof modeling user interface.

10. The computing system of any of claims 6 to 9 wherein the roof estimation module is further configured to display the pitch determination marker as part of an interactive user interface.

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Fig. 1


Customer
115
132
Roof Estimate Report
100
Roof Estimation System
Report Generation Engine
103
Report Data
107
Roof Modeling Engine
102
Model Data
106
User Interface Engine
104
Image Acquisition Engine
101
Image Data
105
133
Operator input
120
131
Aerial images
110
Image Source

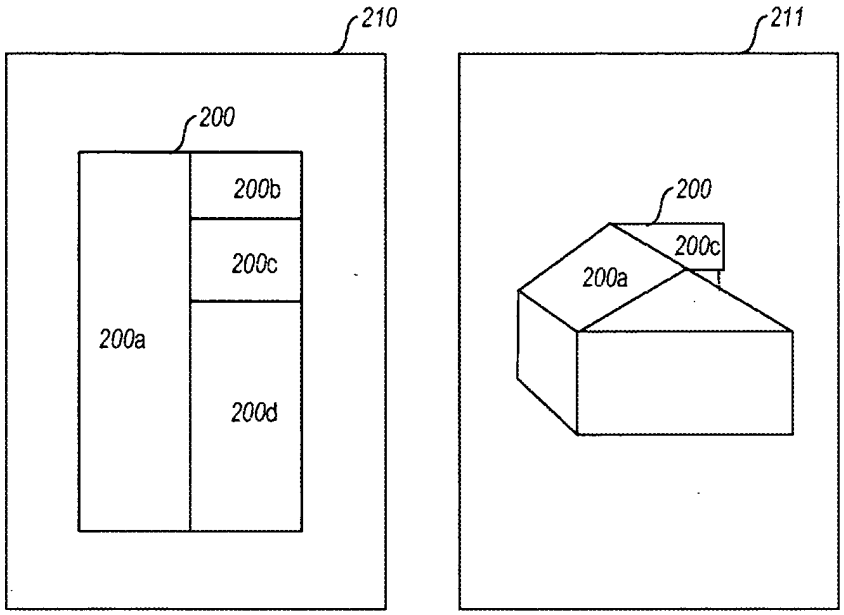


Fig. 2A

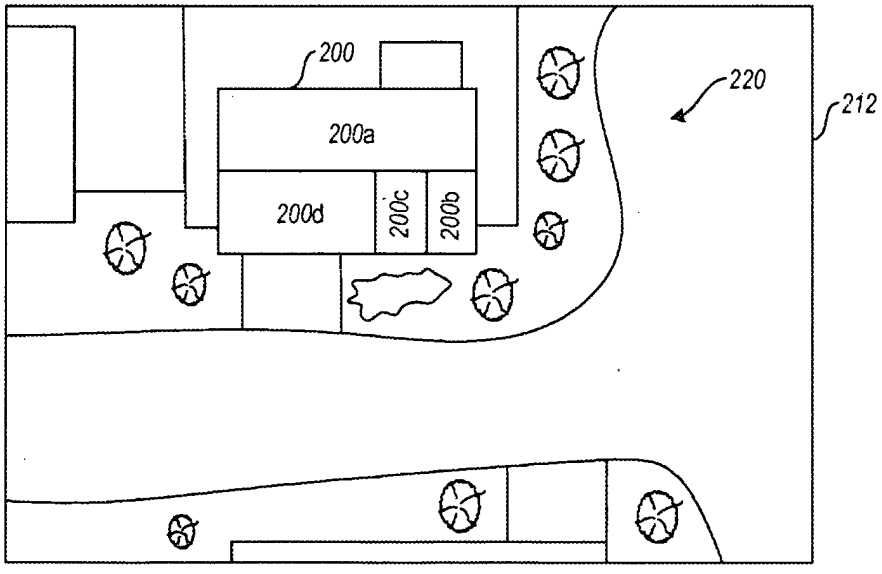


Fig. 2B

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1234 Main Street, Redmond, WA

Order: 2468

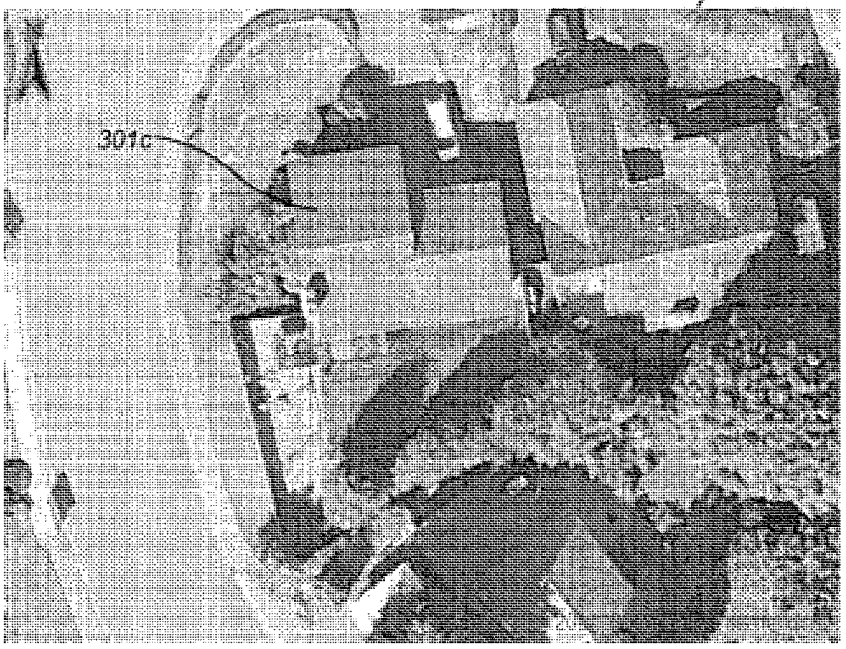
<Customer Name Here>

4/16/2008

301a

1234 Main Street, Redmond, WA

301b



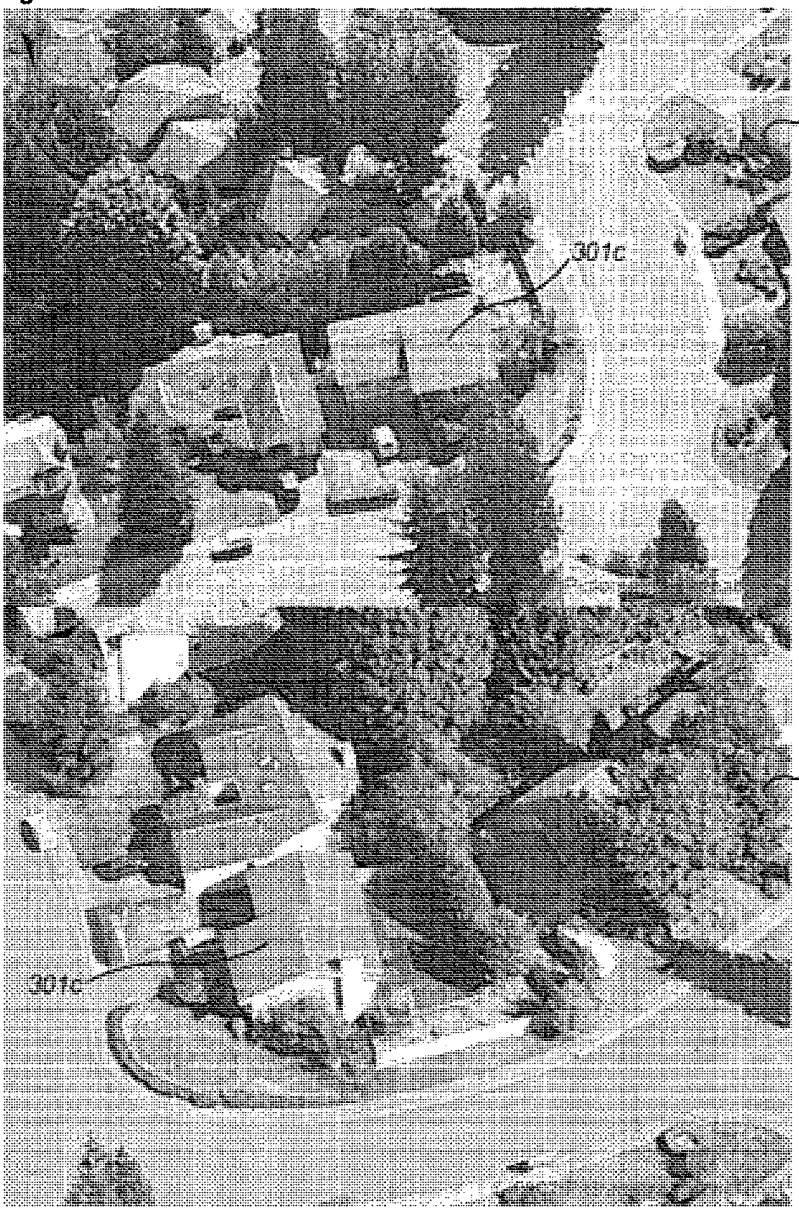
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301

Fig. 3A

1234 Main Street, Redmond, WA

Images:



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302

Fig. 3B

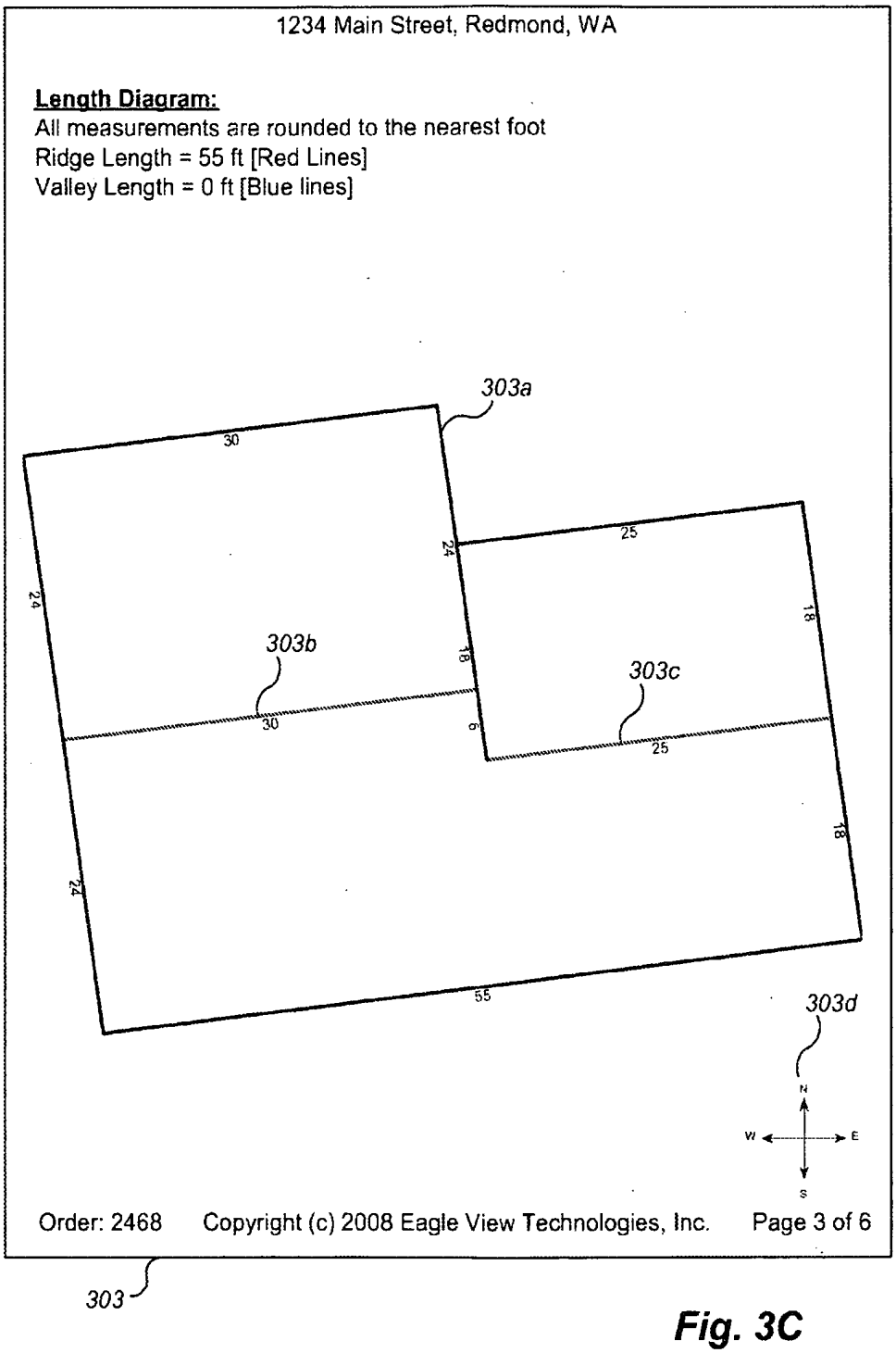

1234 Main Street, Redmond, WA
Length Diagram:
All measurements are rounded to the nearest foot
Ridge Length = 55 ft [Red Lines]
Valley Length = 0 ft [Blue lines]
303a
303b
303c
303d
30
25
24
18
30
6
25
55
N
W
E
S
Order: 2468
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Page 3 of 6
303

Fig. 3C

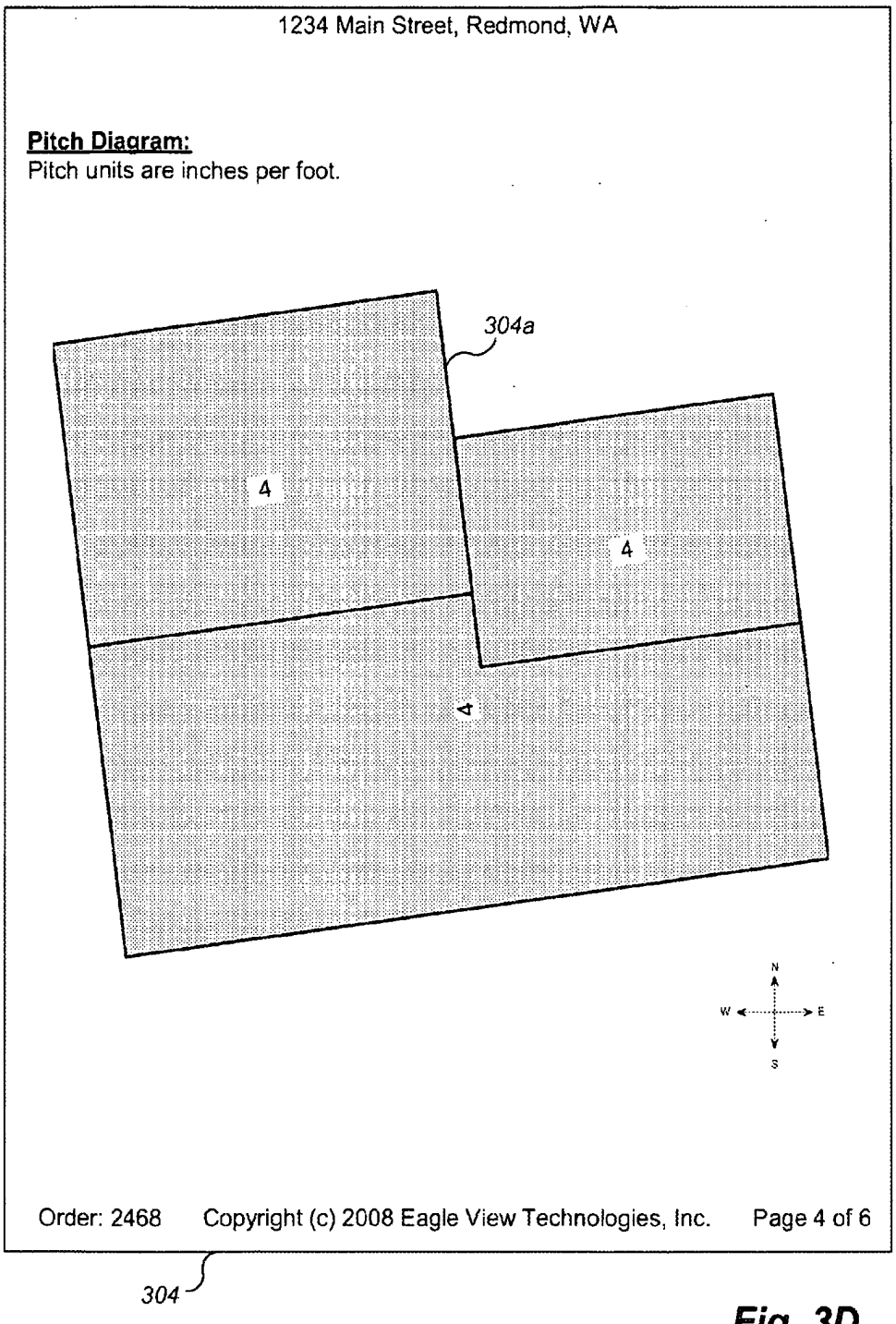

1234 Main Street, Redmond, WA
Pitch Diagram:
Pitch units are inches per foot.
304a
4
4
4
N
W
E
S
Order: 2468
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Page 4 of 6
304

Fig. 3D

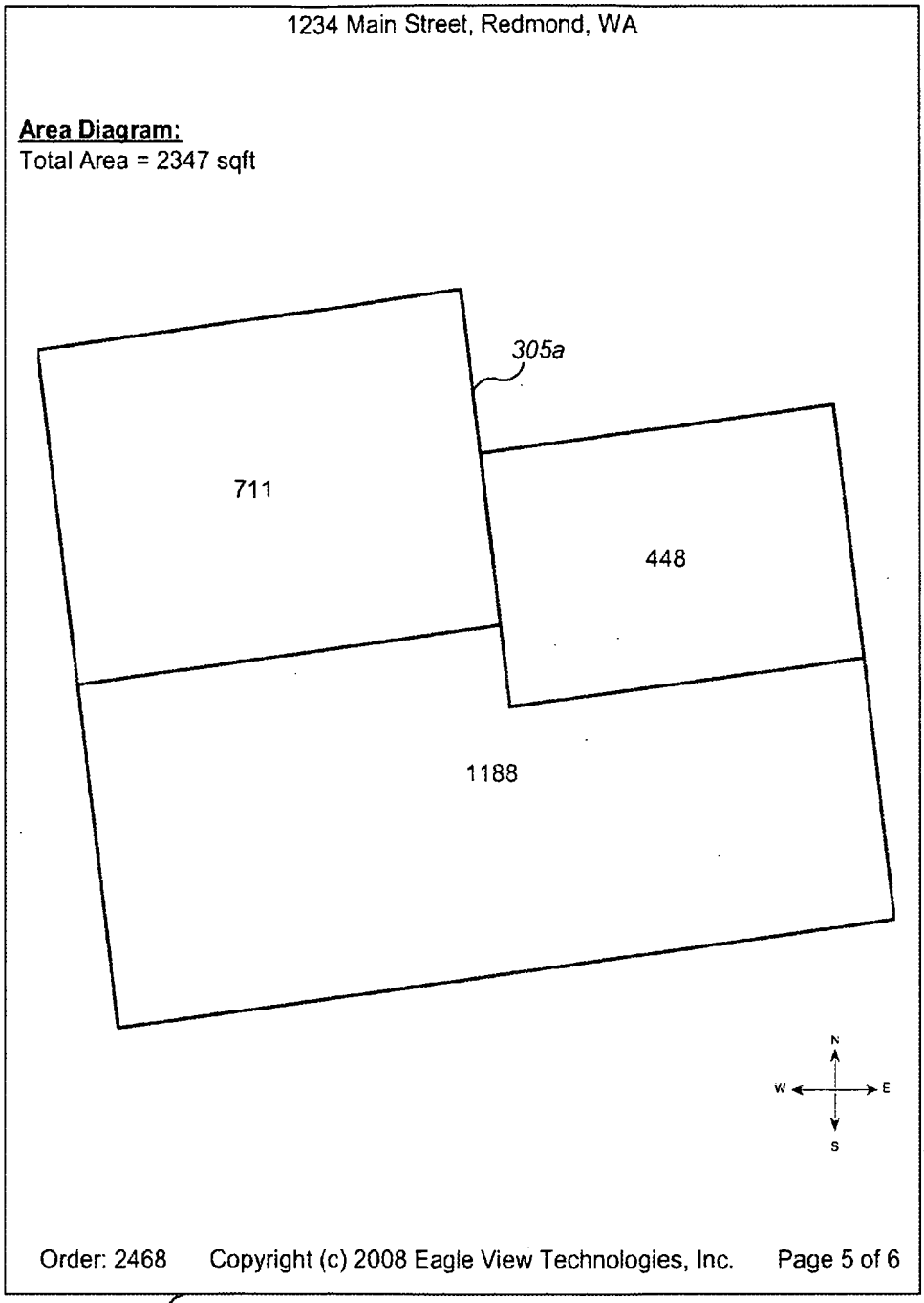

1234 Main Street, Redmond, WA
Area Diagram:
Total Area = 2347 sqft
305a
711
448
1188
N
W
E
S
Order: 2468
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Page 5 of 6
305

Fig. 3E

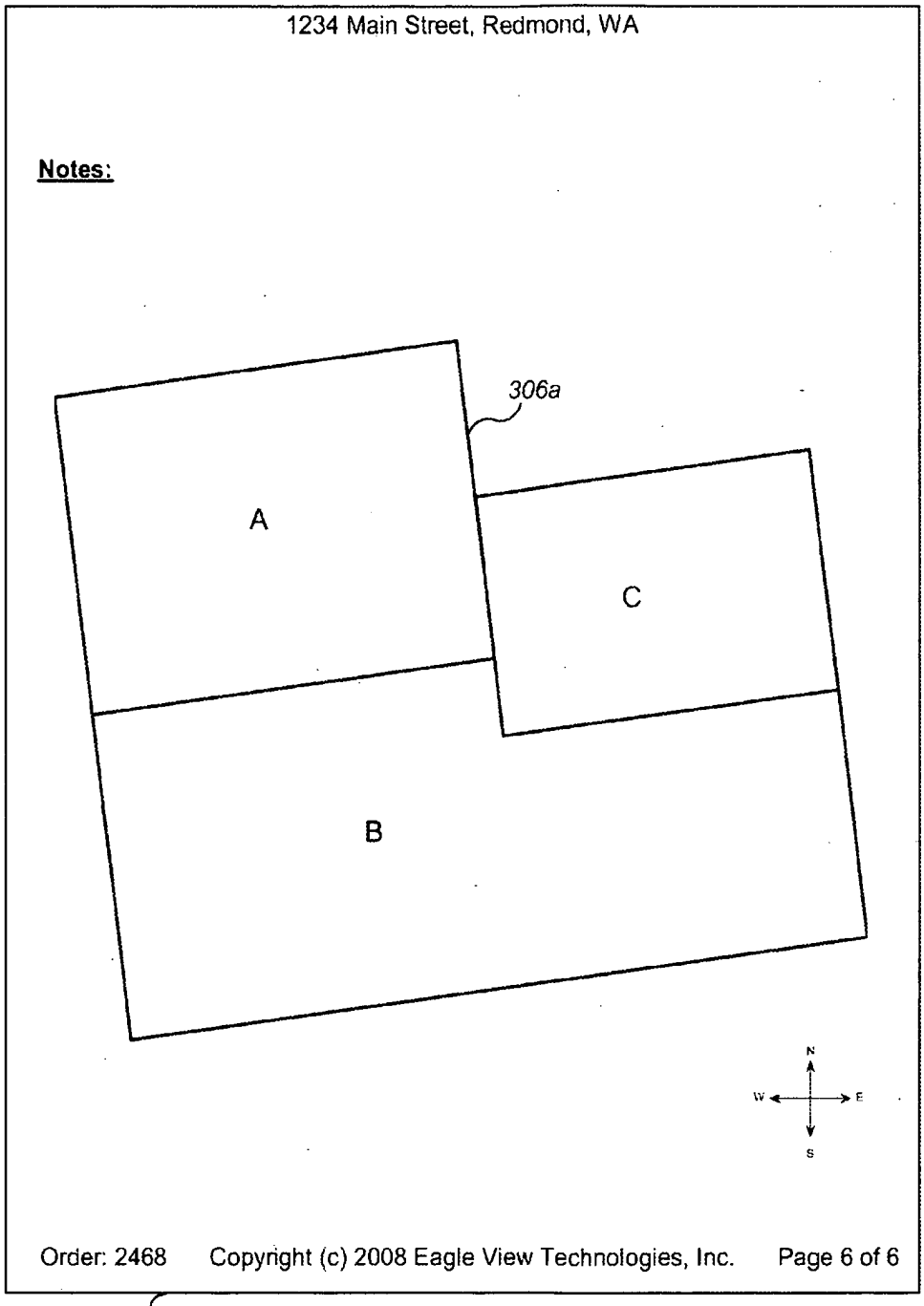

1234 Main Street, Redmond, WA
Notes:
306a
A
C
B
N
W
E
S
Order: 2468
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Page 6 of 6
306

Fig. 3F

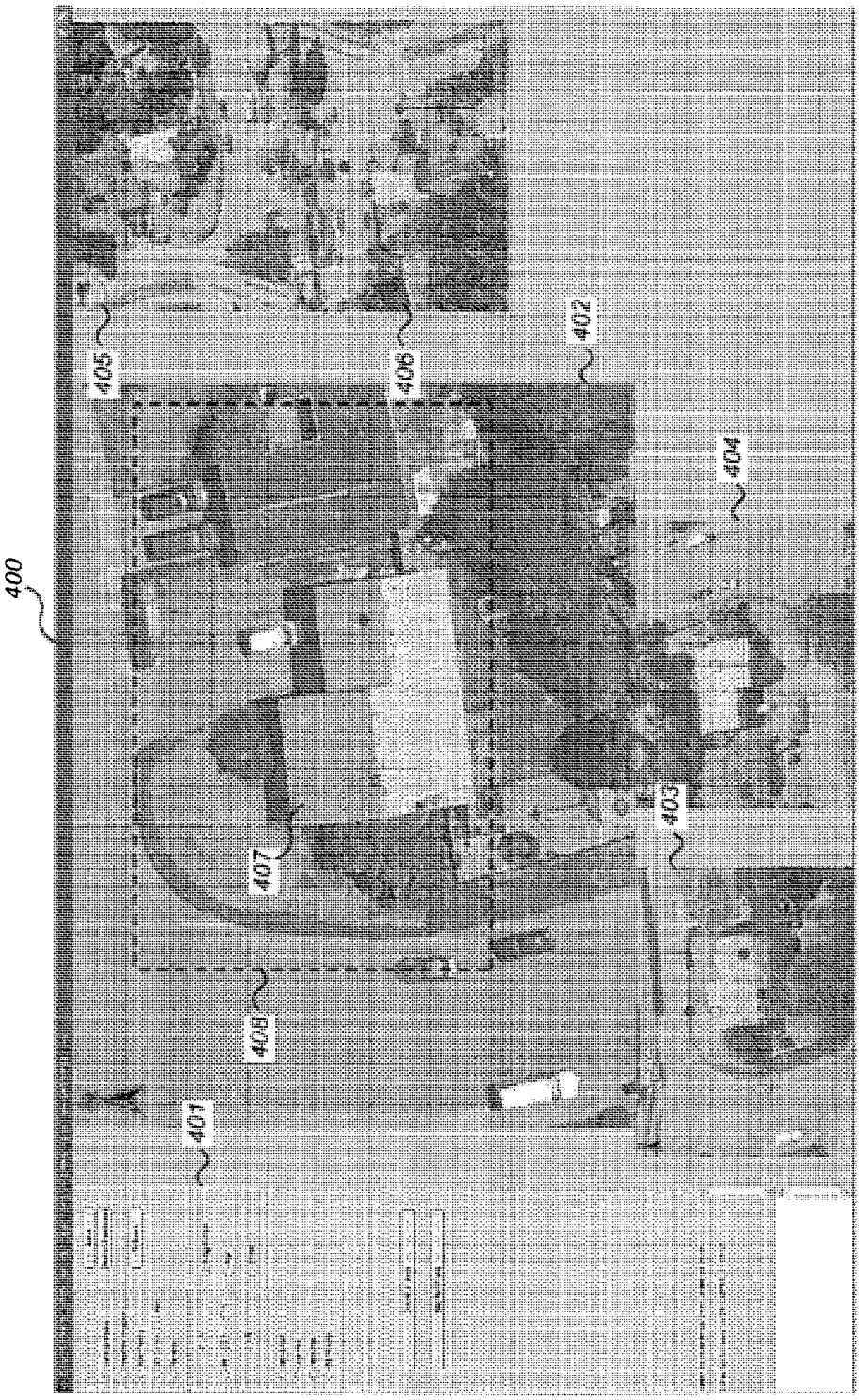


Fig. 4A

Roofr Exhibit 1002, Page 181

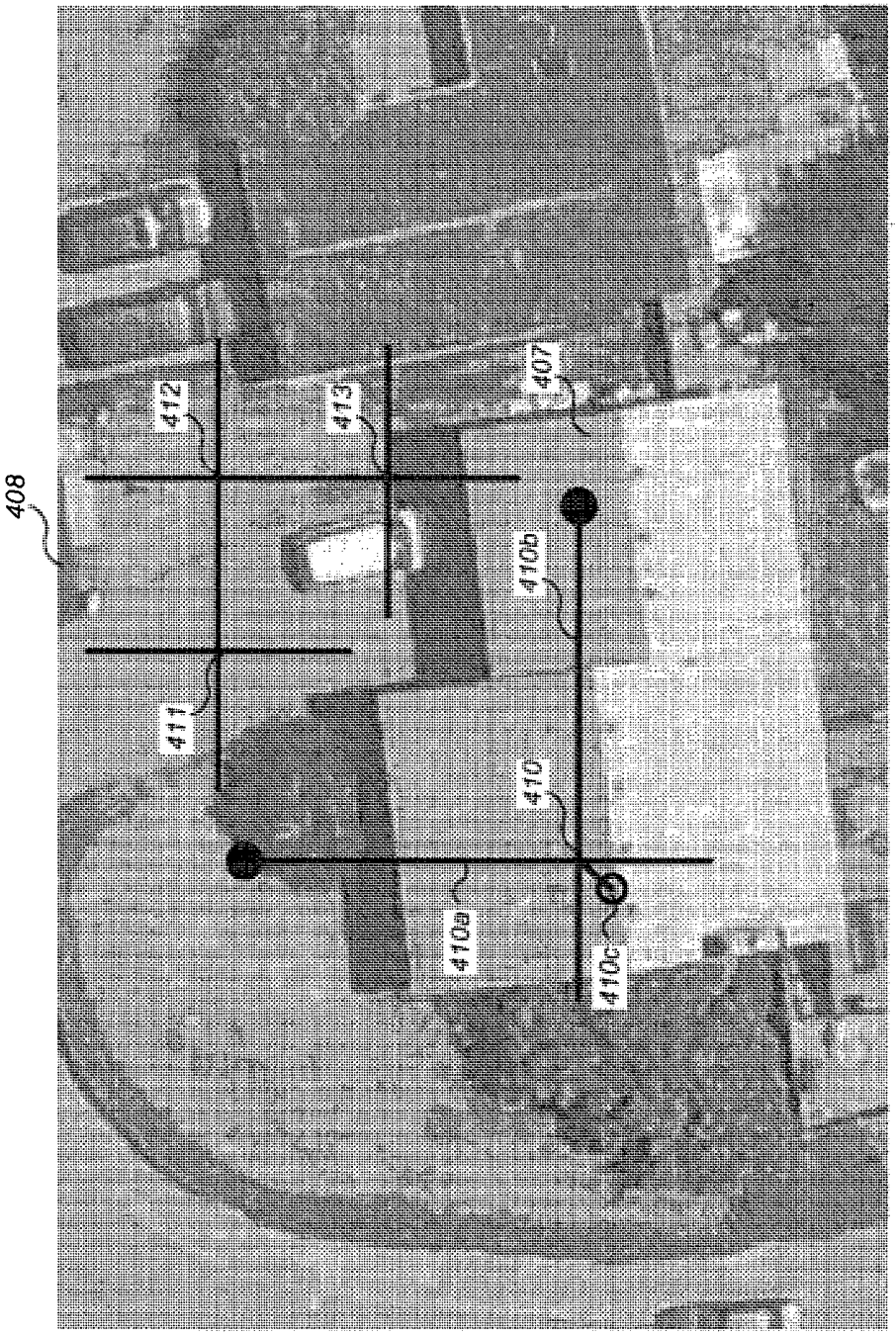


Fig. 4B

Roofr Exhibit 1002, Page 182

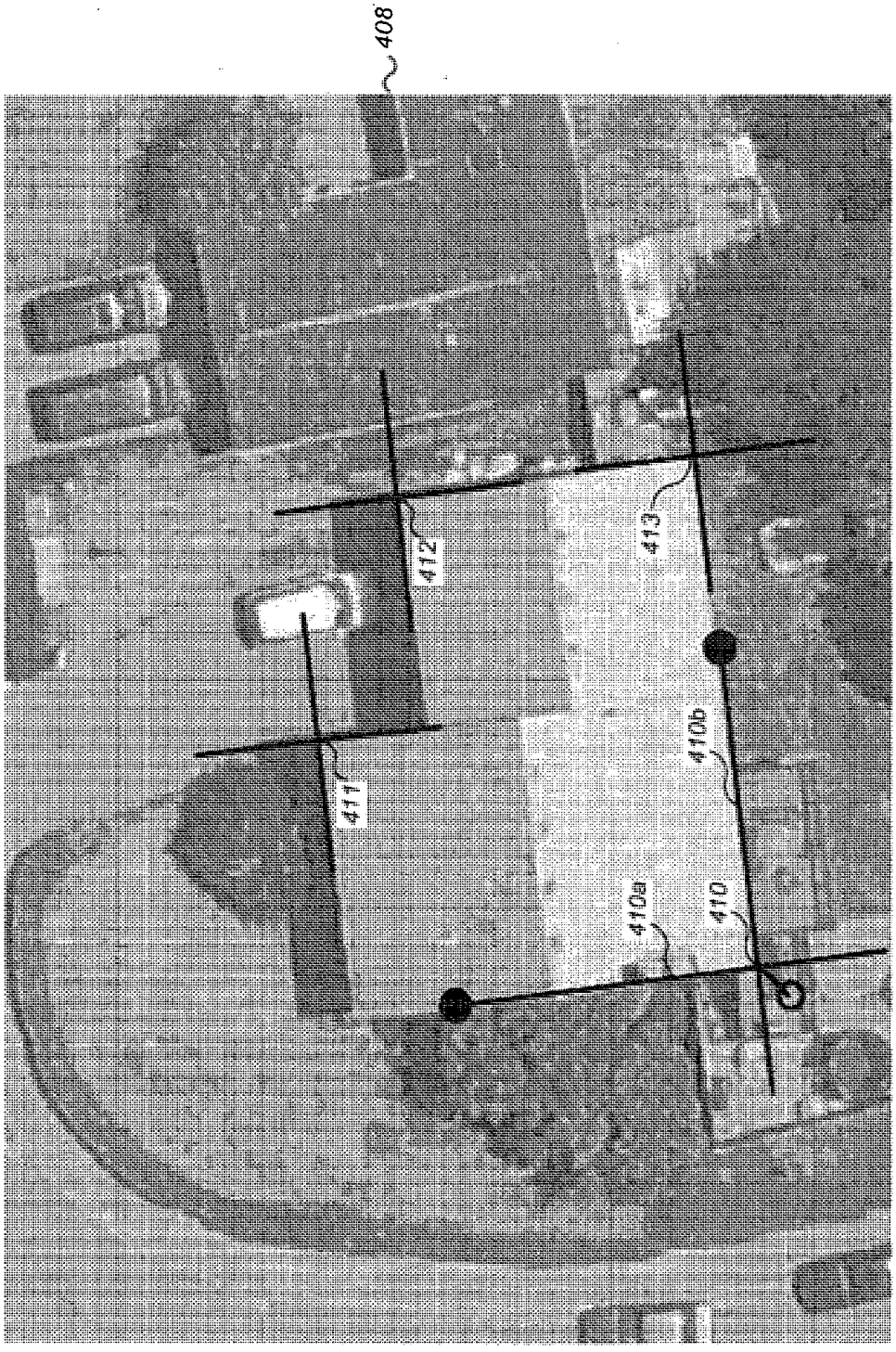


Fig. 4C

Roofr Exhibit 1002, Page 183

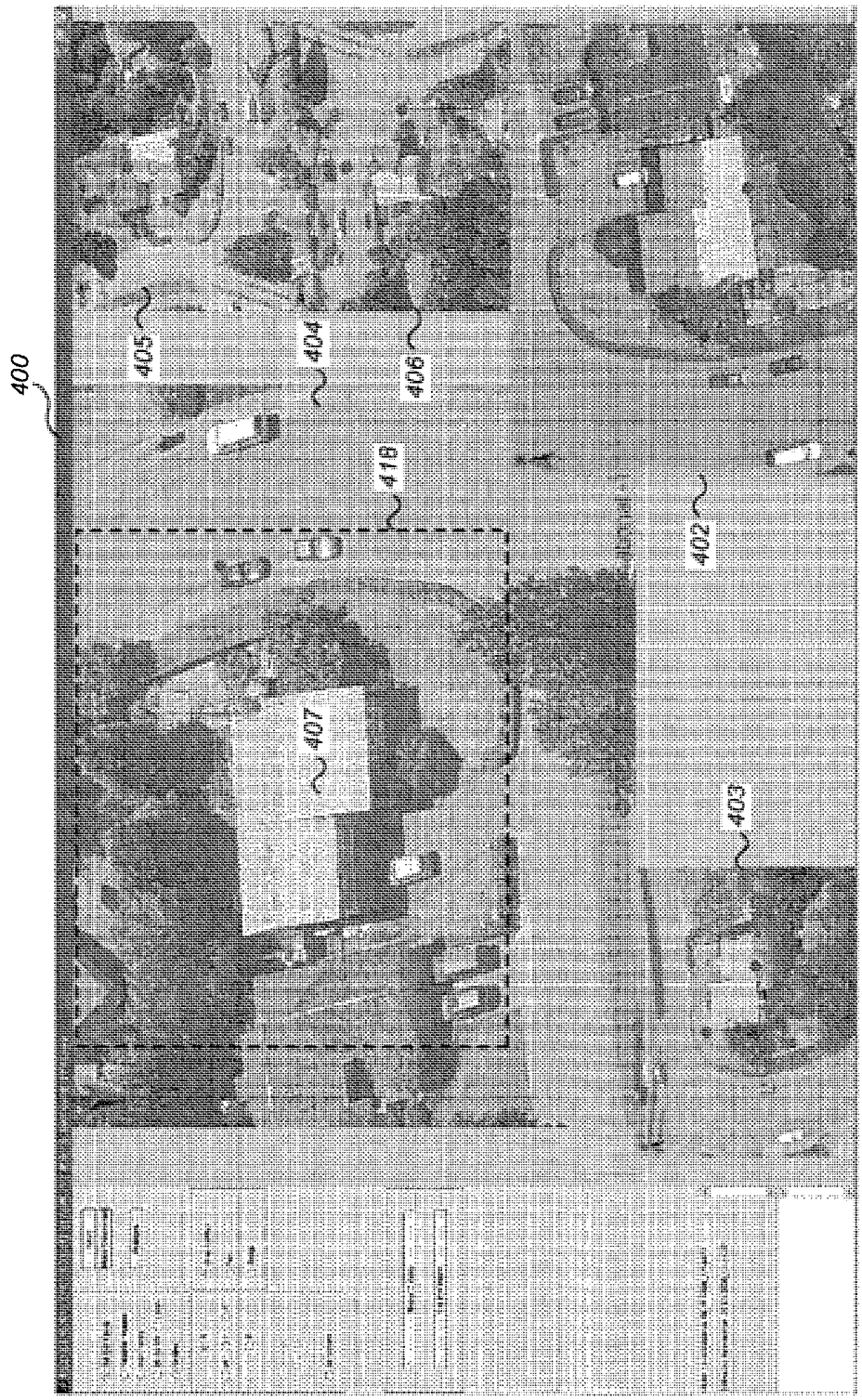


Fig. 4D

Roofr Exhibit 1002, Page 184

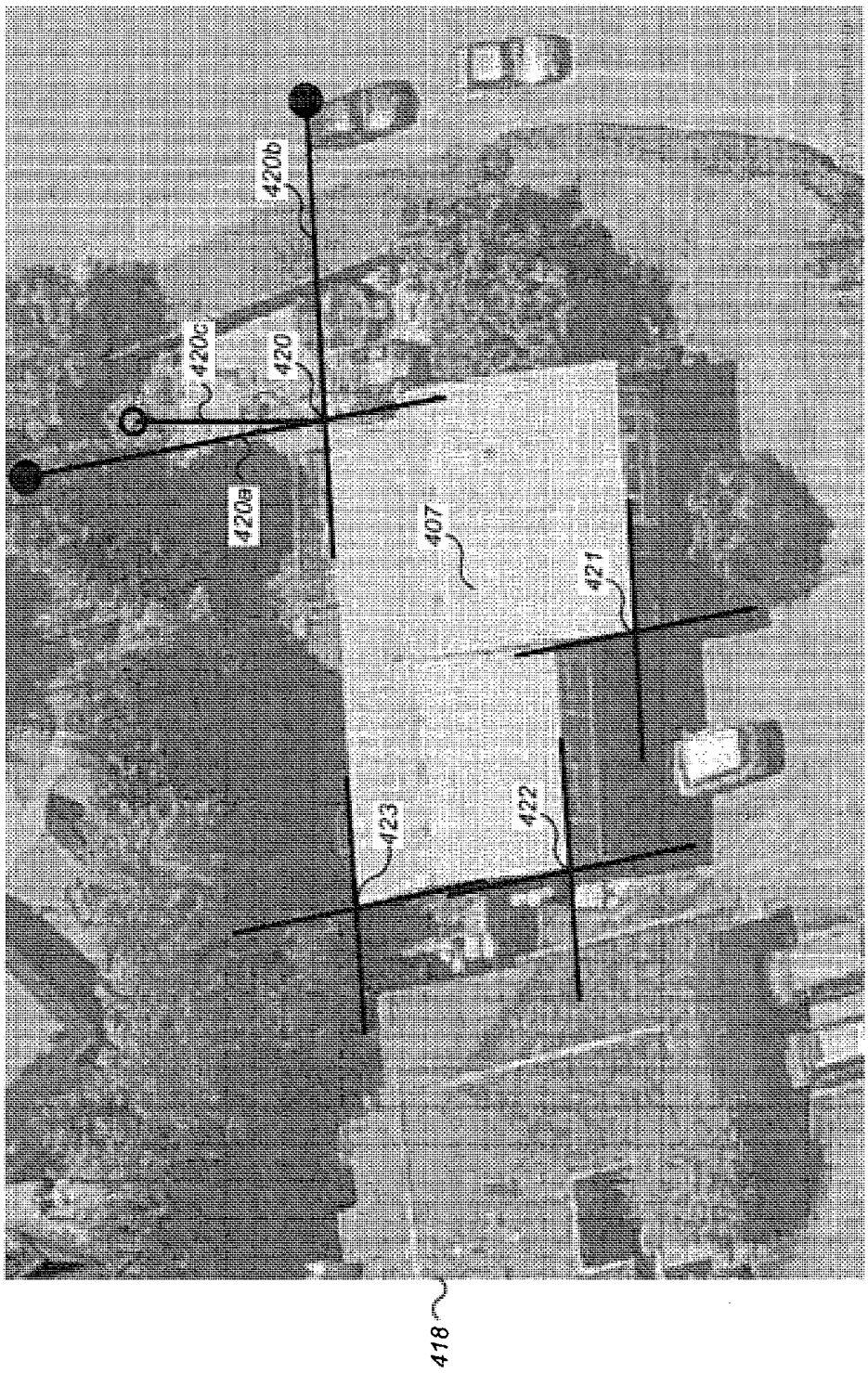


Fig. 4E

Roofr Exhibit 1002, Page 185

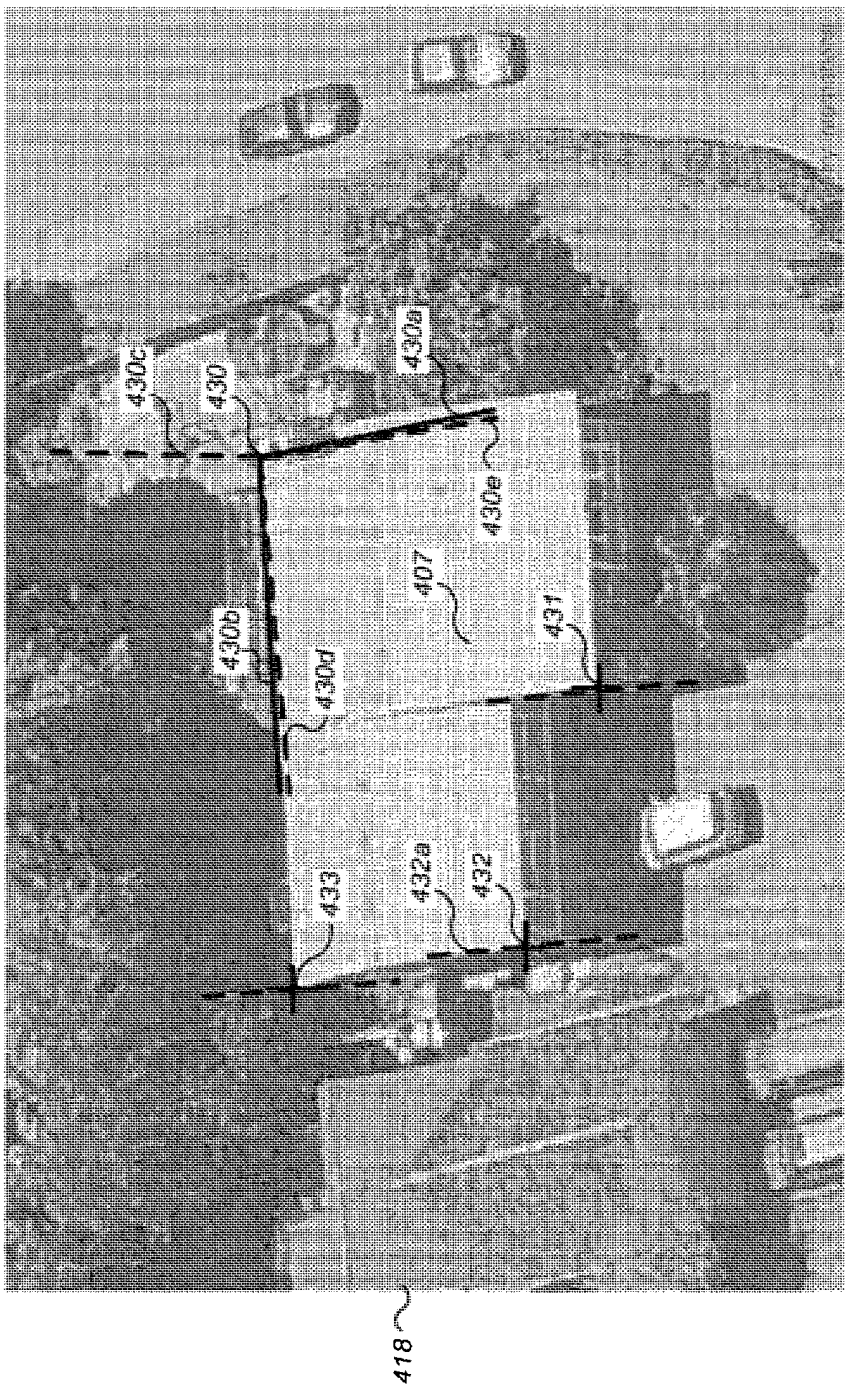


Fig. 4F

Roofr Exhibit 1002, Page 186

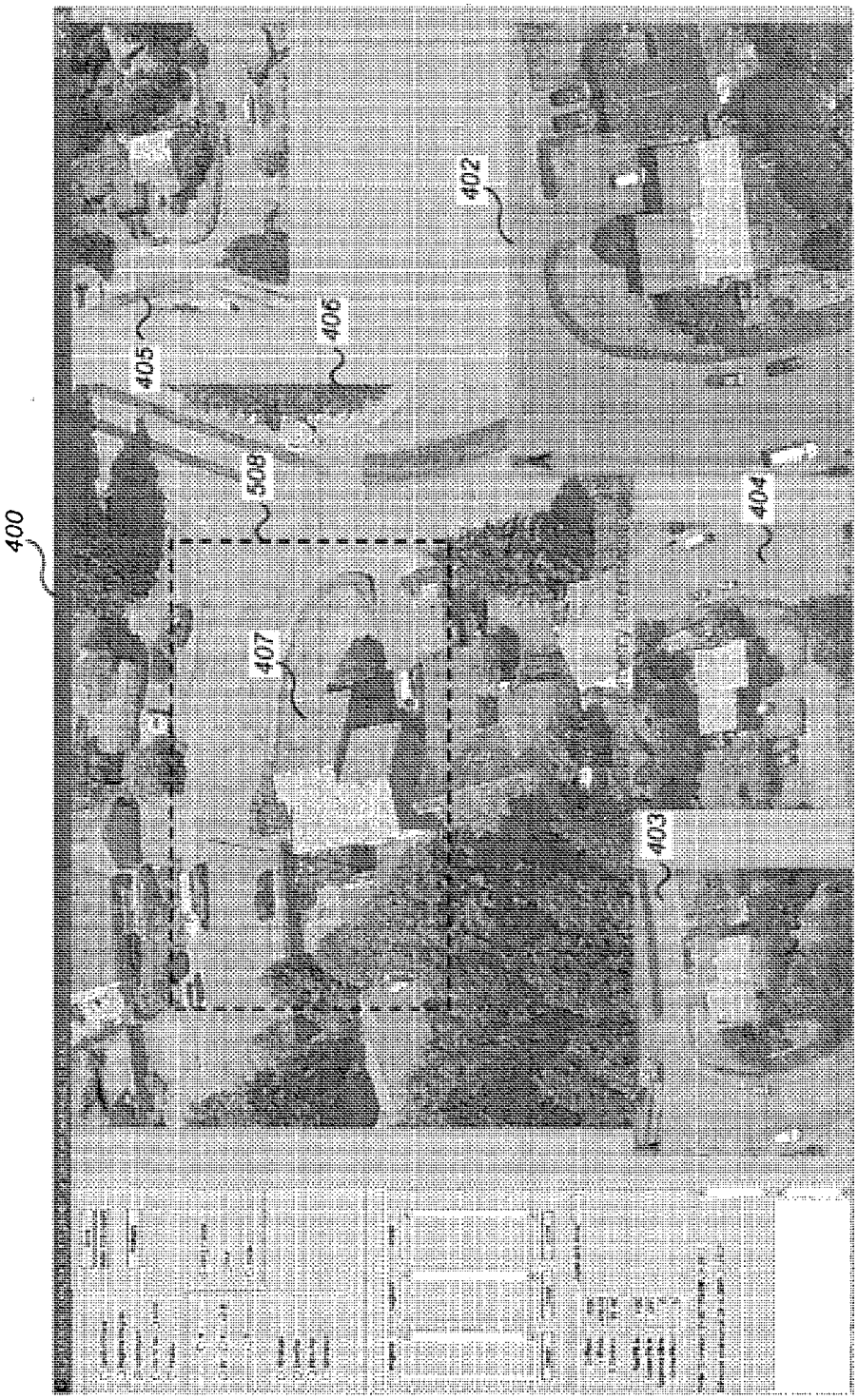


Fig. 5A

Roofr Exhibit 1002, Page 187

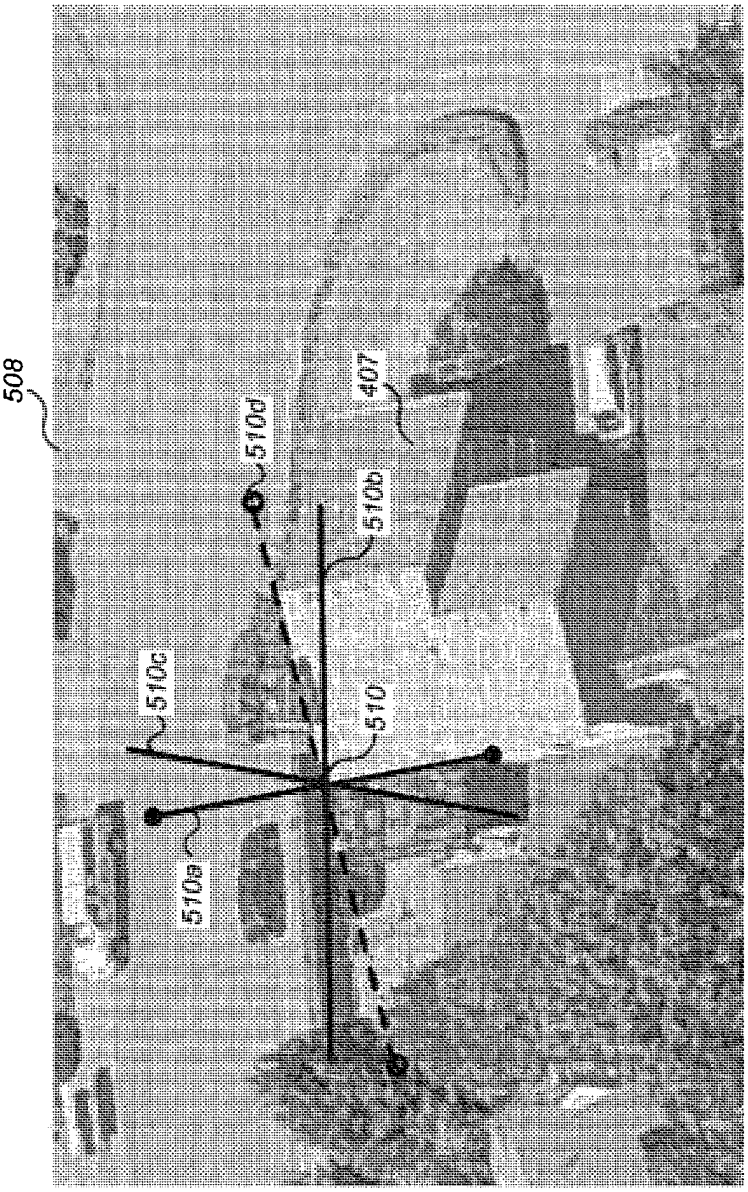


Fig. 5B

Roofr Exhibit 1002, Page 188

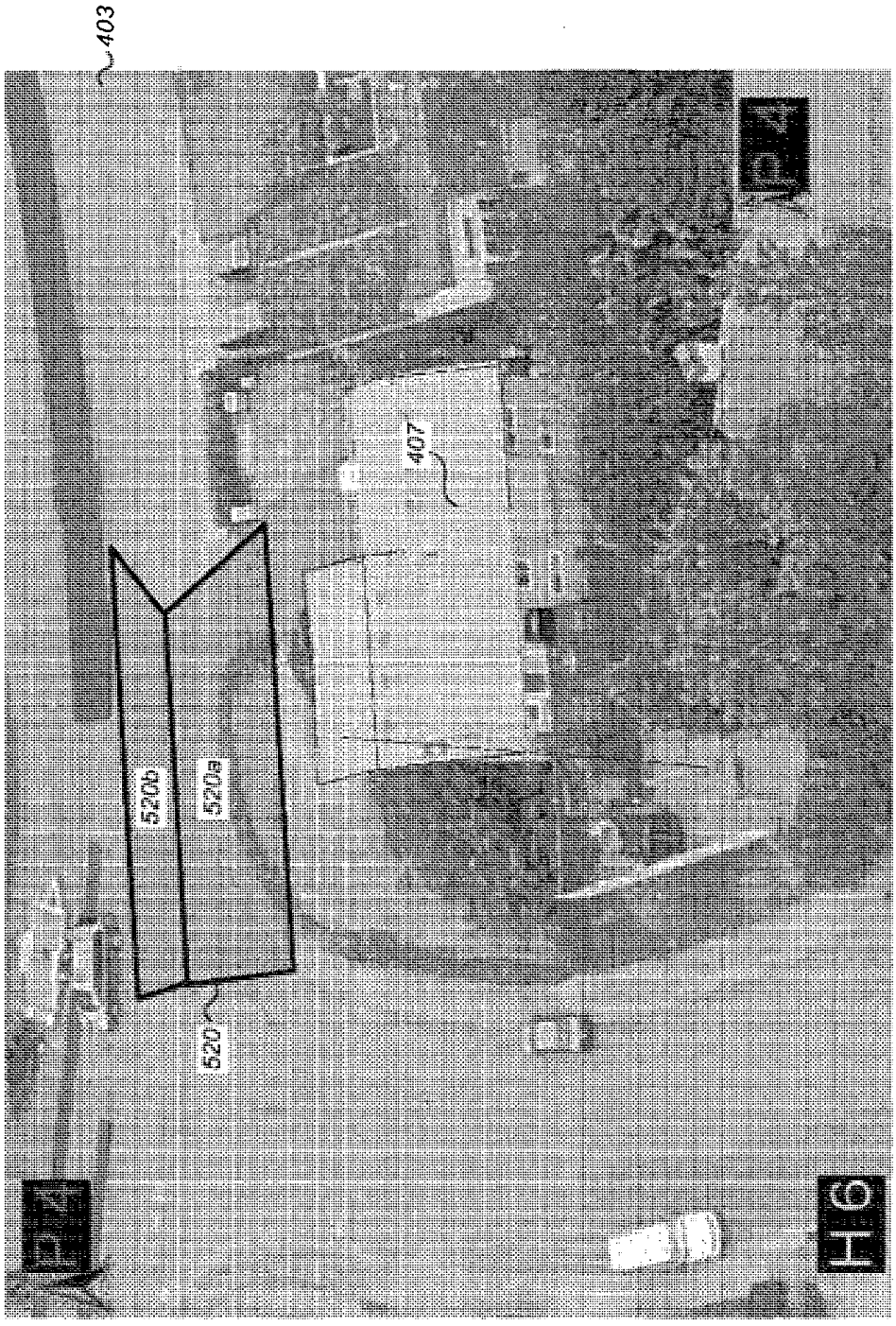


Fig. 5C

Roofr Exhibit 1002, Page 189

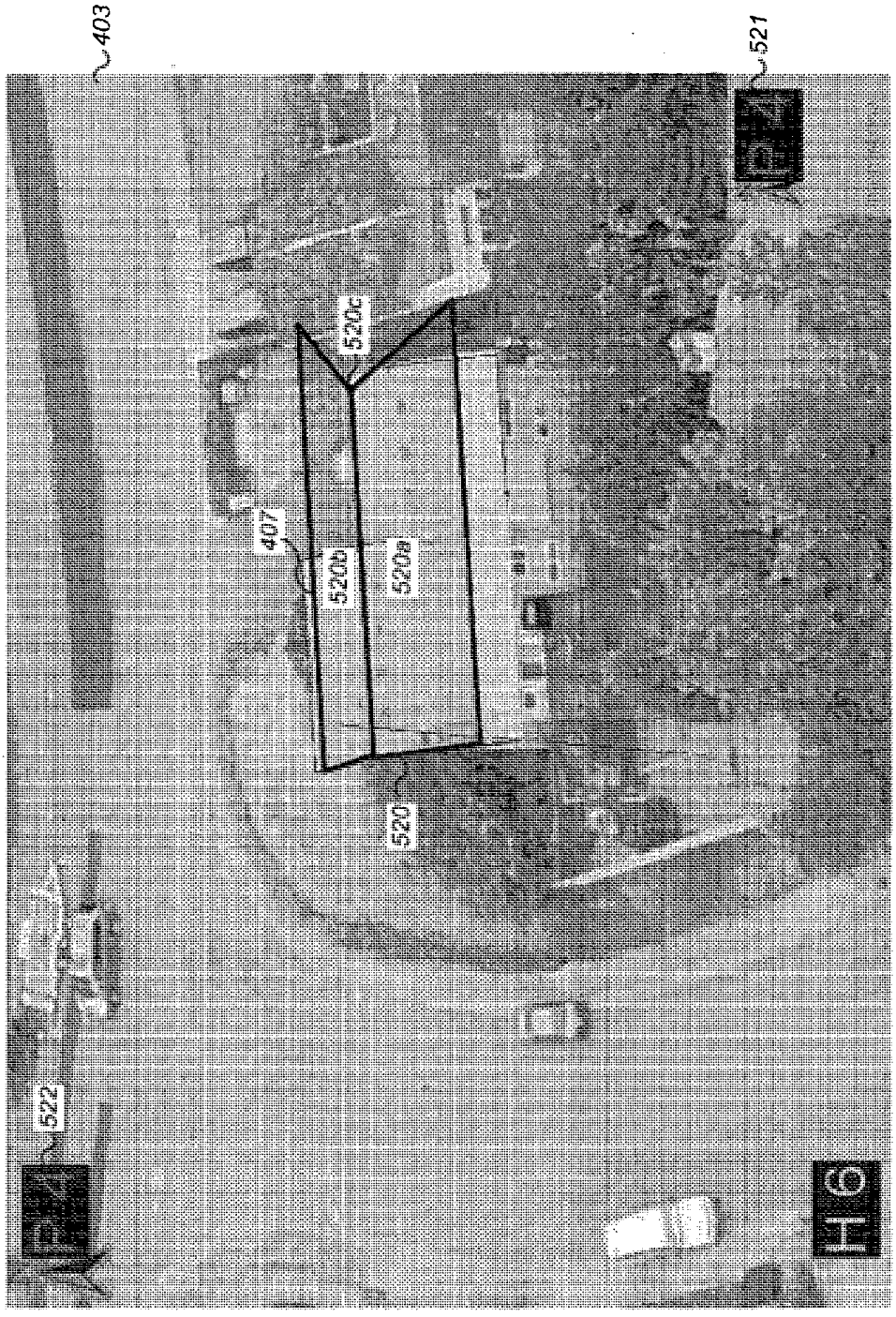


Fig. 5D

Roofr Exhibit 1002, Page 190

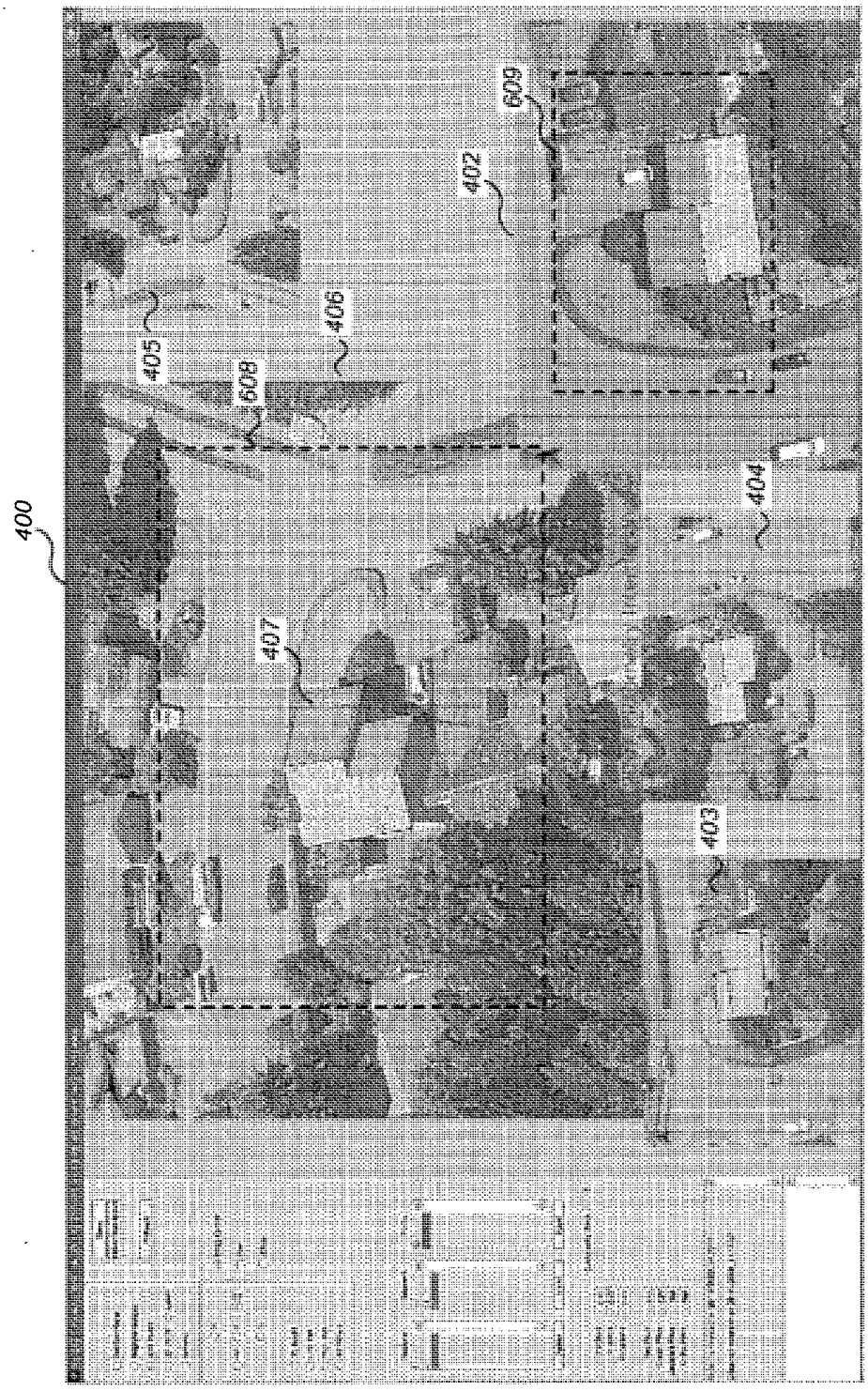


Fig. 6A

Roofr Exhibit 1002, Page 191

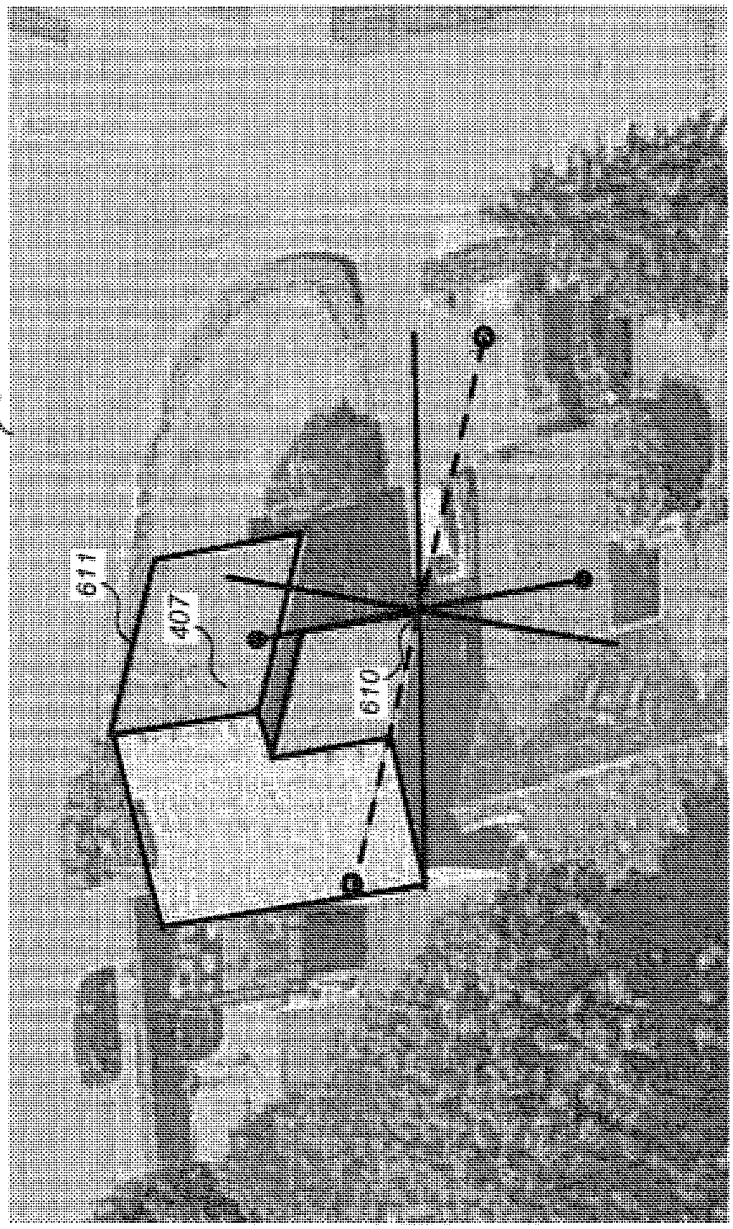


Fig. 6B

Roofr Exhibit 1002, Page 192

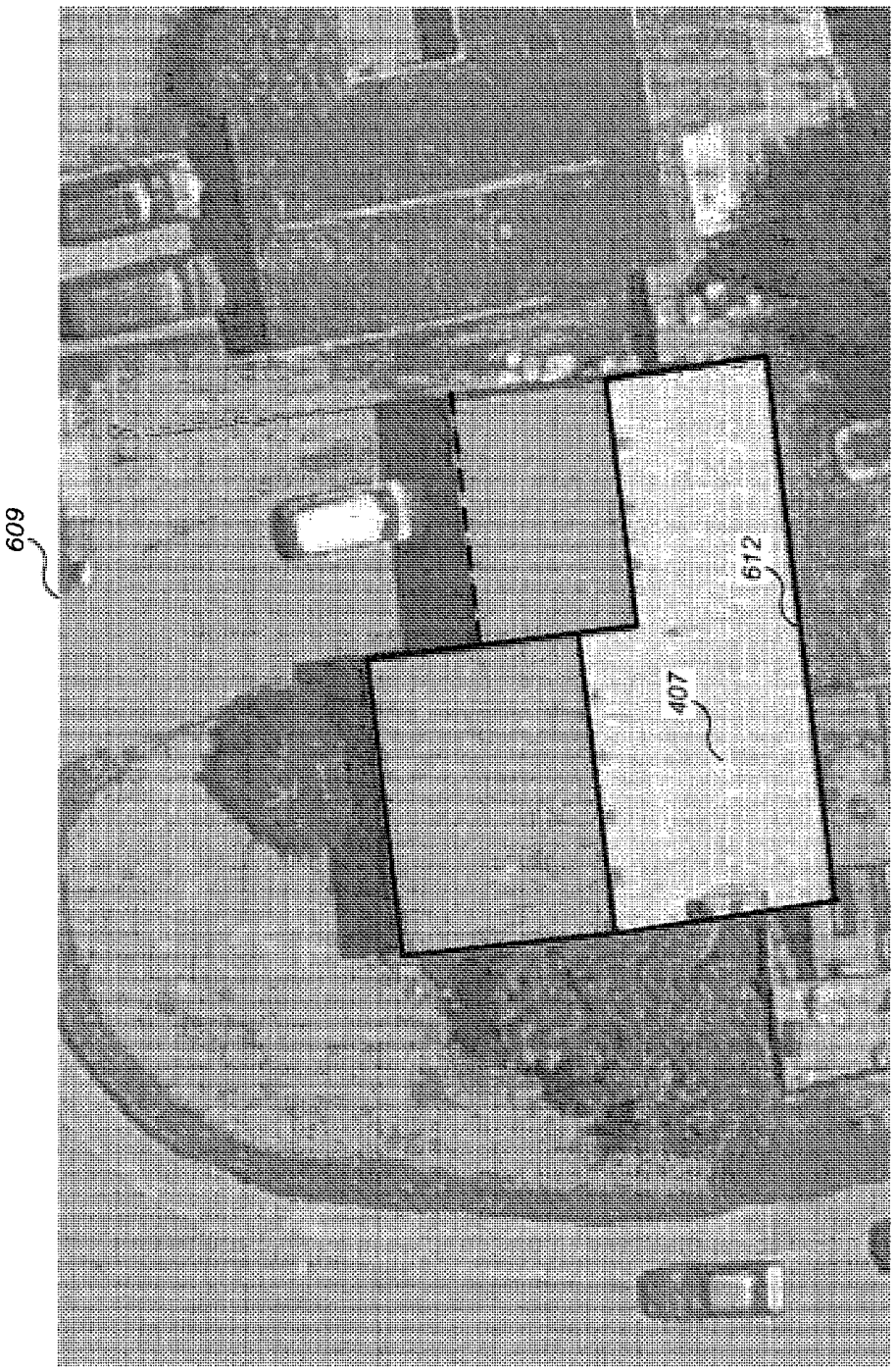


Fig. 6C

Roofr Exhibit 1002, Page 193

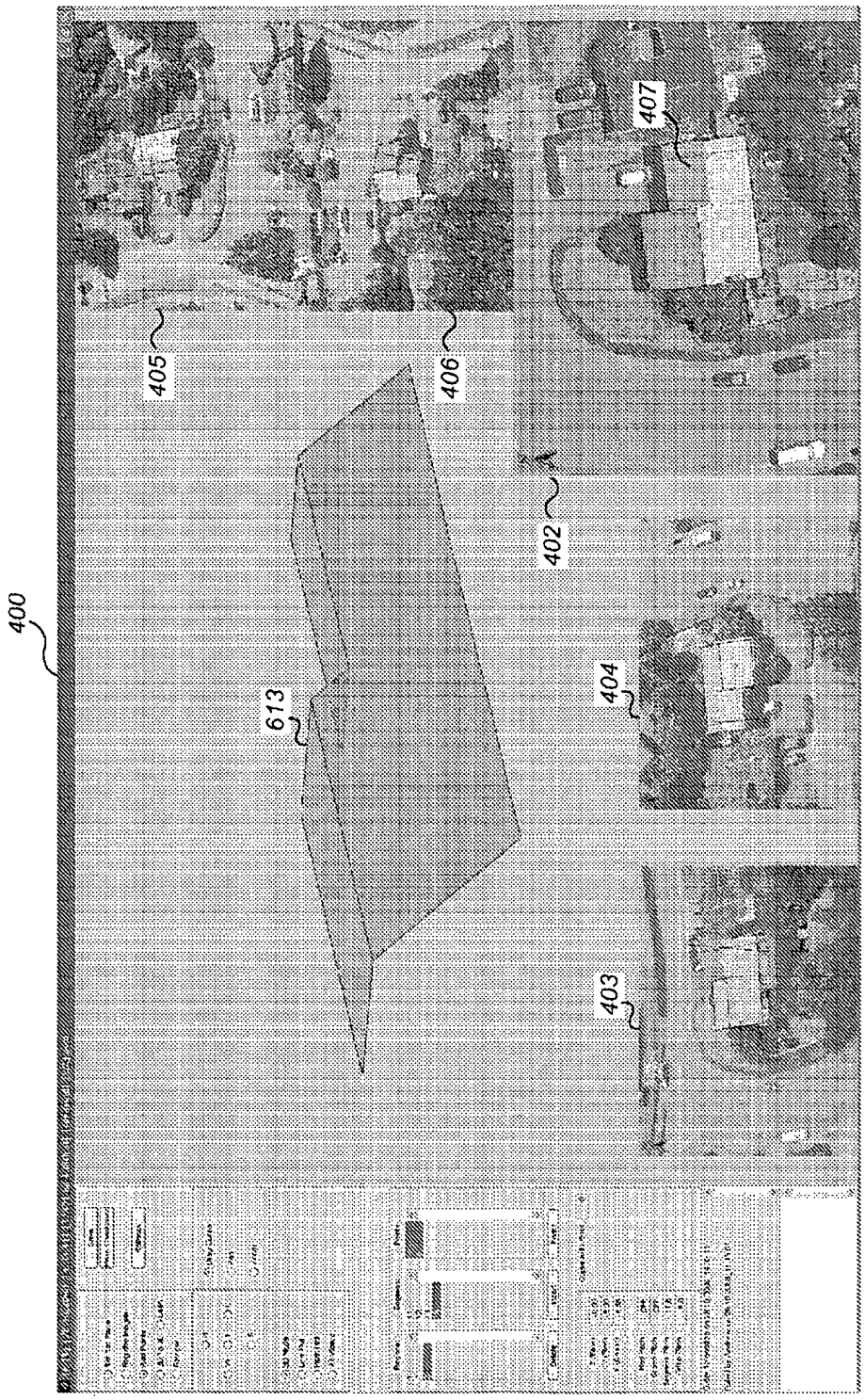


Fig. 6D

Roofr Exhibit 1002, Page 194

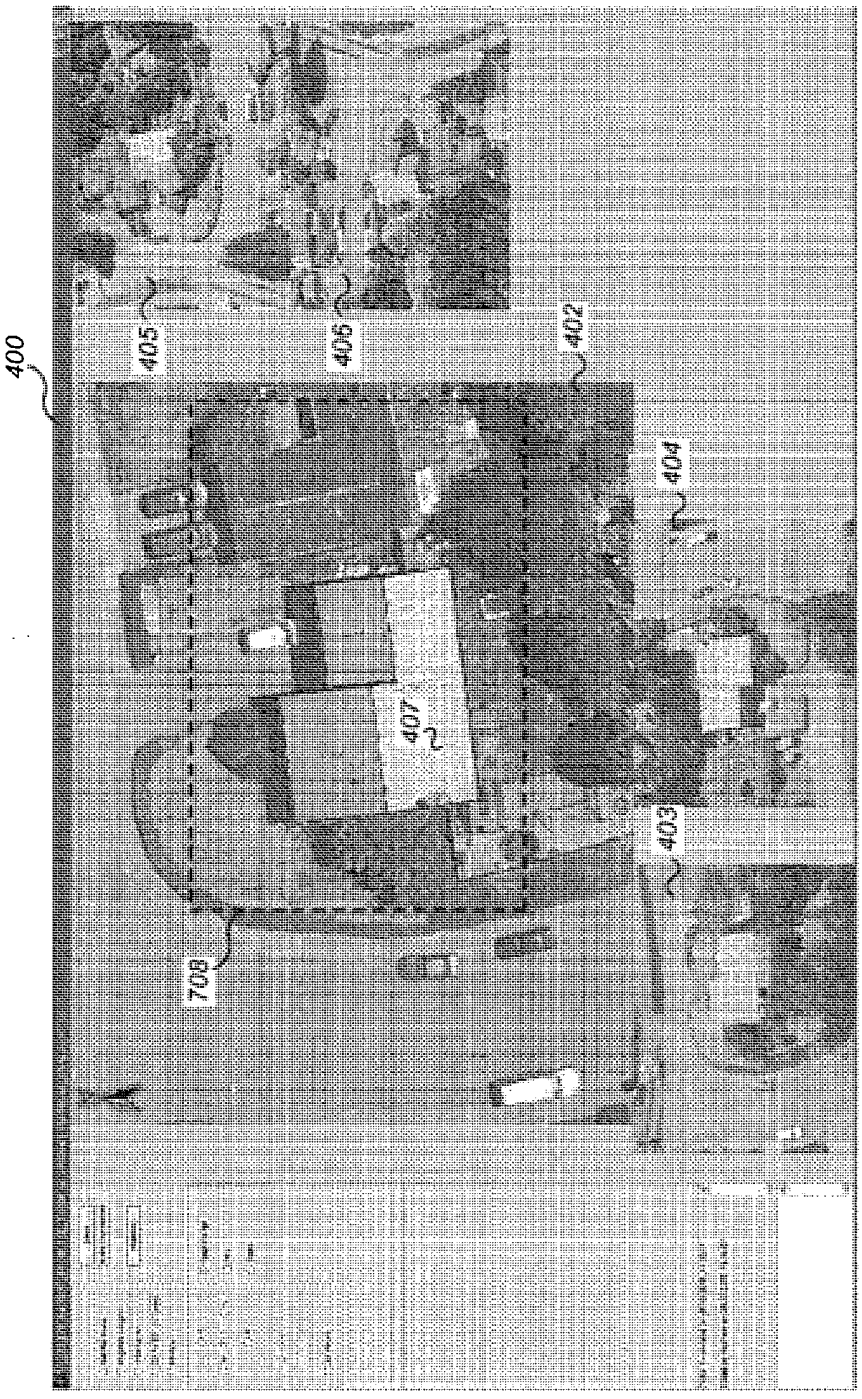


Fig. 7A

Roofr Exhibit 1002, Page 195

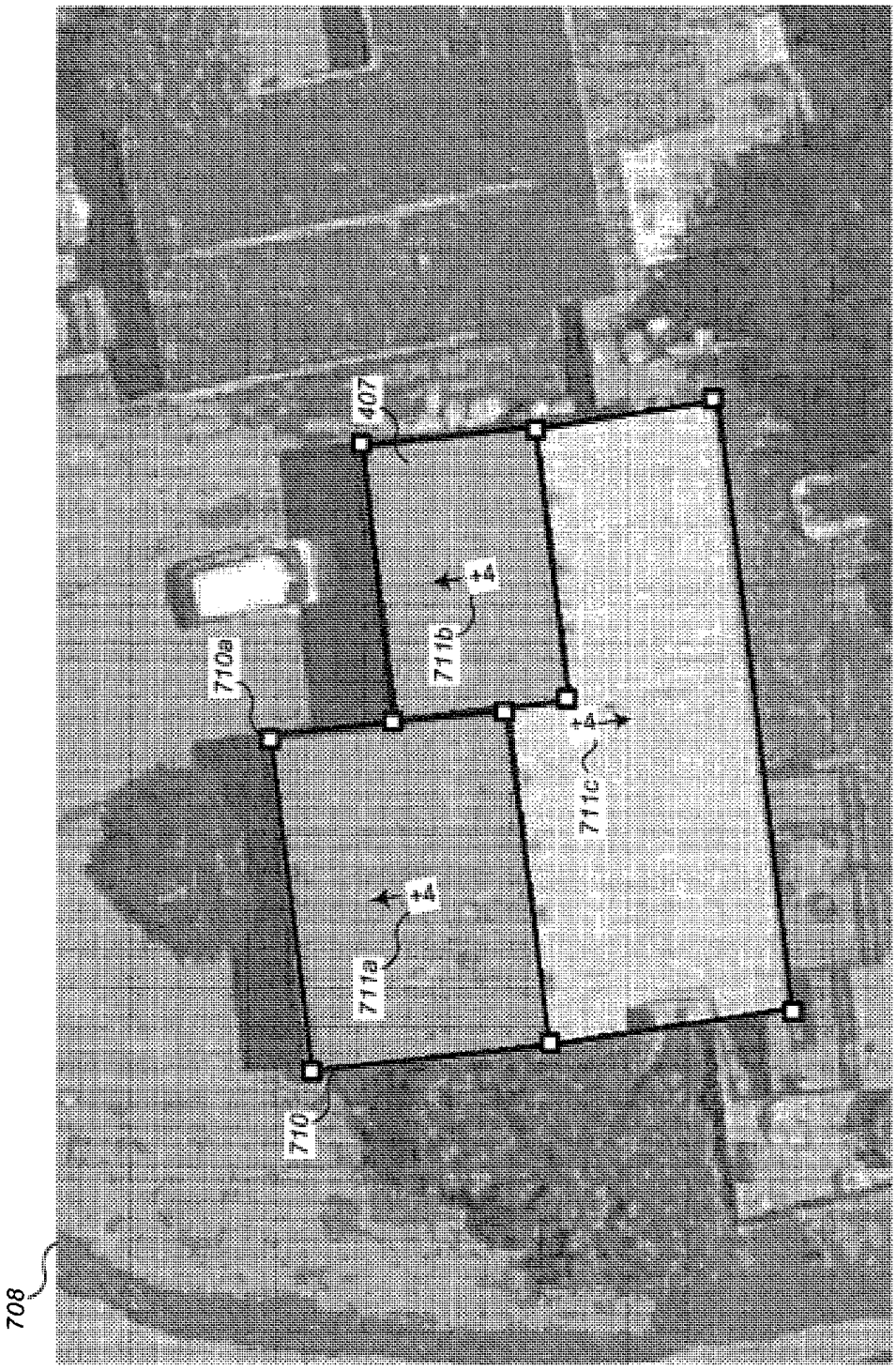


Fig. 7B

Roofr Exhibit 1002, Page 196

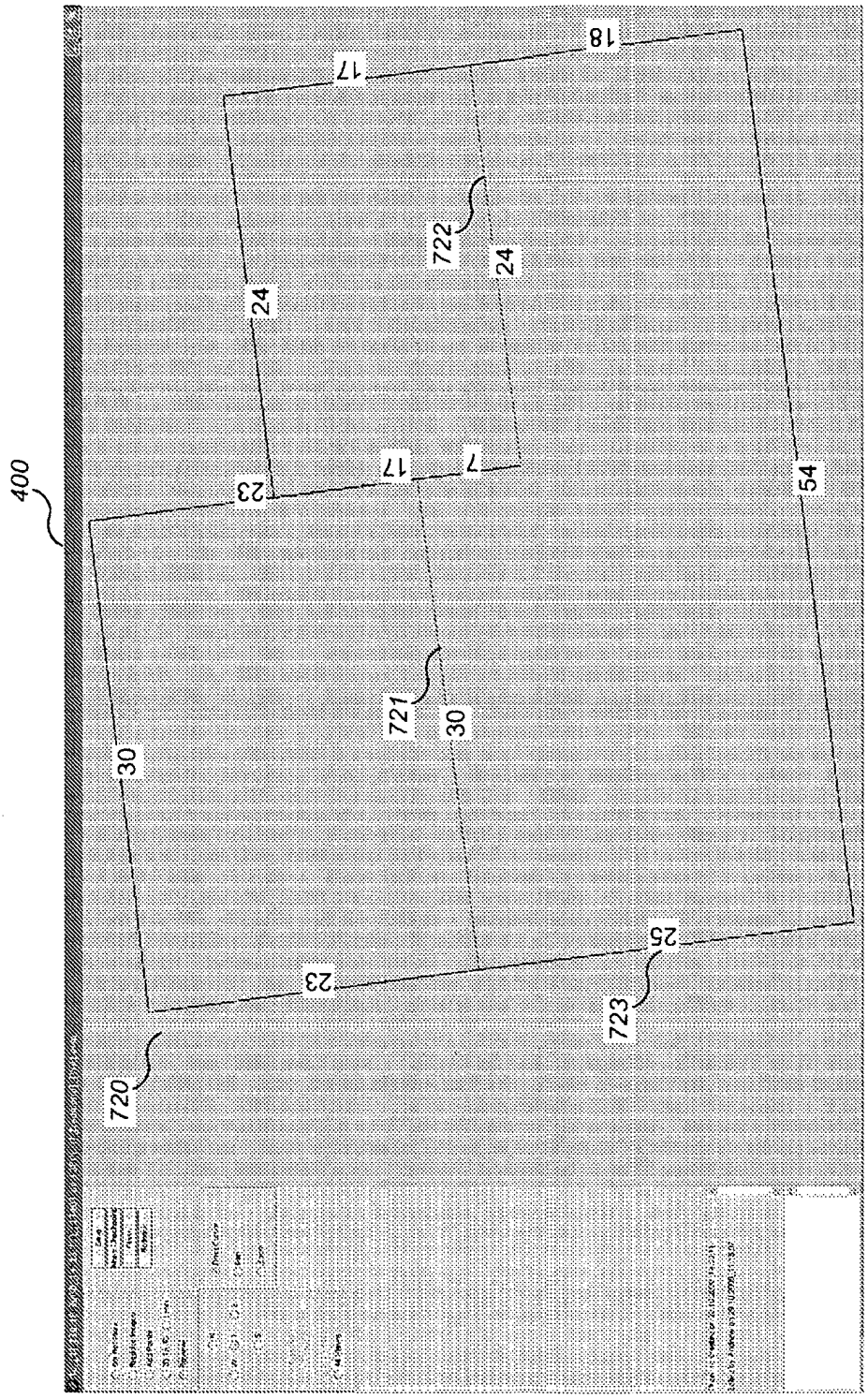


Fig. 7C

Roofr Exhibit 1002, Page 197

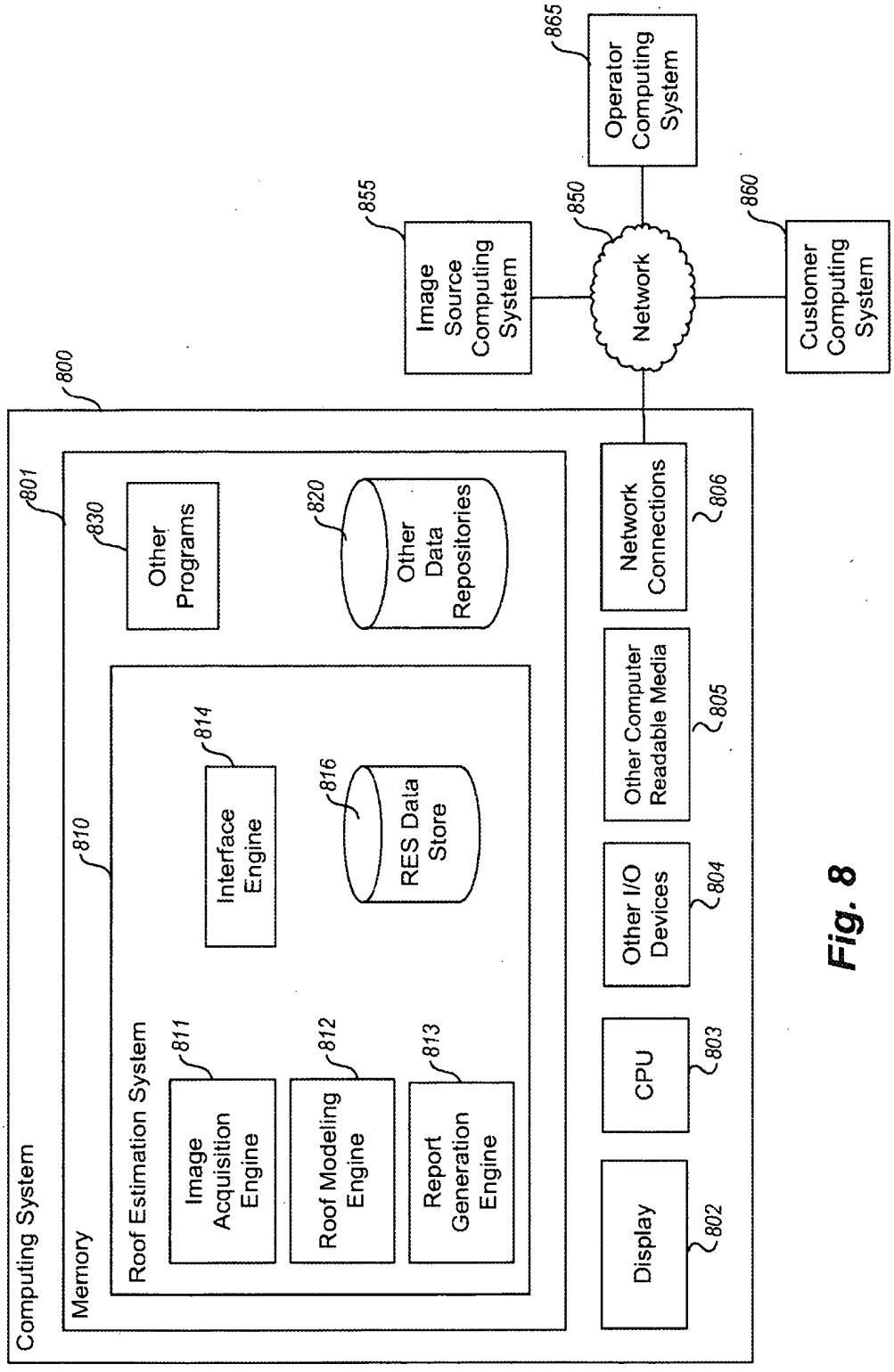

Computing System
800
Memory
801
Roof Estimation System
810
Image Acquisition Engine
811
Roof Modeling Engine
812
Report Generation Engine
813
Interface Engine
814
RES Data Store
816
Other Programs
830
Other Data Repositories
820
Display
802
CPU
803
Other I/O Devices
804
Other Computer Readable Media
805
Network Connections
806
Image Source Computing System
855
Network
850
Operator Computing System
865
Customer Computing System
860

Fig. 8

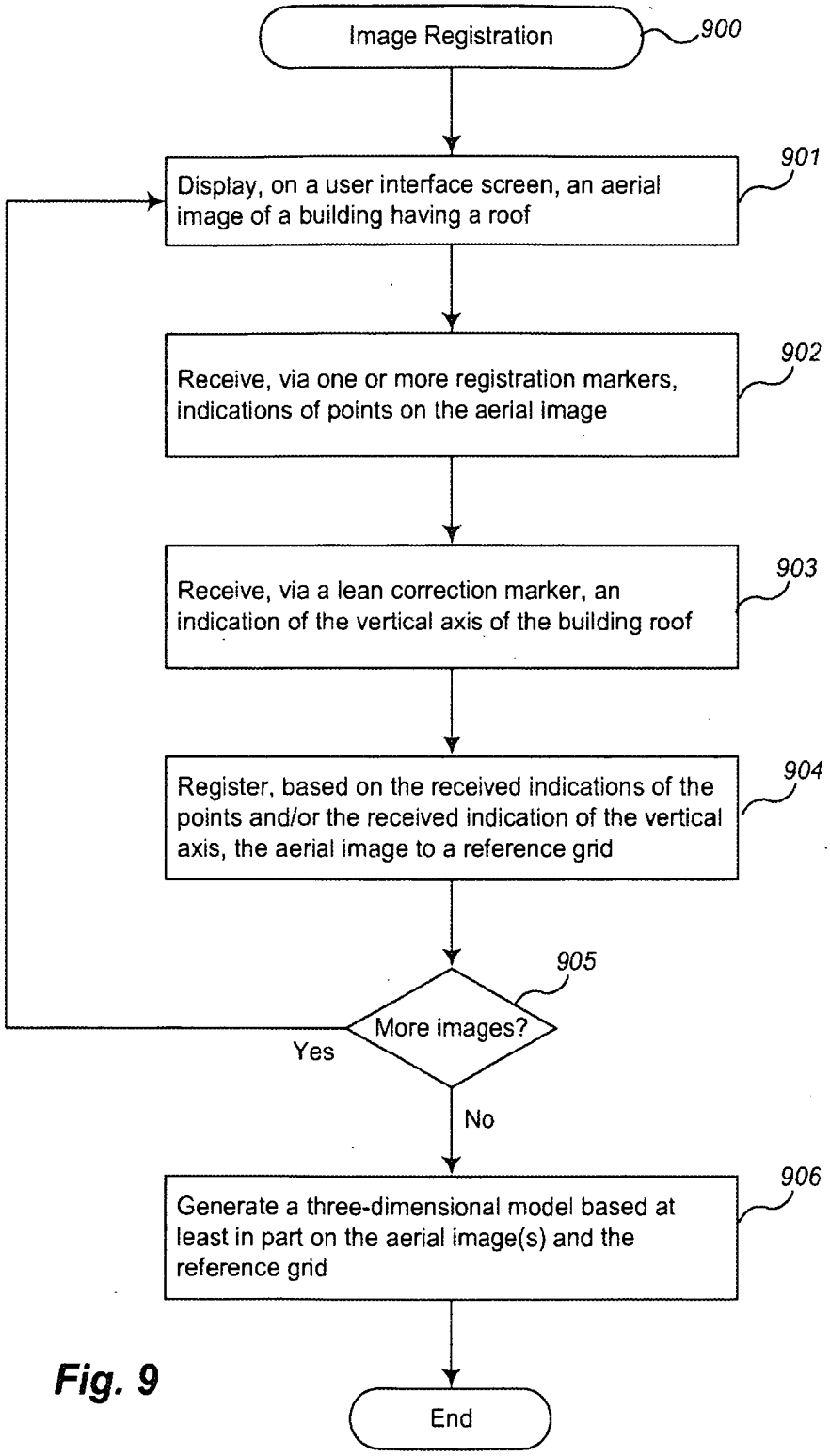


Fig. 9

Roofr Exhibit 1002, Page 199

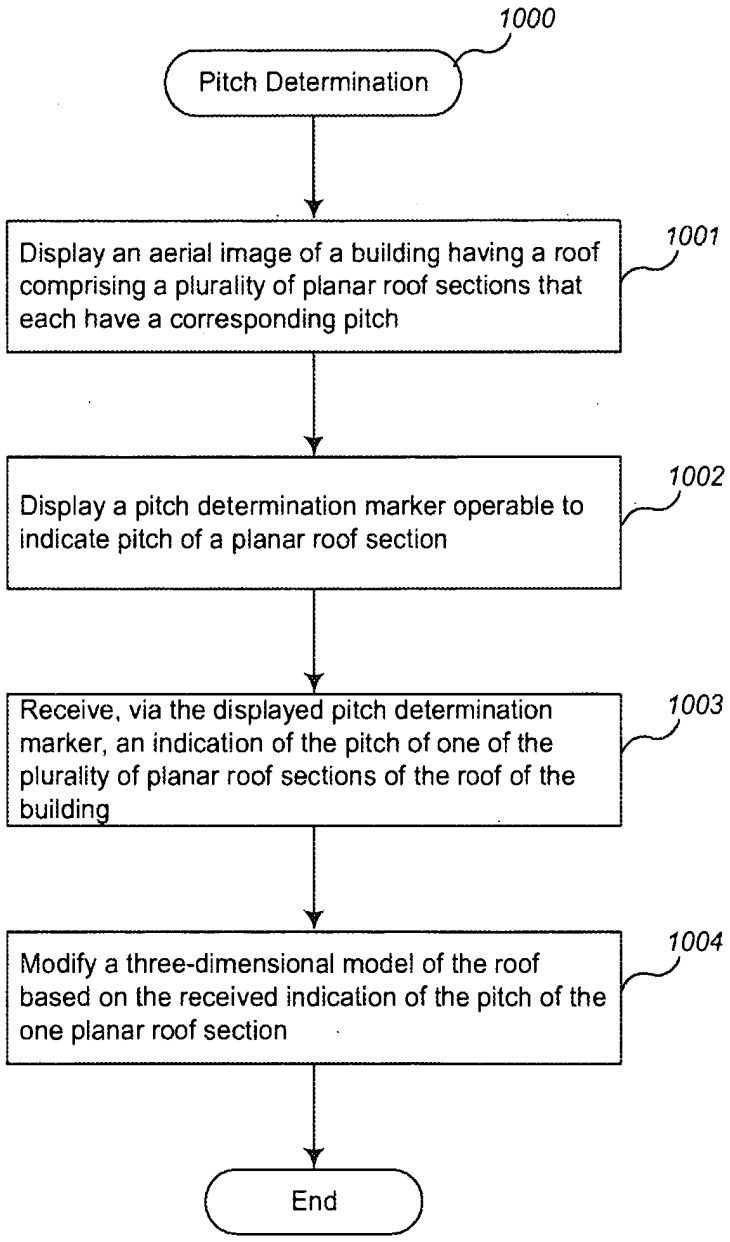


Fig. 10

Roofr Exhibit 1002, Page 200

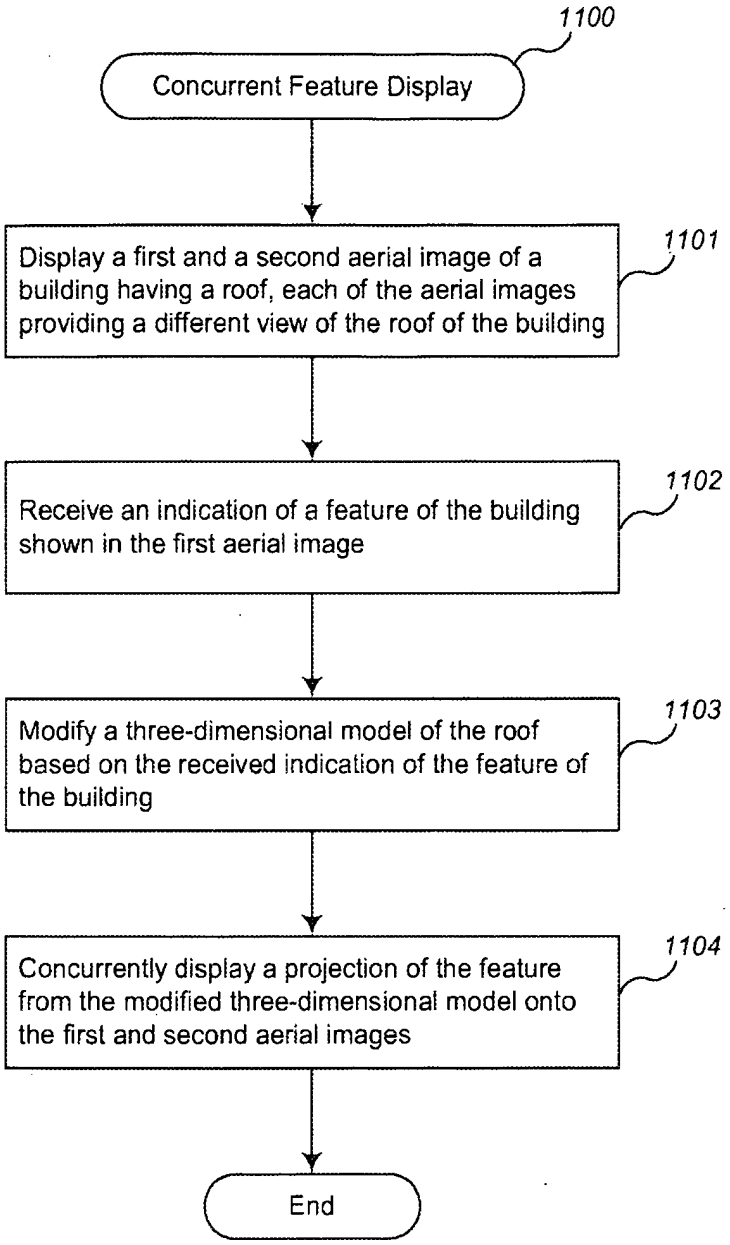


Fig. 11

Roofr Exhibit 1002, Page 201

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 46724409 A **[0001] [0130]**

Roofr Exhibit 1002, Page 202

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

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INTERNATIONALE ANMELDUNG VERÖFFENTLICHT NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT)

(51) Internationale Patentklassifikation 7 : G01B	A2	(11) Internationale Veröffentlichungsnummer: **WO 00/29806**
		(43) Internationales Veröffentlichungsdatum: 25. Mai 2000 (25.05.00)

(21) Internationales Aktenzeichen: PCT/EP99/08431

(22) Internationales Anmeldedatum: 3. November 1999 (03.11.99)

(30) Prioritätsdaten:
198 51 163.9 6. November 1998 (06.11.98) DE

(71)(72) Anmelder und Erfinder: GANTE, Friedhelm [DE/DE]; Perker Strasse 53, D–51674 Wiehl (DE). MAASSEN, Dieter [DE/DE]; Blumenstrasse 15, D–40667 Meerbusch (DE).

(74) Anwalt: COHAUSZ & FLORACK; Kanzlerstrasse 8a, D–40472 Düsseldorf (DE).

(81) Bestimmungsstaaten: AU, CA, JP, NZ, US, ZA, europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

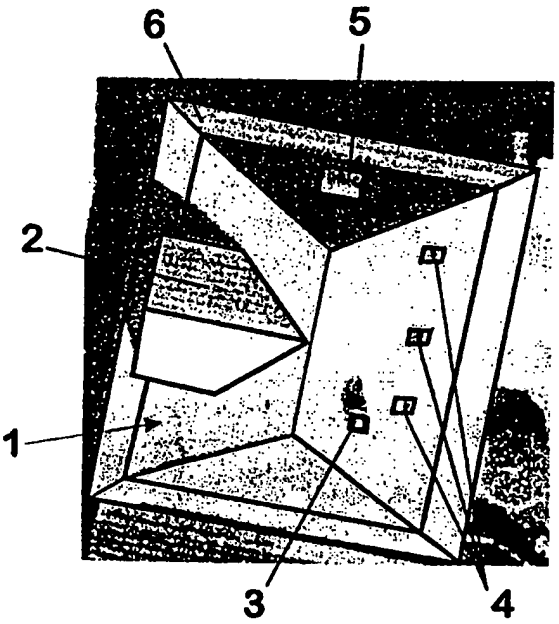
Veröffentlicht
Ohne internationalen Recherchenbericht und erneut zu veröffentlichen nach Erhalt des Berichts.

(54) Title: METHOD FOR MEASURING THE SURFACES OF A HOUSE ROOF

(54) Bezeichnung: VERFAHREN ZUM VERMESSEN DER FLÄCHEN EINES HAUSDACHS

(57) Abstract

The invention relates to a method for measuring the roof surfaces of a building with which the mentioned safety risks are avoided and a scaled, detail–exact reproduction of the house roof is made possible. According to the inventive method, at least one image of the roof (1) is generated which can be processed using data technology methods. The image is fed as a data set into a data processing device. The progression of roof edges which respectively enclose one of the roof surfaces is determined by the data processing device. The dimensions of the respective roof surface is determined by the data processing device from the detected progression of the roof edges.



(57) Zusammenfassung

Die vorliegende Erfindung betrifft ein Verfahren zum Vermessen der Dachflächen eines Gebäudes, mittels dessen die genannten Sicherheitsrisiken vermieden werden und eine massstäbliche, detailgetreue Wiedergabe des Hausdachs ermöglicht wird. Bei einem solchen Verfahren wird mindestens eine datentechnisch verarbeitbare Abbildung des Dachs (1) erstellt, die Abbildung als Datensatz in eine Datenverarbeitungseinrichtung eingespeist, von der Datenverarbeitungseinrichtung der Verlauf der Drachkanten ermittelt, welche jeweils eine der Dachflächen umschliessen, und von der Datenverarbeitungseinrichtung aus dem ermittelten Verlauf der Dachkanten die Abmessungen der jeweiligen Dachfläche bestimmt.

LEDIGLICH ZUR INFORMATION

Codes zur Identifizierung von PCT-Vertragsstaaten auf den Kopfbögen der Schriften, die internationale Anmeldungen gemäss dem PCT veröffentlichen.

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EE	Estland	LR	Liberia	SG	Singapur		

Verfahren zum Vermessen der Flächen eines Hausdachs

Die Erfindung betrifft ein Verfahren zum Vermessen der Flächen eines Hausdachs. Derartige Verfahren werden eingesetzt, um Angaben für die Planung einer Renovierung von Hausdächern zu erhalten. Insbesondere werden diese Angaben für die Erstellung von Angeboten für derartige Renovierungen benötigt. Darüber hinaus kann ein derartiges Verfahren aber auch für städtebauliche Planungsverfahren und als Grundlage für architektonische Neugestaltungen eingesetzt werden.

Bisher werden zur Ermittlung der benötigten Angaben die Abmessungen des Hausdachs vor Ort beispielsweise von einem Dachdecker aufgenommen. Dabei werden die Längen der einzelnen Dachkanten, Firste, Traufen, Grate und Kehlen etc. von Hand ausgemessen. Darüber hinaus werden die Dachneigung ermittelt und die Lage von Dachfensterflächen erfaßt.

Der Nachteil dieser Vorgehensweise besteht darin, daß der mit der Vermessung beauftragte Fachmann das zu vermessende Hausdach begehen muß. Da zum Zeitpunkt der Planung der Renovierung eines Hausdachs in der Regel noch kein Gerüst oder sonstige Sicherheitsvorkehrungen bestehen, ist diese Begehung insbesondere dann mit erheblichen Sicherheitsrisiken verbunden, wenn es sich um ein Giebeldach handelt. Dabei besteht eine besondere Gefährdung dann, wenn ungünstige Witterungsbedingungen, wie etwa Regen oder Schnee, herrschen. Gerade bei solchen

Witterungen kommt es jedoch häufig aufgrund von Stürmen zu Schäden an Dächern, welche unverzüglich behoben werden müssen.

Ein weiteres Problem besteht darin, daß häufig beispielsweise die Neigung des Dachs nur ungefähr abgeschätzt werden kann. Ebenso ist es oft aufgrund der damit einhergehenden erhöhten Gefährdung nicht möglich, die exakten Eckpunkte des zu vermessenden Dachs zu erfassen. Deshalb enthält die auf Grundlage der in der voranstehend erläuterten Weise erfaßten Angaben erstellte Kalkulation in der Regel Ungenauigkeiten, die in der weiteren Angebotsabwicklung berücksichtigt werden müssen. So sind zum Beispiel bei der Materialplanung Zuschläge einzurechnen, die sicherstellen, daß auch für den Fall einer Abweichung der aufgenommenen Maße von den tatsächlichen Maßen des Hausdachs genügend Material zur Renovierung zur Verfügung steht. Die für diese Zuschläge anfallenden zusätzlichen Kosten sind gegenüber dem Kunden oft nur schwer zu begründen.

Der Erfindung liegt die Aufgabe zugrunde, ein Verfahren zur Vermessung eines Hausdachs zu schaffen, daß die genannten Sicherheitsrisiken vermeidet und eine maßstäbliche, detailgetreue Wiedergabe des Hausdachs ermöglicht.

Diese Aufgabe wird erfindungsgemäß dadurch gelöst, daß mindestens eine datentechnisch verarbeitbare Abbildung des Hausdachs erstellt wird, daß die Abbildung als Datensatz in eine Datenverarbeitungseinrichtung eingespeist wird, daß von der Datenverarbeitungseinrichtung der Verlauf der Dachkanten ermittelt wird, welche jeweils eine der Dachflächen

umschließen, und daß von der Datenverarbeitungseinrichtung aus dem ermittelten Verlauf der Dachkanten die Abmessungen der jeweiligen Dachfläche bestimmt werden.

Die Erfindung stellt ein Verfahren zur Verfügung, welches es ermöglicht, automatisch diejenigen Angaben zu ermitteln, welche für die Kalkulation und Vorbereitung der bei einer Dachrenovierung durchzuführenden Arbeiten benötigt werden. Zu diesem Zweck ist lediglich eine Aufnahme des jeweiligen Dachs zu erstellen, welche in digitalisierter, d.h. datentechnisch verarbeitbarer Form vorliegt. Dies kann beispielsweise dadurch erfolgen, daß eine herkömmlich erstellte Photographie eines Hauses mit zugehöriger Dachfläche in einem handelsüblichen Scanner in digital verarbeitbare Daten umgesetzt wird, oder dadurch, daß mittels einer digitalen Kamera ein ohne weitere Umsetzungsschritte von einem Computer verarbeitbarer Datensatz erstellt wird. Dann wird von der Datenverarbeitungseinrichtung aus diesem Datensatz anhand bekannter Filter-Algorithmen der Kantenverlauf der Dachflächen ermittelt. Schließlich werden aus den zuvor bestimmten Kantenverläufen, die ggf. in eine geglättete vektorielle Darstellung umgerechnet worden sind, die metrischen Abmessungen des Dachs bestimmt und für die Weiterverarbeitung zur Verfügung gestellt.

Selbstverständlich kann die Datenverarbeitungseinrichtung in einem unmittelbar anschließenden Arbeitsgang aus den so ermittelten Angaben unter Berücksichtigung bestimmter Vorgaben, wie zu verarbeitendes Material, Art der Renovierung etc., automatisch eine Kalkulation erstellen oder einen Arbeitsplan generieren.

Bei Einsatz des erfindungsgemäßen Verfahrens ist es für den Fachmann nicht mehr notwendig, daß zu vermessende Hausdach zu begehen. Damit entfallen für ihn die mit einer solchen Begehung verbundenen Sicherheitsrisiken. Statt dessen erhält er auf einfache Weise sämtliche Angaben, die er für seine Arbeiten benötigt.

Grundsätzlich ist es möglich, bei der Durchführung des erfindungsgemäßen Verfahrens jede Art von Abbildung des jeweiligen Hausdachs zu verwenden, auf welcher die jeweilige Dachfläche in ausreichender Weise genau und erkennbar abgebildet ist. Vorteilhaft ist es jedoch, wenn es sich bei der Abbildung um eine Luftaufnahme handelt, in welcher das jeweils interessierende Hausdach in Draufsicht dargestellt ist. Weiter verbessert werden kann die Qualität des Ergebnisses bei der Durchführung des erfindungsgemäßen Verfahrens dadurch, daß anstelle eines einfachen, in der Regel mit Verzerrungen behafteten Photos eine photogrammetrische Aufnahme des Hausdachs verwendet wird.

Derartige photogrammetrische Aufnahmen werden beispielsweise zur exakten Erfassung der Höhenlinien von Landschaften u.ä. eingesetzt und ermöglichen die verzerrungsfreie Wiedergabe eines aus der Luft aufgenommenen Objekts. Durch eine geeignete, im Grundsatz bekannte Interpretation einer solchen zentralperspektivischen photogrammetrischen Abbildung ist es möglich, zum einen den räumlichen Verlauf der Dachkanten zu ermitteln und zum anderen die Dachneigung zu bestimmen. Auf diese Weise können die Dachkantenverläufe, der von sich kreuzenden Kanten eingeschlossene Winkel und die Dachneigung mit erhöhter Genauigkeit ermittelt werden.

Nach einer vorteilhaften Ausgestaltung der Erfindung wird anhand der ermittelten Dachkanten eine Zeichnung des Dachs erstellt. Diese Zeichnung erleichtert nicht nur die Kalkulation und Planung der durchzuführenden Arbeiten, sondern kann auch zur Visualisierung der jeweiligen Erfordernisse gegenüber dem Kunden verwendet werden. Je nach Art und Umfang der aus der ursprünglichen Abbildung ermittelten Angaben kann dabei nicht nur eine zweidimensionale, sondern auch eine dreidimensionale Zeichnung erstellt werden, welche das Nachvollziehen der erforderlichen Renovierungsarbeiten zusätzlich erleichtert.

Die Handhabung und Weiterleitung der von der Datenverarbeitungseinrichtung ermittelten Angaben kann dadurch vereinfacht werden, daß die Datenverarbeitungseinrichtung die betreffenden Daten an eine Datenübertragungseinrichtung übergibt. Bei dieser Datenübertragungseinrichtung kann es sich um ein herkömmliches Modem handeln, über welches beispielsweise der potentielle Kunde oder der sich jeweils vor Ort befindliche Fachmann die ermittelten Angaben abrufen kann.

Ebenso kann es sich bei der Datenübertragungseinrichtung um einen Internetzugang handeln, über welchen die Daten ebenfalls durch entsprechend autorisierte Dritte fernabfragbar sind. Eine solche Anbindung der Datenverarbeitungseinrichtung an ein Datenübertragungsnetz ermöglicht es problemlos, auf Anfrage für Dritte zu einem bestimmten Objekt die erforderlichen Angaben nach dem erfindungsgemäßen Verfahren zu ermitteln und sie anschließend zur

unverzüglichen Weiterverarbeitung in datentechnisch aufbereiteter Form zur Verfügung zu stellen.

Nachfolgend wird die Erfindung anhand eines Ausführungsbeispiels näher erläutert. Es zeigen:

Fig. 1 eine Luftaufnahme eines zu vermessenden Hausdachs;

Fig. 2 die Luftaufnahme gemäß Fig. 1, in welche zusätzlich der Verlauf der ermittelten Dachkanten hervorgehoben ist;

Fig. 3 eine zeichnerische Darstellung des in Fig. 1 gezeigten Hausdachs in Draufsicht;

Fig. 4 eine zeichnerische Darstellung des zu bemaßenden Hausdachs in einer Seitenansicht.

Bei der in Fig. 1 gezeigten Aufnahme A eines Hausdachs 1 handelt es sich um einen vergrößerten Ausschnitt aus einer photogrammetrisch erstellten, verzerrungsfreien Luftaufnahme, welche aus großer Höhe von einem überfliegenden Flugzeug aufgenommen wurde.

Das Hausdach 1 weist die Form eines Walmdachs mit vier angeschrägt aufeinander zulaufenden, relativ stark geneigten Dachflächen 1a,1b,1c,1d und einer umlaufenden Traufe 6 auf, welche eine geringere Neigung hat. Die gegenüberliegenden Dachflächen 1b,1d weisen die Form eines gleichschenkligen Dreiecks auf, während die gegenüberliegenden Dachflächen 1a,1c trapezförmig ausgebildet sind. In der Dachfläche 1a ist eine mittig angeordnete Dachgaube 2 vorhanden, während in der Dachfläche 1c ein Schornstein 3 und drei in einer Reihe nebeneinander beabstandet angeordnete Dachflächenfenster

4 eingebaut sind. Ein weiteres Dachflächenfenster 5 ist in der Dachfläche 1d mittig positioniert.

Zur Ermittlung der Flächeninhalte der Dachflächen 1a,1b,1c,1d wird die Aufnahme A, sofern sie nicht schon in datentechnisch verarbeitbarer Form vorliegt, digitalisiert, indem sie über einen Scanner in einen Graphik-Datensatz umgesetzt wird. Der so gewonnene Datensatz wird in einer herkömmlichen, hier nicht gezeigten Datenverarbeitungseinrichtung (Computer) weiterverarbeitet.

Von der Datenverarbeitungseinrichtung werden zunächst mittels eines bekannten Bilderkennungsverfahren (Tracing) durch Anwendung geeigneter Filter die Verläufe der Kanten der Dachfläche 1 ermittelt. Dabei berücksichtigt das Bilderkennungsverfahren nicht nur die einfache bildliche Wiedergabe des Dachs, wie sie in der Aufnahme A zu erkennen ist, sondern verarbeitet zusätzlich die Informationen, welche die Photogrammetrie zur Verfügung stellt, wie beispielsweise die relative Winkelstellung der Kameras, welche die Bilder erzeugt haben, die bei der Erstellung der verzerrungsfreien Abbildung A überlagert worden sind. Gleichzeitig erkennt die Datenverarbeitungseinrichtung die Lage und Größe der Dachflächenfenster 4,5 und des Schornsteins 3.

Anschließend führt die Datenverarbeitungseinrichtung eine Glättung der Kantenverläufe durch, um die jeweiligen Endkoordinaten der Kanten zu bestimmen. Als Ergebnis dieses Verarbeitungsschritts werden dreidimensionale Anfangs- und Endkoordinaten erhalten,
anhand derer die Abmessungen des Dachs 1 (Länge der jeweiligen Kante, Neigung der jeweiligen Kante, Position

der Dachflächenfenster, Flächeninhalte usw.) in bekannter Weise bestimmt werden.

Auf Anforderung durch einen Benutzer generiert die Datenverarbeitungseinrichtung mit Abmaßen versehene Ansichtszeichnungen des Dachs 1 (Fig. 3 und 4). Zusätzlich kann anhand der in dreidimensionaler Form vorliegenden Daten eine dreidimensionale Darstellung des Dachs 1 generiert werden.

Die Datenverarbeitungseinrichtung ist mit einer nicht dargestellten Datenübertragungseinrichtung verbunden, über die sie an das Internet angeschlossen ist. Bei dieser Datenübertragungseinrichtung kann es sich um einen Internet-Server handeln, über den Daten für Dritte abrufbar im Internet bereit gestellt werden. Die derart bereit stehenden Ergebnisse der durchgeführten Vermessung des Dachs 1 können von Interessenten durch einen Zugriff auf den Internet-Server nach vorheriger Einholung einer Genehmigung beim Anbieter dieser Ergebnisse abgerufen werden.

Patentansprüche

1. Verfahren zum Vermessen der Dachflächen (1a,1b,1c,1d) eines Gebäudes, dadurch gekennzeichnet,
   - daß mindestens eine datentechnisch verarbeitbare Abbildung (A) des Dachs (1) erstellt wird,
   - daß die Abbildung (A) als Datensatz in eine Datenverarbeitungseinrichtung eingespeist wird,
   - daß von der Datenverarbeitungseinrichtung der Verlauf der Dachkanten ermittelt wird, welche jeweils eine der Dachflächen (1a,1b,1c,1d) umschließen, und
   - daß von der Datenverarbeitungseinrichtung aus dem ermittelten Verlauf der Dachkanten die Abmessungen der jeweiligen Dachfläche (1a,1b,1c,1d) bestimmt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Abbildung (A) eine photographische Luftaufnahme des Dachs (1) ist.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Abbildung (1) eine photogrammetrische Aufnahme ist.

4. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß von der Datenverarbeitungseinrichtung anhand der ermittelten Abmessungen (1) eine Zeichnung des Dachs (1) generiert wird.

5. Verfahren nach einem der Ansprüche 3 oder 4, dadurch gekennzeichnet, daß die Datenverarbeitungseinrichtung anhand des ermittelten Kantenverlaufs die Dachneigung bestimmt.

6. Verfahren nach einem der voranstehenden Ansprüche, dadurch gekennzeichnet, daß die von der Datenverarbeitungseinrichtung ermittelten Werte, wie Abmessungen und Dachneigung, an eine Datenübertragungseinrichtung übergeben werden.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß die von der Datenverarbeitungseinrichtung an die Datenübertragungseinrichtung übergebenen Daten durch Dritte fernabfragbar sind.

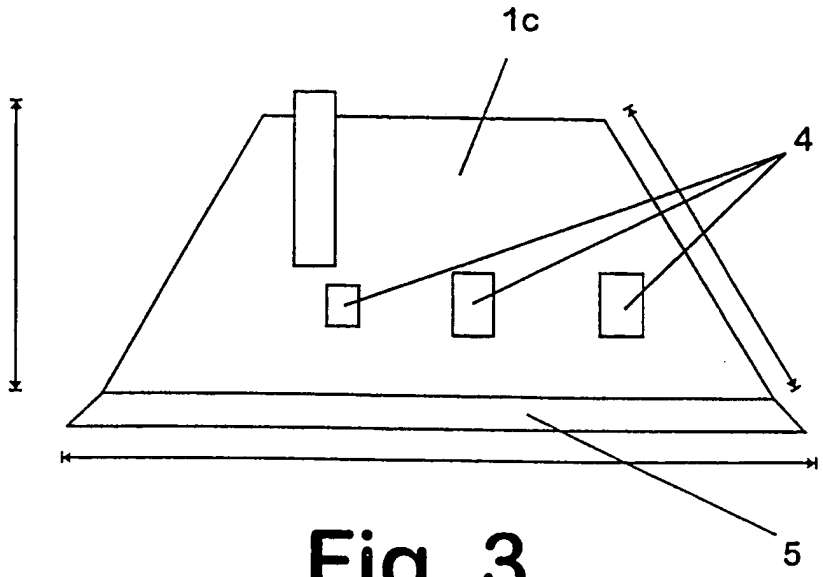


Fig. 3

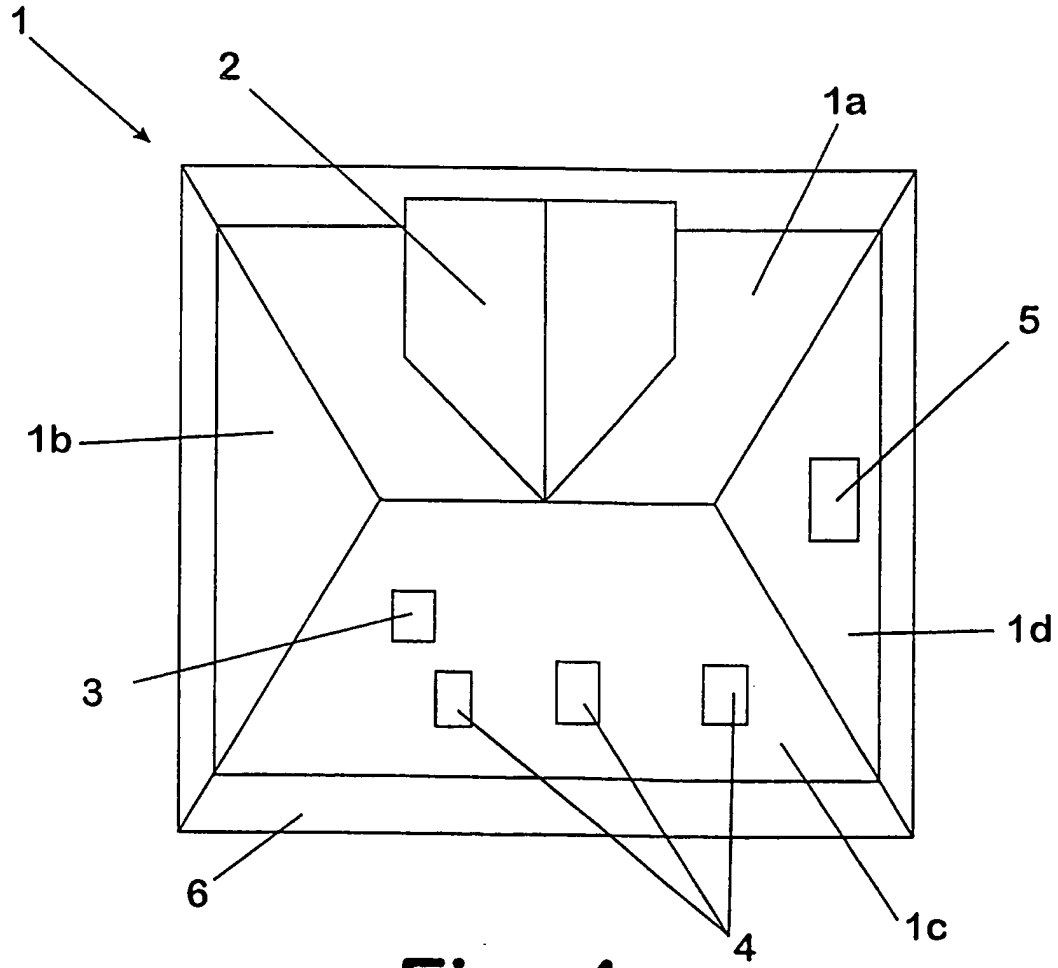


Fig. 4

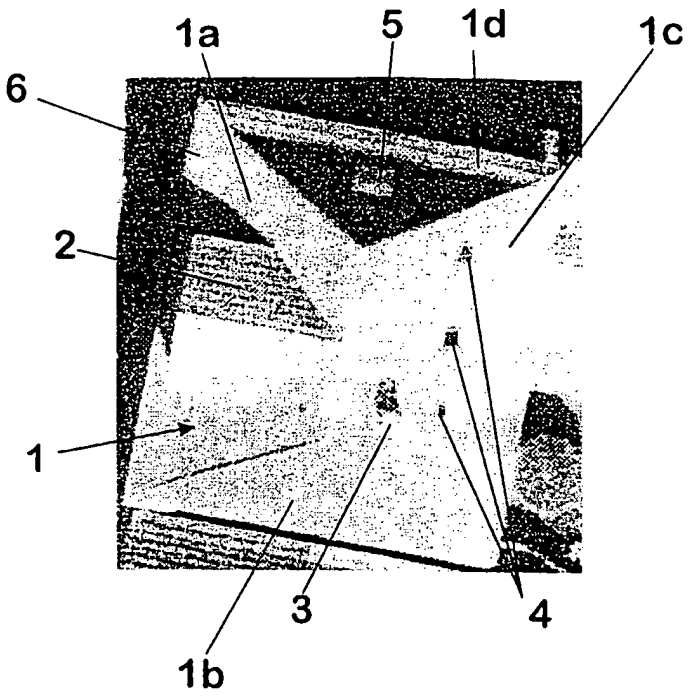


Fig. 1

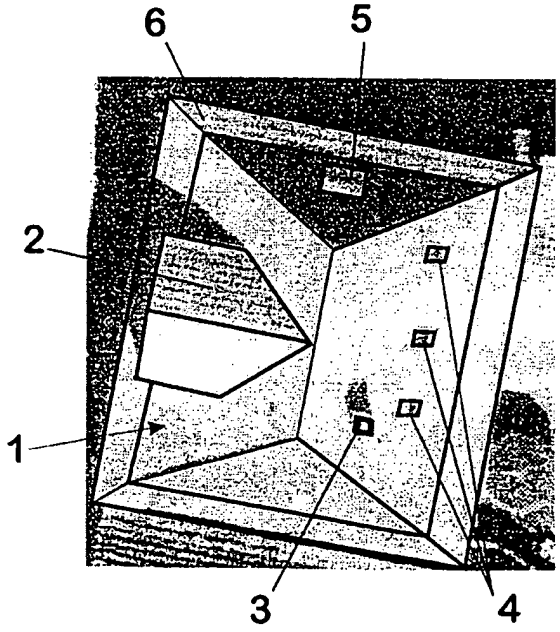


Fig. 2

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
29. Dezember 2005 (29.12.2005)

PCT

(10) Internationale Veröffentlichungsnummer
WO 2005/124276 A2

(51) Internationale Patentklassifikation[7]: G01B 11/00, G02B 21/04

(21) Internationales Aktenzeichen: PCT/DE2005/001048

(22) Internationales Anmeldedatum:
11. Juni 2005 (11.06.2005)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
10 2004 028 635.3 15. Juni 2004 (15.06.2004) DE

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Veröffentlicht:
— *ohne internationalen Recherchenbericht und erneut zu veröffentlichen nach Erhalt des Berichts*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(54) Title: METHOD FOR THE MEASUREMENT OF OBJECTS WITH THE AID OF A CAMERA, AND CALIBRATION/MEASURING MEANS FOR CARRYING OUT SAID METHOD

(54) Bezeichnung: VERFAHREN ZUR VERMESSUNG VON GEGENSTÄNDEN MIT EINER KAMERA UND KALIBRIER-/MESSMITTEL ZUR DURCHFÜHRUNG DIESES VERFAHRENS

(57) Abstract: The invention relates to a method for measuring objects with the aid of a camera by recording and later evaluating a series of pictures of said object taken from at least two directions as well as calibration/measuring means for carrying out said method. The aim of the invention is to make it possible to take measurements from the ground (close range photogrammetry) as well as from the air (aerial photogrammetry) with simple means, using commercial cameras that are not calibrated at the factory end and are available everywhere for private use at low cost while dispensing with the need for expensive special evaluation devices for evaluating the measurement pictures. Said aim is achieved by using at least one conventional (digital) camera comprising a vario lens or zoom lens as a recording system, simultaneously or successively recording the object in a series of pictures using a control point coordinate system as a measuring volume with the aid of said recording system, determining the focal length, the lens distortion, and the main point position of the image from said defined series of pictures, and measuring the object that is to be measured by taking into account the determined focal length, the lens distortion, and the main point position of the image, also in a 3D video.

(57) Zusammenfassung: Die Erfindung betrifft ein Verfahren zur Vermessung von Gegenständen mit einer Kamera durch Aufnahme und späterer Auswertung einer Serie von Objektaufnahmen aus mindestens zwei verschiedenen Richtungen und Kalibrier-/messmittel durch Durchführung dieses Verfahrens. Es ist die Aufgabe der Erfindung, mit einfachen Mitteln eine Möglichkeit zu schaffen, die Vermessung vom Boden (Nahbereichsphotogrammetrie) und aus der Luft (Luftbildphotogrammetrie) mit handelsüblichen, nicht werksseitig kalibrierten Kameras durchzuführen, wie sie derzeit für den Privatbedarf überall zu niedrigen Preisen erhältlich sind. Zur Auswertung der Vermessungsaufnahmen sollen keine hochpreisigen Spezialauswertegeräte benötigt werden. Die Erfindung besteht darin, dass man mindestens eine herkömmliche (Digital-) Kamera mit Vario- bzw. Zoomobjektiv als Aufnahmesystem verwendet, dass man mit diesem Aufnahmesystem das Objekt gleichzeitig oder nacheinander. mit einem Passpunktkoordinatensystem als Messvolumen in einer Aufnahmeserie aufnimmt, dass man die Ermittlung der Brennweite, der Objektiwerzeichnung und der Bildhauptpunktlage aus dieser definierten Aufnahmeserie vornimmt und dass man unter Berücksichtigung der ermittelten Brennweite, der Objektiwerzeichnung und der Bildhauptpunktlage das zu vermessende Objekt vermisst, ebenso im 3D-Video.

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Verfahren zur Vermessung von Gegenständen mit einer Kamera und Kalibrier-/messmittel zur Durchführung dieses Verfahrens

Die Erfindung betrifft ein Verfahren zur Vermessung von Gegenständen mit einer Kamera durch Aufnahme und späterer Auswertung einer Serie von Objektaufnahmen aus mindestens zwei verschiedenen Richtungen und Kalibrier-/messmittel zur Durchführung dieses Verfahrens.

Zur Vermessung von Gegenständen mit einer Kamera durch Aufnahme einer Serie von Bildern aus verschiedenen Richtungen und deren späteren Auswertung ist es bekannt, sehr teure Spezialkameras zu verwenden. Diese Kameras sind sogenannte metrische bzw. teilmetrische Kameras, die mit einem Objektiv fester Brennweite arbeiten, das vom Hersteller werksseitig kalibriert worden ist. Eine Kalibrierung des Objektivs kann nur für eine jeweils bestimmte Brennweite vorgenommen werden. Um der Größe des zu vermessenden Objektes und den Anforderungen an die Messgenauigkeit gerecht zu werden, müssen verschiedene Objektive mit unterschiedlichen Objektivbrennweiten eingesetzt werden. Daher müssen Kameras mit austauschbaren Objektiven zur Vermessung verschieden großer Objekte verwendet werden. Dieses ist in der Anschaffung teuer und während des Vermessungseinsatzes durch den Objektivwechsel und der stationären Bestimmung der Kamerakalibrierung und der Objektivverzeichnung zudem zeitaufwendig. Der vom Hersteller betriebene Aufwand für die Herstellung des Kameragehäuses, des speziellen CCD-Chips und dessen Aufhängung an der Gehäuserückwand ist groß und auch Grund für den hohen Preis einer solchen Fachkamera. Dieses trifft um so mehr für Luftbild-

Roofr Exhibit 1002, Page 218

kameraaufnahmesysteme zu. Zur Auswertung dieser bekannten Systeme werden Stereo-Auswertegeräte benötigt, die sehr kostspielig in der Anschaffung sind.

Ebenfalls bekannte und in der Anschaffung sehr teure Vermessungssysteme sind die 3D-Laserscannervermessung, bei der auf das zu vermessende Objekt direkt Passpunkte aufzubringen sind und photogrammetrische Systeme die auf eine Streifenprojizierung angewiesen sind. Das ist zeitaufwendig und schränkt die zur Vermessung geeigneten Objekte ein.

Die Erfindung vermeidet die Nachteile des Standes der Technik. Es ist die Aufgabe der Erfindung mit einfachen Mitteln eine Möglichkeit zu schaffen, die Vermessung vom Boden (Nahbereichsphotogrammetrie) und aus der Luft (Luftbildphotogrammetrie) mit handelsüblichen, nicht werksseitig kalibrierten Kameras durchzuführen, wie sie derzeit für den Privatbedarf überall zu niedrigen Preisen erhältlich sind. Zur Auswertung der Vermessungsaufnahmen sollen keine hochpreisigen Spezialauswertegeräte benötigt werden.

Die Erfindung besteht darin, wenn man mindestens eine herkömmliche, nicht metrische (Digital-) Kamera, vorzugsweise mit Vario- bzw. Zoomobjektiv als Aufnahmesystem verwendet, dass man mit diesem Aufnahmesystem das Objekt gleichzeitig oder nacheinander mit einem Passpunktkoordinatensystem in einer Aufnahmeserie aufnimmt, dass man die Ermittlung der Brennweite, der Objektivverzeichnung und der Bildhauptpunktlage aus dieser definierten Aufnahmeserie vornimmt und dass man unter Berücksichtigung der ermittelten Brennweite, der Objektivverzeichnung und der Bildhauptpunktlage das zu vermessende Objekt vermisst.

Zur Erhöhung der Genauigkeit ist es vorteilhaft, dass man vor der Vermessung einmalig die Objektivverzeichnung und den Bildhauptpunkt der ver-

wendeten Kamera für die zu verwendenden Brennweiten ermittelt. Diese Daten werden dann der folgenden Aufnahmeserie zugrunde gelegt.

Besonders zweckmäßig ist es, wenn man Kamerakalibrierung, die Ermittlung der Brennweite, der Objektivverzeichnung, der Bildhauptpunktlage und/oder die Auswertung der Daten auf einem Computer mit einer prozesssteuernden Software vornimmt.

Auf diese Weise ist es ermöglicht, mit einer handelsüblichen Standardkamera kleine und auch große Objekte ohne Objektivwechsel photogrammetrisch zu vermessen und zu hochgenauen Vermessungsergebnissen zu gelangen. Da hier nur ein einziges Objektiv verwendet wird, das im Gegensatz zum Stand der Technik ein Varioobjektiv ist, kann der Nutzer dieser Kamera die für seine Objektabbildung optimale Brennweite stufenlos einstellen. Es entfällt ein zeitintensiver Objektivwechsel. Mit diesem Verfahren gelingt es erheblich schneller und kostengünstiger, die zur Vermessung notwendige Aufnahmeserie zu erstellen, die wegen des stufenlosen Einsatzes des Varioobjektives auf nur wenige Bildaufnahmen beschränkt ist.

Es entfällt der hohe zeitliche und finanzielle Aufwand einer werksseitigen Gesamtkalibrierung der Kamera. Das gelingt dadurch, dass die Kalibrierung der Kamera sowie die Ermittlung der Objektivverzeichnung nicht mehr im Herstellungswerk, sondern innerhalb jeder Vermessungsaufnahmeserie erfolgen kann. Vorteilhafterweise kann diese Kalibrierung innerhalb jeder der Vermessung im Computer (‚calibration on the job') zuzuführenden Aufnahmeserie erfolgen. Daher sind an der Kamera auch keine besonderen Maßnahmen zur Vermeidung negativer Umweltfaktoren oder technische Umbauten vorzunehmen.

Die Objektvermessung, eine Konturendigitalisierung oder die Ableitung einer Oberflächenpunktewolke kann nun an der direkten, realen räumlichen

Ansicht von allen fotografierbaren Objekten bzw. Flächen und Situationen unter Beibehaltung von deren Eigenschaften, wie beispielsweise deren Objektoberflächenfarb- und Schattenstrukturen, durchgeführt oder durch Export einer Oberflächenpunktwolke, mit oder ohne Konturendigitalisierung an externe Applikationen für weitere Anwendungen übergeben werden. Dieses ist gegenüber dem bekannten 3D-Laserscanningverfahren vorteilhaft, bei dem die realen Objektoberflächenfarbstrukturen verloren gehen. Denn deren Darstellungen sind Pseudo-3D-Darstellungen einer schattierten Farbstufe.

Als Kameras können eine herkömmliche Kamera, Digitalkamera, Videokamera bzw. Camcorder oder andere Objektaufnahmesysteme, wie z.B. Film- und Fernsehkamera, Mikroskopkamera, Rasterelektronenmikroskopbildaufnahmesysteme, Endoskopsystemkameras auch für die CAD-Vermessungs- und Digitalisierfunktionalität, verwendet werden.

Das Passpunktkoordinatensystem dient als Messvolumen und ist mit definierten, geometrisch exakt angeordneten und einmalig eingemessenen Passpunkten ausgestattet, um definierte Raumkoordinaten in x-, y- und z-Richtung zu liefern. Bei terrestrischen Flächen sind dieses Hoch- und Rechtswerte oder über das GPS ermittelte Koordinaten. Das Messvolumen dient als Kalibriervorlage für die Kamerakalibrierung und als exakte Grundlage für die Objektvermessung.

Als Passpunktkoordinatensystem kann man für kleine Objekte auf einem Objektträger angeordnete Passpunktfestkörper zum Aufspannen eines Messvolumens verwenden oder für kleinste Objekte dreidimensionale in ihren Abmaßen bekannte Mikrokörper oder Nanostrukturen ggfs. in Kombination mit Rasterlinien unterschiedlicher Maßstäbe, für mittelgroße bis große Objekte einen mit Messmarken versehenen Kalibrierkäfig oder ein mit Messmarken versehenes dreistrahliges Koordinatengestell und für terrestri-

sche und atmosphärische Objekte Bodenmarkierungen in x-, y- Richtung und in z- Richtung definiert fliegende oder schwebende Objekte als kombiniertes Messvolumen verwenden.

Man geht folgendermaßen vor:
Kleinste Objekte werden zur Kameraaufnahme auf einen horizontalen Glasobjektträger gelegt, nachdem zuvor mit einer 3D-Kalibriermessplatte die Kalibrierung der Kameras und des Linsensystems eines (Stereo)mikroskops oder einer (Stereo)lupe bestimmt wurde. Diese 3D-Kalibriermessplatte weist definierte Raster aus x-/y-Rasterlinien sowie Mikrokörper auf, die im definierten Tiefenschärfebereich der Vergrößerungsstufe liegen und die z-Koordinate liefern. Es kann auch ein Nanostrukturkörper, beispielsweise ein Kristallgitter mit bekannten Gitterstrukturmaßen, als Kalibrier- und Messvolumen dienen.

Kleine Objekte werden mit einem Passpunktkoordinatensystem, bestehend aus einer das Objekt tragenden horizontalen Objektplattform und einer an der hinteren Kante der Objektplattform angeordneten vertikalen Objektträgerrückwand, auf denen Passpunktfestkörper zum Aufspannen eines Messvolumens angeordnet sind, fotografiert. Diese Anordnung kann vorab als Kalibrierstation für die Kamera dienen, indem die Objektträgerückwand durch eine Kalibriertafel, später dargestellt in der Fig. 6, ausgetauscht wird.

Mittelgroße bis große Objekte werden in einen Messkäfig mit definiert angeordneten Passpunkten eingestellt oder werden mithilfe eines dreiachsigen, einen Raum aufspannenden, mobilen Koordinatengestelles mit einmalig eingemessenen Messmarken als Messvolumen zur Vermessung aufgenommen. Die drei Achsen des Passpunktkoordinatengestelles können zusammensteckbar oder -klappbar angeordnet sein, um für den Transport zum nächsten Messeinsatz wiederverwendbar platzsparend zusammenlegbar zu sein.

Vorteilhaft ist es, wenn das Passpunktkoordinatensystem mobil und vor Ort an dem zu vermessendem Objekt einzusetzen ist. So muss nicht das zu vermessende Objekt in ein Labor transportiert werden, wodurch das Objekt beschädigt werden könnte und was unnötig zeitaufwendig ist.

Die Aufnahmen können vor Ort (auch freihändig) getätigt werden. Das zu vermessende Objekt muss nicht direkt mit Passpunkten bzw. Messmarken markiert werden.

Das mobile Passpunktkoordinatensystem (Messvolumen) kann auch durch Flugobjekte gestellt werden, die synchron, timergesteuert und mit einem Positioniersystem gekoppelt sind, um für Luft- und Satellitenbildaufnahmesysteme, ebenso für eine 3D-Vermessung von terrestrischen oder außerterrestrischen Flächen oder atmosphärischen Objekten (z.B. Wolken, Tornados) einsetzbar zu sein.

Der verfahrensgemäße Einsatz des mobilen Passpunktkoordinatensystems eignet sich auch im Natursteinabbau zur Berechnung des Absprengvolumens, der Absprengfläche und der Sprengbohrlochprofile, indem aus verfahrensgemäß aufgenommenen Fotos aus unterschiedlichen Richtungen die benötigten Koordinaten zu berechnen sind. Dabei bilden lotrechte Messlatten mit definiertem, eingemessenem Abstand das Messvolumen. Somit findet das erfindungsgemäße Verfahren bereits aus Arbeitssicherheitsgründen seine Berechtigung und wird von der BG-Natursteinabbau innerhalb eines digitalen fotografischen Bruchwand-Vermessungssystems empfohlen (Branchenversion). Dieses Verfahren hat zudem den Innovationsförderpreis 2005 von der BG in der Kategorie „Sicherheitstechnik" verliehen bekommen und ist mittlerweile als ein neues anerkanntes photogrammetrisches Messverfahren, neben der Laservermessung, bestätigt worden.

Durch das erfindungsgemäße Verfahren sind alle fotografierbaren Objekte unabhängig von deren Dimensionen, sowohl durch Einzelbilder als auch durch Filmsequenzen, in ihrer realen räumlichen Stereoansicht mit all ihren realen Oberflächen- und Schattenstrukturen und Farbschattierungen darstellbar und zusätzlich mit CAD-Funktionalität messtechnisch auswertbar und/oder digitalisierbar. Durch die freie Wahl der Kamera sind mit diesem Verfahren neue Anwendungsgebiete der photogrammetrischen Vermessung erschlossen.

Für die Vermessung von sich bewegenden Objekten ist es zweckmäßig, ein Zwei-Kamerasystem zu verwenden. Dabei nimmt man mit den beiden Kameras eine Videosequenz oder eine dicht hintereinander liegende Einzelbildfolge auf und sucht aus dieser ein korrespondierendes Bildpaar für die Vermessung heraus, welches auch der Kalibrierung zugrunde gelegt wird.

Besonders vorteilhaft ist es, wenn man dreidimensionale Messmarken verwendet. Diese können keil- oder kugelförmig ausgebildet sein. Wenn man würfelförmige Passpunktfestkörper als Messmarken verwendet, die definierte Markierungen auf den Festkörperflächen besitzen, können die Koordinaten eines Passpunktfestkörpers sehr exakt bestimmt werden.

Die mehrflächigen Passpunktfestkörper können bei Rundum-Aufnahmen auch mit Kugeln kombiniert bzw. getauscht werden, auch sind geometrisch exakte karierte Linien geeignet, allerdings ergibt sich bei kugelförmigen Passpunktfestkörpern lediglich nur eine Anmessung zur Ermittlung der Passpunktkoordinate, dafür sind sie in Luftbildaufnahmen gleichzeitig verwendbar, bei den mehrflächigen Würfeln ein Mittelwert aus maximal drei Würfelflächenanmessungen je Passpunktfestkörper.

Wenn ein Objekt ohne eine Verdeckung durch am mobilen Passpunktkoordinatensystem angeordneten Messmarken aufgenommen werden soll, kann

so vorgegangen werden, dass man zunächst mit zwei (Video)Kameras die Objektumgebung mit einem mobilen Passpunktkoordinatensystem zur Ermittlung von Objektivverzeichnung, Brennweite und Bildhauptpunktlage aufnimmt, dass man anschließend das Passpunktkoordinatensystem entfernt und dann von den selben Standorten aus mit den selben Kameraeinstellungen das Objekt zur Vermessung bzw. als 3D-Video aufnimmt.

Zur besseren Kenntlichkeit des Aufnahmeobjektes im Rahmen der Korrelation innerhalb der beiden Objektaufnahmen ist es zweckmäßig, wenn man bei einer strukturarmen Oberfläche des zu vermessenden Objektes (Gegenstandes) diese Oberfläche vor der Vermessung zur besseren Erkennbarkeit behandelt oder eine Struktur auf die Oberfläche projiziert.

Bei der Vermessung von sich bewegenden Objekten ist es vorteilhaft, ein Aufnahmesystem zu verwenden, das aus zwei synchron geschalteten Kameras besteht und bei dem man vor der Objektaufnahme die Objektivverzeichnung, Brennweite und die Bildhauptpunktlage und das Messvolumen ermittelt hat.

Bei der Vermessung eines ortsfesten oder sich bewegenden Objektes oder einer Situation mit einem sich bewegenden Aufnahmesystem ist es zweckmäßig, ein starres mobiles vorkalibriertes Aufnahmesystem zu verwenden, welches aus zwei synchron geschalteten Kameras besteht und bei dem man vor der Objektaufnahme die Objektivverzeichnung, Brennweite und die Bildhauptpunktlage und das Messvolumen ermittelt hat.

Genauigkeiten

Die Genauigkeit des Messverfahrens lässt sich gemäß *Richtlinie VDI/VDE 2634 Blatt 1/2 v. 12.04.02 für Optische 3D-Messsysteme – Bildgebende Systeme mit punktförmiger Antastung* - bestimmen. Die Abnahmekriterien sind

Längenmessabweichungen durch Abstandsmessungen an Endmaßobjekten in einem definierten Messvolumen.

Die Genauigkeiten die mit diesem Messverfahren zu erzielen sind, hängen von folgenden Parametern ab:

Pixelauflösung der Kamera, Qualität der Kamerakalibrierung sowie manuelle Messfehler und Geometrieverhältnisse bzgl. des Messvolumens (nicht beeinflussbar).

Die Messgenauigkeit kann wie im folgenden Beispiel abgeschätzt werden:

Die verwendete Kamera hat 3.2 Mio. Pixel (2048*1536 Pixel), das Objekt eine Länge von 200 mm und wird möglichst bildfüllend aufgenommen, so dass die 200 mm Länge von ca. 2000 Pixel erfasst wird. Hieraus resultiert zunächst eine Pixelgröße auf das Objekt bezogen von 0,1 mm.

Die Koordinatengenauigkeit kann über die Standardabweichung an den Passpunkten (äußere Orientierung) abgeschätzt werden – diese liegt bei günstiger Passpunktsituation und genauer Messung im Bereich von 1 Pixel, kann aber in ungünstigeren Fällen auch deutlich höher sein. Zu beachten ist schließlich auch die visuelle Einstellgenauigkeit in den Bildern, die je nach Kontrast und Zoom bei 0,25 Pixel liegt.

In unserem Beispiel ergibt sich die abgeschätzte Messgenauigkeit damit zu 0,1mm x 1 x 0,25 = 0,025 mm.

Zur Standardabweichung an den Passpunkten:

Angenommen, diese Werte liegen bei rund 5 µm und die Pixelgröße des Kamerasensors betrage 2,5 µm, dann liegt die Standardabweichung bei ca. 2 Pi-

xel. Der dichteste Pixelrasterabstand einer Punktwolke, nach diesem Beispiel, beträgt dann 0,1mm. Dieser Wert ist voreinstellbar und sollte mit Bedacht gewählt werden, da er die Kapazität des Rechners sprengen kann - eine Abstimmung mit externen Weiterverarbeitungsschritten eigener Applikationen ist zu empfehlen.

Allgemein also:

Messgenauigkeit [mm]=Pixelgröße am Objekt [mm] x mittlere Standardabweichung an den Passpunkten [pxl] x Einstellgenauigkeit im Bild [pxl].

Werden hochpräzise Messungen verlangt, sollte man gemäß vorab genannter Richtlinie vorgehen und mit z.B. einem Endmaß, einer Messlatte etc. neben dem Aufnahmeobjekt die Fotoserien aufnehmen. Vor Beginn der Objektvermessung die Abmaße des Endmaßes oder der Messlatte in der Stereobetrachtung messen, um dann den Grad der Abweichung zum SOLL - Endmaß zu bekommen. Die gleiche Abweichung trifft dann auch bei der Objektvermessung zu. Dieser IST-SOLL Vergleich wird nur einmalig durchgeführt, quasi zur Genauigkeitsbestimmung des Messvolumens sowie der Kameras (z.B. einer Bauteilvermessung), sofern das Messvolumen und die Kameras stabil bzw. unverrückbar bleiben und nur die Messobjekte getauscht werden.

Technische Grundlagen

Die Genauigkeiten, die bei der Ausmessung von Objekten in Bildern erzielt werden können, hängen unter anderem davon ab, wie genau die einzelnen nachstehend aufgeführten Kameraparameter bekannt sind und welche Konstanz diese aufweisen. Konstanz bezieht sich dabei auf den zeitlichen Aspekt, aber auch auf Umwelteinflüsse (Temperatur, Luftfeuchte).

In jedem Fall müssen für die photogrammetrische Auswertung der Bilder folgende Parameter bekannt sein:

- Größe des Sensors (Länge und Breite in Pixel)
- Pixelgröße [µm]
- Brennweite [mm]

Hinzu kommen zu Erhöhung der Genauigkeit:

- Lage des Bildhauptpunktes
- radial-symmetrische Objektivverzeichnung

Weitere Einflussfaktoren sind u.a.:

- Planlage des Sensors
- Mechanische Stabilität der Kamera
- Weitere Komponenten der Objektivverzeichnung

Dabei gelten folgende Zusammenhänge:

Die Größe des Sensors ist bekannt und konstant.
Die Pixelgröße ist konstant, aber i.d.R. unbekannt, und muss zunächst ermittelt werden.

Die Brennweite ist bei Varioobjektiven nicht konstant und wird zusätzlich durch die Fokussierung beeinflusst. Die gewählte Brennweite wird heutzutage üblicherweise in der Bilddatei abgespeichert (EXIF-Format), dieser Wert ist jedoch nicht wirklich exakt.

Die Lage des Bildhauptpunktes ist nicht konstant, sondern u.a. von der Brennweite abhängig, und zunächst nicht bekannt. Ebenso ist die radialsymmetrische Objektivverzeichnung von der gewählten Brennweite abhängig und muss durch eine Kalibrierung ermittelt werden.

Die weiteren aufgeführten Parameter werden nicht oder nur indirekt in das beschriebene Verfahren einbezogen. Bei metrischen Kameras sind sie bekannt.

Ermitteln der Pixelgröße

Da nicht nur die Pixelgröße allein, sondern das Verhältnis dieses Wertes zur Brennweite für die weitere Auswertung entscheidend ist, genügt es, für die Pixelgröße zunächst einen Näherungswert zu bestimmen. Dies geschieht nach der empirisch entwickelten Formel:

$$\text{Pixelgröße [µm]} = \frac{\text{Nominelle Sensordiagonale [Zoll]}}{\text{Sensordiagonale [Pixel]}} \times 17018 \qquad (1)$$

Wie bereits erwähnt, ist die Pixelgröße konstant – der ermittelte Wert kann demnach für alle Bilder als Näherung beibehalten werden.

Ermitteln der radial-symmetrischen Verzeichnung und des Bildhauptpunktes

Die radial-symmetrische Verzeichnung des Objektivs ist von der aktuellen Brennweite abhängig, bei identischer Brennweite jedoch weitgehend konstant. Aus diesem Grund kann die Verzeichnung einmalig für jede der gewünschten Brennweiten ermittelt und die daraus abgeleiteten Korrekturfunktionen für alle Bilder verwendet werden. Für diese einmalige Ermittlung der Verzeichnung wird eine spezielle 2D-Kalibriertafel (abgebildet in der Fig. 6) und Algorithmen zur Erfassung der Verzeichnung bzw. zum Aufstellen der Korrekturfunktion verwendet.

Die Kalibriertafel hat das Format A3 und besteht aus einem hochstabilen Material worauf das eigentliche Kalibrierfeld mit Zielmarken im definierten Abstand auflaminiert ist.

Diese Tafel ist mit den jeweiligen Brennweiten zu fotografieren in der Weise, dass sich die Kamera möglichst senkrecht zur Tafel befindet und diese möglichst flächendeckend abgebildet wird. Tafel und Kamera sind dabei sicher zu fixieren (Stativ), und es ist für eine gute Ausleuchtung zu sorgen.

Die vier in den Ecken gelegenen Zielmarken werden von Hand gemessen, alle übrigen automatisch. Die Ermittlung der radial-symmetrischen Verzeichnung verläuft dann wie folgt:

Für alle Zielmarken existieren die Sollkoordinaten. Die Marken werden als Passpunkte aufgefasst und mit Hilfe der Soll- sowie der gemessenen Koordinaten ein räumlicher Rückwärtsschnitt mit Ausgleichung (kleinste Quadrate) gerechnet. Ergebnis sind zunächst für jede Zielmarke die gemessenen bzw. die berechneten Bildkoordinaten. Aus diesen Werten kann sodann die Verzeichnung ermittelt werden.

Vorteile dieses Verfahrens:

- Es ist nicht zwingend nötig, dass sich die Kamera genau senkrecht über der Tafel befindet
- Es ist ebenfalls nicht zwingend nötig, dass sich die Kamera exakt über der Mitte der Tafel befindet
- Der Punkt in geringster Entfernung zur Bildmitte und mit minimaler Verzeichnung ist der Bildhauptpunkt, der also zugleich mit der Verzeichnung ermittelt wird.

Die Korrekturfunktion wird berechnet aus den Soll- bzw. Ist-Koordinaten der Zielmarken und ist ein Polynom 3. Grades:

$$f(r) = a_0 + a_1 r + a_2 r^2 + a_3 r^3 \qquad (2)$$

Ermitteln der Brennweite

Es wurde bereits darauf hingewiesen, dass nicht zwingend beide Parameter Pixelgröße und Brennweite hochgenau bekannt sein müssen, sondern lediglich das Verhältnis beider Werte, woraus sich der Öffnungswinkel des Objektivs ableitet.

Für die Pixelgröße wurde mit Formel (1) ein i.a. schon recht genauer Näherungswert bestimmt. Dieser wird im folgenden als konstant angesetzt und davon ausgehend die tatsächliche Brennweite in jedem Bild separat berechnet.

Für die photogrammetrische Auswertung muss ohnehin für jedes Bild die äußere Orientierung (Projektionszentrum, Rotationswinkel) bestimmt werden. Dieses geschieht durch die Messung von Passpunkten, deren Objektkoordinaten bekannt und die im Bild erkennbar sind.

Unter der Voraussetzung, dass hinreichend viele (mindestens 6), gut verteilte und räumliche angeordnete Passpunkte vorliegen, kann nicht nur die äußere Orientierung bestimmt werden. Die vorgegebene (in der Bilddatei abgespeicherte) Brennweite wird rechnerisch um einen bestimmten Bereich (z.B. $\pm$ 25 mm) verändert und die jeweils resultierende Standardabweichung an den Passpunkten ermittelt. Diejenige Brennweite, bei der die Standardabweichung ihren kleinsten Wert erreicht, ist dann die tatsächliche, bei der Aufnahme verwendete Brennweite.

Die Passpunktanordnung muss sich dabei an der Objektgröße orientieren. Allgemein gilt, dass der Passpunktverband (Messvolumen) das Objekt umschließen sollte, in jedem Fall aber nicht wesentlich kleiner als das Objekt sein darf.

Das Wesen der Erfindung ist nachstehend anhand von in den Zeichnungen schematisch dargestellten Ausführungsbeispielen näher erläutert. Die Gestaltung dieser Beispiele kann im Einzelfall variieren, weil sie auf die Objektdimensionen der Messobjekte und die vor Ort gegebenen Voraussetzungen angepasst werden. Es zeigen die:

Fig.1: eine mobile Kalibrier- und 3D-Objektvermessungsstation mit Kalibriertafel (Fig. 6);

Fig.2: einen Käfig zur Vermessung mittelgroßer Objekte;

Fig.3: ein dreiachsiges Koordinatengestell zur Vermessung von Mittel- und Großobjekten;

Fig.4: mehrflächige keilförmige 3D-Messmarkenflächen für die Passpunkbestimmung;

Fig.5: keilförmige Messmarkentafeln für den Messkäfig und das Koordinatengestell;

Fig.6: eine 2D-Kalibriertafel für die Ermittlung der Objektivverzeichnung (Fig. 7), der Bildhauptpunktlage, der Brennweite, der Kamerakalibrierung

Fig.7: eine Kurve der radial-symmetrischen Verzeichnung

Fig.8: eine 3D-Kalibriermessplatte in Planansicht .

Fig. 9: eine 3D-Kalibriermessplatte (Maßstab überhöht) in Perspektivansicht

Die in Fig.1 gezeigte mobile Kalibrier- und Objektvermessungsstation 5 ist mit einer Kalibriertafel 1, einer Objektträgerplattform 2 und einer mit Spannbügelsätzen geometrisch exakten Trägerprofilkonstruktion 3 zur Montage

von Kameras 4 für verschiedene Aufnahmerichtungen ausgerüstet. Der Objektträger 2 trägt das zu vermessende Objekt sowie mehrflächige Passpunktfestkörper 6 als mehrflächige Messmarken. Die Kalibriertafel 1 (in der Zeichnung an der hinteren Kante der Objektträgerplattform 2 angeordnet) und die Objekträgerrückwand 11 sind gegeneinander austauschbar anzuordnen. So ist mit dieser Station bei Anordnung der Kalibriertafel 1 die Kalibrierung einer Kamera vorzunehmen oder separat fotografiert, in dem die Kamera einzeln auf Stativ positioniert wird. Bei Anordnung der Objektträgerrückwand 11 sind Aufnahmen zur Vermessung des Objektes zu machen. Anstelle von würfelförmigen Messmarken oder Messmarkentafeln kann auch ein präzises kariertes Linienmuster auf dem Träger und der Rückwand aufgebracht oder sich kreuzende Laserlichtstrahlen als Koordinatenreferenz eingesetzt werden. Die Ausprägung des Messvolumens ist auf das zu vermessende Objekt anzupassen.

Erfindungsgemäß wird mindestens eine herkömmliche (Digital-) Kamera mit Vario- bzw. Zoomobjektiv als Aufnahmesystem verwendet, indem man mit diesem Aufnahmesystem das Objekt gleichzeitig oder nacheinander mit dem Passpunktkoordinatensystem als Messvolumen in einer Aufnahmeserie aus mindestens zwei Richtungen aufnimmt, indem man die Ermittlung der Brennweite, der Objektivverzeichnung und der Bildhauptpunktlage aus dieser definierten Aufnahmeserie vornimmt und indem man unter Berücksichtigung der ermittelten Brennweite, der Objektivverzeichnung und der Bildhauptpunktlage das zu vermessende Objekt vermisst.

Die Kalibriertafel 1, gezeigt in der Fig. 6, ist in dieser Objektvermessungsstation gegen die vertikale x/y-Ebene (Trägerrückwand 11) über einen Flansch austauschbar, sofern eine Kalibrierung durchgeführt werden soll. Die Kameras 4 sind über eine Schwenkvorrichtung 12 für Messaufnahmen kippbar. Über eine nicht dargestellte Kabelverbindung oder auch kabellos

(z.B. W-LAN) werden die Daten der Aufnahmeserie einem ebenfalls nicht dargestellten Computer zugeführt und dort ausgewertet werden.

Die dem dargestellten Verfahren zugrundeliegenden Messvolumen sind generell für die photogrammetrische Rundum-Vermessung und zur vollautomatischen Kamerakalibrierung hergerichtet, wie auch zur Generierung von z.B. 3D-Videos mit Messfunktionalität, sofern man zwei Video-Kameras vorab kalibriert und synchron steuert. Diese Generierung wird z.B. über zwei so genannte Framegrabbereinheiten (Zusammenführung zweier Videosignale mit Generierung der Einzelbilder; je 25 Stück pro Sek., PAL) oder über zwei kaskadierte Videokameras am Fire-Wire-Anschluss, einem Hochgeschwindigkeitsrechner mit der Video-Engine-Einheit, zugeführt. Das Resultat ist derzeit ein Anagplyphenfilm und ein Shutterfilm, der von den Fernsehanstalten ausgestrahlt und an jedem Fernseher betrachtet werden kann. Mit einer Anaglyphenbrille (Rot-Grün; eingeschränktes Farbspektrum) oder einer sogenannten Shutterbrille (24 Bit Echtfarbfilm) können diese Filme in realer 3D-Ansicht betrachtet werden.

Das Messverfahren eignet sich unter anderem auch zur vollautomatischen Bauteilevermessung an industriellen Fertigungslinien, gekoppelt mit einem IST-SOLL Vergleich, z.B. für die Qualitätskontrolle im Warenverkehr im Qualitätsmanagement (gem. z.Zt. DIN EN ISO 9001). Das Messverfahren erfüllt die bereits vorab genannte Richtlinie *VDI/VDE 2634 Blatt 1/2.*

Für das Messverfahren sind mehrere Kameras montiert und vom Computer fernsteuer- und synchronisierbar zu bedienen.

Mittelgroße Objekte, wie z.B. Maschinenbauteile, können in einem stationären Messraum oder mit dem Messkäfig 7 der Fig. 2 vermessen werden, in dem man sie in den Käfig hineinbringt. Dieses Messvolumen weist eine Reihe einmalig kalibrierter Messmarkentafeln der Fig. 5 auf, die Teile eines

Stecksystems sind. Mindestens drei, vorzugsweise sechs bis neun auseinander liegende Messmarkentafeln des Käfigs für die x-, y- und z-Richtung werden zusammen mit dem Objekt in einer definierten Aufnahmeserie abgelichtet und mit einem Computer die Auswertung bzw. Vermessung vorgenommen. Eine fahrbare Objektaufnahmeeinheit, bestehend aus zwei Kameras und ggfs. einem Musterprojektor (für kontrastarme Objektoberflächenstrukturen) und evtl. einem PC, die vorher einmalig kalibriert wurde, erlaubt das Heranfahren z.B. an Fertigungslinien, um eine Qualitätskontrolle (IST-SOLL Vergleich) vor Ort am Bauteil durchzuführen.

Die Brennweitenkalibrierung eines Varioobjektives erfolgt hierbei vollautomatisch im Rahmen der Objektvermessung. Die CCD-Chip-, die Gehäusekalibrierung und die Objektivverzeichnung und -kalibrierung sollten zuvor in der Kalibrier- und Objektvermessungsstation der Fig. 1 erfolgt sein (Vorschlag eines mobilen Messvolumens). Die anzuordnende(n) Kamera(s) sind in Fig. 2 nicht dargestellt, da deren Position(en) nicht festgelegt zu werden braucht, gleichwohl ermittelt die Orientierung der Aufnahmen deren Lage bzw. Position(en) im Messvolumen.

Das mobile dreiachsige Koordinatengestell der Fig. 3 besteht aus drei Profilstäben 10, die an einem mit Eckverstärkungen versehenden Eckknotenpunkt 9 zusammengeführt sind. Die drei Profilstäbe bilden geometrisch exakt die x-, y- und z-Achse ab. Das dreiachsige Koordinatengestell ist für den Transport zerlegbar und kann über eine Steck- oder Gelenkverbindung, vorzugsweise einer starren Exzenter-Gelenkverbindung in Betriebsstellung geklappt werden. Es weist am Ende der Profilstäbe sowie im Eckknotenpunkt 9 Passpunktfestkörper 8 auf, die mit eingemessenen Messmarkentafeln der Fig. 5 versehen sind. Das dreiachsige Koordinatengestell ist in seiner Dimensionierung auf die Objektgröße abgestimmt und wird an das zu vermessende Objekt herangetragen. Die Brennweitenkalibrierung erfolgt vollautomatisch im Rahmen der Objektvermessung. Die CCD-Chip-, die

Gehäusekalibrierung und die Objektivverzeichnung und –kalibrierung der digitalen Kamera, sollte zuvor in der Kalibrier- und Objektvermessungsstation der Fig. 1 (kalibriertes Messvolumen) erfolgt sein, welches aber auch vor Ort (‚calibration on the job') erfolgen kann. Die Aufnahmekameras, auch unterschiedlicher Bauarten, sind in Fig. 3 nicht dargestellt, da deren Standort nicht festgelegt zu werden braucht.
Durch die Verwendung eines mobilen Passpunktkoordinatensystems brauchen an das Messobjekt selber keine Passpunktmarkierungen aufgebracht zu werden, so dass das erfindungsgemäße Verfahren auch zur vollautomatischen und berührungsfreien Bauteilvermessung an industriellen Fertigungslinien, beim Prototyping und bei IST-SOLL Vergleichen einzusetzen ist.

Die Anzahl der definierten Passpunktfestköper oder Messkreuze des Messvolumens ist durch die geforderte Messgenauigkeit am Objekt sowie durch die Pixelauflösung und die Brennweite der eingesetzten Kamera(s) festzulegen.

Es sind auch Kameras unterschiedlichen Bautyps mit unterschiedlichen Brennweiten einsetzbar, da das Verfahren in der Lage ist, die für jede Kamera exakten Werte (z.B. Brennweite, Objektivverzeichnung, Bildhauptpunktlage etc.) automatisch zu ermitteln, auch bei eingeschalteten Autofokus.

Es besteht die Möglichkeit, dass man die einzelnen Befehle zur Ausführung der verschiedenen Verfahrensschritte in einer einfach zu bedienenden auch branchenspezifisch anpassbaren Software kleidet und mit dieser die Tätigkeiten des Computers steuert.

Die Fig. 4-5 zeigen Messmarken mit keilförmiger Struktur. Der Vorteil dieser Struktur liegt darin begründet, dass sie sowohl für Nah- und Fernaufnah-

men geeignet sind, indem die bei Fernaufnahmen beginnende zentrische Unschärfe dadurch ausgeglichen wird, dass das Messfadenkreuz sich über den breiten Keilansatz noch zentrisch positionieren lässt. Dadurch entfällt die Vorhaltung unterschiedlicher Größen von Messmarken.

Die Kalibriertafel der Fig. 6 dient zur Kalibrierung des CCD-Chips, des Kameragehäuses, der Objektivverzeichnung und der Ermittlung der Bildhauptpunktlage. Die Kalibriertafel enthält zweckmäßigerweise eine Serie von präzisen Messmarken in definierter x- und y-Richtung, so dass darüber auch die Objektiv- bzw. Brennweitenkalibrierung bzw. –verzeichnung sowie die Bildhauptpunktlage, die für die Brennweite der Aufnahmeserie gilt, vollautomatisch ermittelt werden kann, sofern bei der Objektaufnahme eine dreidimensionale Anordnung von Passpunkten gegeben ist. Die Vorteile dieser mobilen 2D-Kalibriertafel liegen darin begründet, dass nunmehr kein stationäres 3D-Kalibrierfeld für die Kamerakalibrierung, die Ermittlung der Objektivverzeichnung, der Brennweite und des Bildhauptpunktes bzw. –mittelpunktes benötigt wird. Die Kalibriertafel besteht aus einem hochstabilen Material, vorzugsweise im Sandwichaufbau: Aluminium-Kunststoff-Aluminium, worauf das eigentliche Kalibrierfeld mit definierten Zielmarken, welche auf eine Folie aufgebracht worden ist, auflaminiert ist.

Die Fig. 7 zeigt ein Messergebnis der Objektivverzeichnung in Form eines Polynoms 3. Grades nach Abschluss der Kalibrierung, bezogen auf der berechneten Bildhauptpunktlage. Auf der Rechtsachse ist der Radius, ausgehend vom Bildhauptpunkt (etwa Chipmitte), auf der Hochachse die Verzeichnung abgetragen; alle Werte in [mm]. Die Punkte stellen die Zielmarken der Kalibriertafel dar, der Graph das Polynom 3. Grades. Die radialsymmetrische Verzeichnung ist nicht konstant, sondern hängt von der Brennweite ab. Durch die Ableitung der Brennweite und der dazugehörigen Objektivverzeichnungswerte für vorher ermittelter Brennweitenstufen gelingt beim Vario- bzw. Zoomobjektiv neben der Ermittlung der vom Nutzer vor-

eingestellten Brennweite auch die Ermittlung der dazugehörigen radialsymmetrischen Verzeichnungswerte, zudem braucht der Autofokus nicht abgeschaltet zu werden. Insofern braucht dieses Objektiv nicht mehr auf Anschlag voreingestellt zu werden, sondern der Nutzer wählt die für seine Aufnahme geeignete Brennweite stufenlos, was die Anzahl der Bilder einer Aufnahmeserie reduziert. Die Ableitung der Brennweite gelingt wie folgt:

Für die Bestimmung der Brennweite ist bei dem hier vorgestellten Verfahren wichtig, dass in jedem Bild eine hinreichend große Anzahl auch räumlich gut verteilter Passpunkte vorhanden ist. Diese dürfen insbesondere nicht alle in einer Ebene liegen, sondern müssen definiert in einem Raum verteilt angeordnet sein. Nun erfolgt die Messung der äußeren Orientierung, wobei zunächst der aus den Bilddateien (EXIF-Header) ausgelesene Wert der Brennweite benutzt werden kann. Nach der Ausgleichung mittels kleinster Quadrate liegen Werte für die Standardabweichung der Restfehler an den Passpunkten vor.

Ausgehend vom verwendeten Wert der Brennweite wird diese nun in kleinen Schritten von 0,1 mm sukzessive erhöht bzw. erniedrigt und jeweils die äußere Orientierung neu berechnet. Diejenige Brennweite, welche die geringste Standardabweichung der Restfehler aufweist, wird anschließend in die Bilddatei eingetragen und für alle weiteren Auswertungen verwendet. Über eine Staffelung von Aufnahmen der Kalibriertafel (Fig. 6) mit unterschiedlichen Brennweiten ergeben sich unterschiedliche Koeffizienten der jeweiligen Polynome 3. Grades. Dadurch wird es möglich jegliche vom Nutzer voreingestellte Brennweite nebst Verzeichnungswerte rechnerisch zu ermitteln. Ein Varioobjektiv wird somit stufenlos für messtechnische Aufnahmen einsetzbar.

In der Fig. 8 ist eine Planaufsicht auf eine 3D-Kalibriermesstafel/ -platte 14 dargestellt, die in der Fig. 9 in perspektivischer Ansicht (überhöht) gezeigt ist. Diese ist für die verfahrensmäßig notwendige Kalibrierung der Kamera und der Vermessung des Objektes durch Stereomikroskope und –lupen geeignet und hierfür neu entwickelt worden. Die 3D-Kalibriermessplatte 14 stellt das für die Kalibrierung und Vermessung mit einer Kamera notwendige Messvolumen zur Verfügung. Es besteht hier aus drei beabstandet nebeneinander auf einer Platte angeordneten definierten Rasterlinien (x- und y-Koordinaten), vergleichbar in ihrer Funktion mit der beschriebenen Kalibriertafel der Fig. 6, in unterschiedlichen Maßstäben (abhängig von der gewählten Vergrößerungsstufe) und einem vor einer Seite jeden Rasters angeordneten Mikrokörpers 16 definierter Höhe, welcher die z-Koordinate des Messvolumens in Abhängigkeit von der Tiefenschärfe der gewählten Mikroskopauflösung bildet. Der Rastermaßstab ist in Abhängigkeit von der Mikroskopauflösung zu wählen.

Liste der Bezugszeichen

1 Kalibriertafel
2 Objektplattformträger (horizontale x/z-Ebene)
3 Trägerprofile
4 Digitalkamera
5 Kalibrier- und Objektträgeraufnahme- und 3D-photogrammetrische Vermessungsstation für kleine Objekte
6 Passpunktfestkörper mit mehreren messbaren Messmarkenflächen alle in keilförmiger Ausprägung
7 3D-photogrammetrischer Brennweitenkalibrier- und Messkäfig, mit eingemessenen Messmarkentafeln für mittlere Objektgrößen
8 würfelförmiger Passpunktfestkörper mit Messmarkentafeln
9 Eckknotenpunkt

10 dreiachsiges Koordinatengestell mit eingemessenen Messmarkentafeln für große Objekte

11 Trägerrückwand (vertikale x/y-Ebene)

12 Kameraaufhängungsprofilträger (schwenk- und kippbar)

13 Exzenter-Gelenke

14 3D-Kalibriermessplatte

15 Rasterlinien unterschiedlicher Maßstäbe für x-, y-Koordinaten (für Kalibrierung, vgl. Fig.6)

16 Mikrokörper mit definierter Höhe (z-Koordinate des Messvolumens)

PATENTANSPRÜCHE

1. Verfahren zur Vermessung von Gegenständen mit einer Kamera durch Aufnahme und späterer Auswertung einer Serie von Objektaufnahmen aus mindestens zwei verschiedenen Richtungen,
dadurch gekennzeichnet,
dass man mindestens eine herkömmliche (Digital-) Kamera, vorzugsweise mit Vario- bzw. Zoomobjektiv als Aufnahmesystem verwendet,
dass man anschließend mit diesem Aufnahmesystem das Objekt gleichzeitig oder nacheinander mit einem Passpunktkoordinatensystem aufnimmt,
dass man die Ermittlung der Brennweite, der Objektivverzeichnung und der Bildhauptpunktlage aus dieser definierten Aufnahmeserie vornimmt und
dass man unter Berücksichtigung der ermittelten Brennweite, Objektivverzeichnung und der Bildhauptpunktlage das zu vermessende Objekt vermisst.

2. Verfahren nach Anspruch 1,
dadurch gekennzeichnet,
dass man vor der Vermessung einmalig die Objektivverzeichnungen der verwendeten Kamera für die zu verwendenden Brennweiten ermittelt.

3. Verfahren nach Anspruch 1,2,
dadurch gekennzeichnet,
dass man die Ermittlung der Brennweite, der Objektivverzeichnung, der Bildhauptpunktlage und/oder die Auswertung

der Daten auf einem Computer mit einer prozesssteuernden Software vornimmt.

4. Verfahren nach einem der vorangehenden Ansprüche,
dadurch gekennzeichnet,
dass man als Passpunktkoordinatensystem
für kleine Objekte eine auf einem Objektträger mit definierten, zusätzlichen Passpunktfestkörpern oder eine dreidimensionale Nanostruktur,
für mittelgroße bis große Objekte einen mit Messmarken versehenen Kalibrierkäfig oder ein mit Messmarken versehenes dreistrahliges Koordinatengestell,
für terrestrische und atmosphärische Objekte Bodenmarkierungen in x-, y- Richtung und in z- Richtung definiert fliegende oder schwebende Objekte als kombiniertes Luft-/ Bodenmessvolumen verwendet.

5. Verfahren nach Anspruch 1,
dadurch gekennzeichnet,
dass man für die Vermessung von sich bewegenden Objekten ein Zwei-Kamerasystem verwendet.

6. Verfahren nach Anspruch 5,
dadurch gekennzeichnet,
dass man mit den beiden Kameras eine dicht hintereinander liegende Bildfolge oder ein Video aufnimmt und aus dieser ein korrespondierendes Bildpaar für die Kalibrierung und die Vermessung heraussucht und der Vermessung zugrunde legt.

7. Verfahren nach Anspruch 1,
dadurch gekennzeichnet,
dass man für die Kamerakalibrierung, die Ermittlung der Objektivverzeichnung, der Brennweite und der Bildhauptpunktlage bzw. –mittelpunktes eine Kalibriertafel verwendet, deren Kalibrierungsmarken im Digitaldruck mit UV-Tinte auf Polyesterfolie aufgebracht worden sind, wobei die Polyesterfolie auf einer maßhaltigen Unterlage fest angeordnet ist.

8. Verfahren nach Anspruch 4,
dadurch gekennzeichnet,
dass man die Genauigkeit eines Passpunktfestkörpers erhöht, indem man dreidimensionale Messmarken verwendet.

9. Verfahren nach Anspruch 8,
dadurch gekennzeichnet,
dass man als Messmarkenstruktur keilförmige Messmarken verwendet.

10. Verfahren nach Anspruch 8,
dadurch gekennzeichnet,
dass man würfelförmige Passpunktfestkörper als Messmarken verwendet, die definierte Messmarkenstrukturen auf den Festkörperflächen besitzen.

11. Verfahren nach Anspruch 1,
dadurch gekennzeichnet,
dass man zunächst mit mindestens einer Kamera aus mindestens zwei definierten unterschiedlichen Standorten die Objektumge-

bung mit Passpunktkoordinatensystem zu Ermittlung von Objektivverzeichnung, Brennweite und Bildhauptpunktlage aufnimmt, dass man bei einem Zwei-Kamerasystem das Passpunktkoordinatensystem entfernt und dann von dem selben Standort aus mit den selben Kameraeinstellungen das Objekt zur Vermessung aufnimmt.

12. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass man bei einer strukturarmen Oberfläche des zu vermessenden Objektes die Oberfläche vor der Vermessung zur besseren Erkennbarkeit behandelt.

13. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass man der Objektvermessung Einzelbilder oder Filmsequenzen zugrunde legt.

14. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass man die Brennweite aus der vom Benutzer voreingestellten Brennweite eines Vario- bzw. Zoomobjektives über die Ermittlung der geringsten Standardabweichung der Restfehler an den Passpunkten derart bestimmt, dass man sukzessiv die Brennweite erhöht oder erniedrigt und die äußere Orientierung jeweils wiederholt.

15. Verfahren nach Anspruch 1-4 dadurch gekennzeichnet,

dass man zur Vermessung von sich bewegenden Objekten ein Aufnahmesystem verwendet, das aus zwei synchron geschalteten Kameras besteht und
bei dem man vor der Objektaufnahme die Objektivverzeichnung, Brennweite und der Bildhauptpunktlage und das Messvolumen ermittelt hat.

16. Verfahren nach Anspruch 1-4,
dadurch gekennzeichnet,
dass man zur Vermessung eines ortsfesten Objektes mit einem sich bewegenden Aufnahmesystem ein mobiles Aufnahmesystem verwendet, welches aus zwei fest zueinander montierten und synchron geschalteten Kameras besteht und
bei dem man vor der Objektaufnahme die Objektivverzeichnung, Brennweite und de Bildhauptpunktlage und das Messvolumen ermittelt hat.

17. Verfahren nach Anspruch,
dadurch gekennzeichnet,
dass man für Nahbereichs- und Luftbildaufnahmen kugelförmige Messmarken verwendet.

18. Kalibriermesstafel für Mikroskope und Lupen
dadurch gekennzeichnet,
dass diese aus einer ebenen, horizontalen Auflagefläche und einem auf dieser Fläche angeordneten quader- oder würfelförmigen Körper besteht,
dass ein definiertes Raster auf dieser Unterlage angeordnet ist,

dass das Raster mindestens eine derartige Flächengröße aufweist, dass es die Okularansicht voll abbildet und eine genügende Anzahl von Messpunkten aufweist und
dass der Körper derart zum Raster angeordnet ist, dass dieser durch das Mikroskop/Lupe erkennbar eine senkrecht zur Rasterung angeordnete dritte Raumrichtung mit gleicher Höhe aufspannt, die im Tiefenschärfebereich der Mikroskopauflösung liegt.

19. Kalibriermesstafel nach Anspruch 18,
dadurch gekennzeichnet,
dass die Auflagefläche ein Objektträger ist.

20. Kalibriermesstafel nach Anspruch 18
dadurch gekennzeichnet,
dass das Raster ein Linienraster aus senkrecht aufeinander stehenden Linien ist.

21. Kalibriermesstafel nach Anspruch 18-20
dadurch gekennzeichnet,
dass mehrere Raster unterschiedlicher Rasterweiten und mehrere Körper unterschiedlicher Körperhöhen auf einer Auflage angeordnet sind,
wobei jedem Raster ein der Rasterweite und Tiefenschärfe entsprechend dimensionierter Körper zugeordnet ist.

22. Kalibriertafel
dadurch gekennzeichnet,
dass diese aus einer form- und verwindungssteifen Platte besteht,
wobei auf der Oberseite dieser Platte ein Kalibrierfeld mit definierten Zielmarken angeordnet ist.

23. Kalibriertafel nach Anspruch 22,
dadurch gekennzeichnet,
dass die Platte aus Lagen aus Aluminium und Kunststoff aufgebaut ist, wobei die innenliegende Kunststofflage sandwichartig von außenliegenden Aluminiumlagen fest umschlossen ist.

24. Kalibriertafel nach Anspruch 22,
dadurch gekennzeichnet,
dass die Messmarken auf definierten (gedachten) Rasterpunkten angeordnet sind.

25. Kalibriertafel nach Anspruch 22,
dadurch gekennzeichnet,
dass die Messmarke aus einer geometrischen Struktur besteht, und im gleichen Abstand beabstandet zur nächsten Messmarke angeordnet ist.

26. Messmarkentafel,
dadurch gekennzeichnet,
dass die Messmarke aus 4 keilförmigen Flächen besteht, deren Keilspitzen in dem Messmarkenmittelpunkt enden und deren Keilansatz am Umfang der Messmarke angeordnet ist,
wobei jede keilförmige Fläche einen gleichen Winkel von 90 Grad aufspannt und
jede keilförmige Fläche im gleichen Abstand beabstandet zur nächsten keilförmigen Fläche angeordnet ist.

27. Koordinatengestell als mobiles Messvolumen,
dadurch gekennzeichnet,

dass das Gestell aus mindestens drei lotrechten Stäben besteht, die mit jeweils einem Stabende in einem gemeinsamen Punkt angeordnet sind und
dass Messmarken oder Passpunktfestkörper definiert an diesen Stäben in jeder Raumrichtung angeordnet sind.

28. Koordinatengestell nach Anspruch 26,
dadurch gekennzeichnet,
dass die Stäbe Steckverbindungen oder Gelenkverbindungen aufweisen.

29. Koordinatengestell nach Anspruch 26,
dadurch gekennzeichnet,
dass weitere Stäbe derart anzuordnen sind,
so dass ein Käfig aufspannbar ist und
dass die weitere Stäbe weitere Messmarken oder Passpunkte aufweisen.

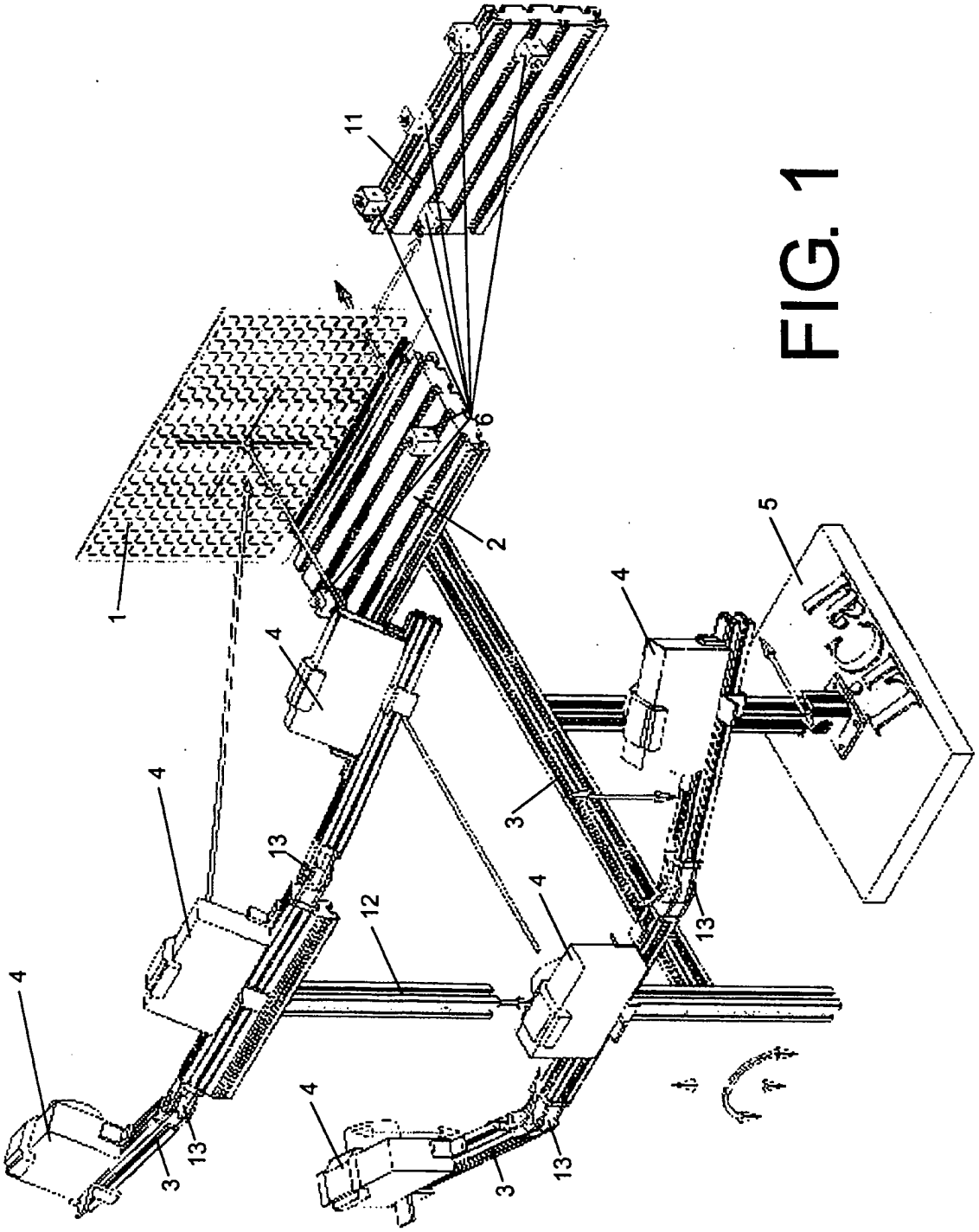


FIG. 1

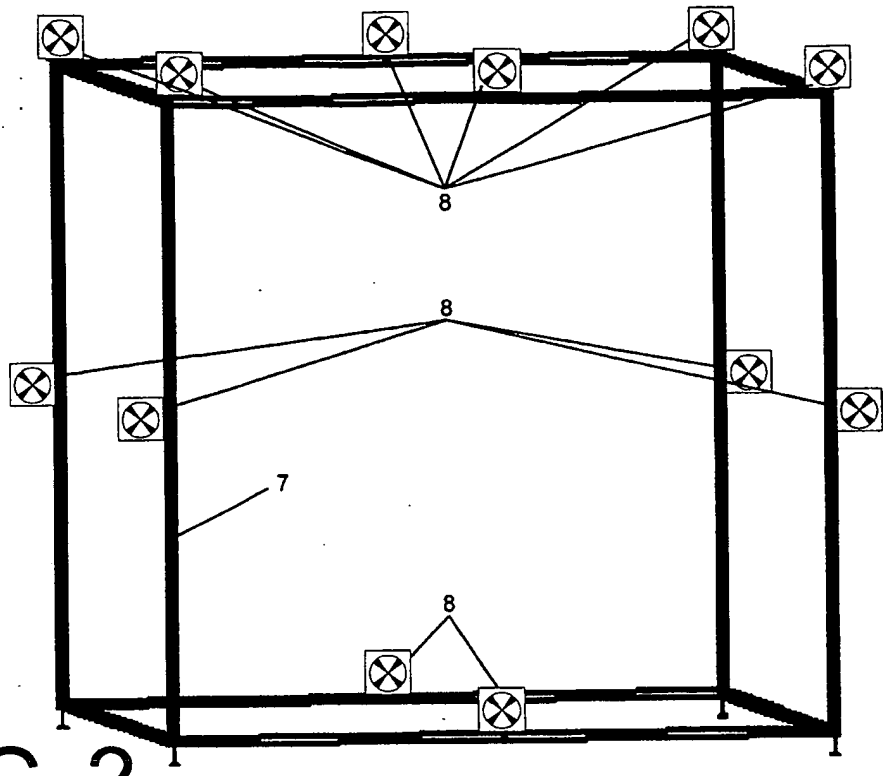


FIG. 2

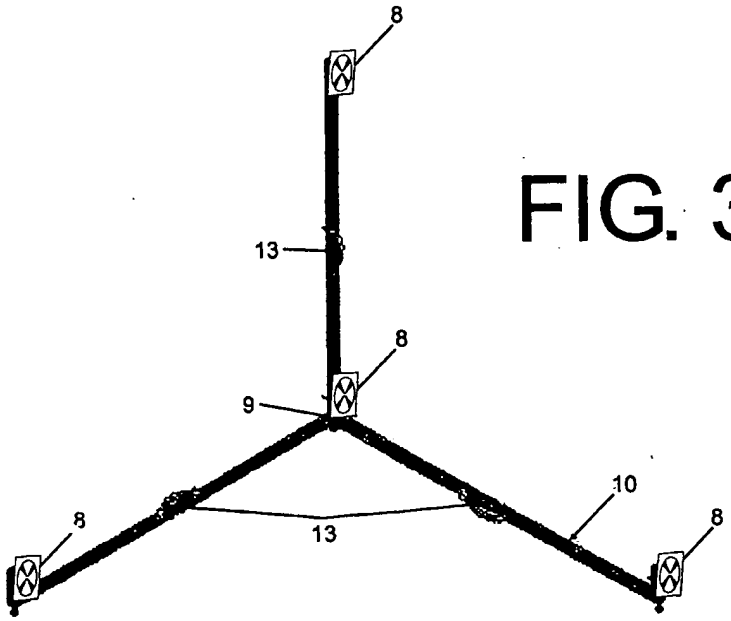


FIG. 3

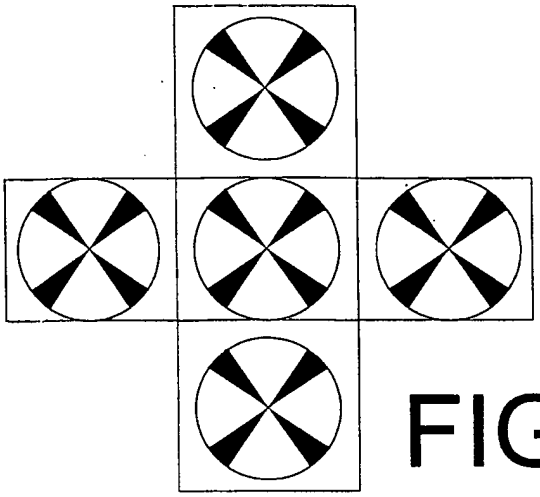


FIG. 4

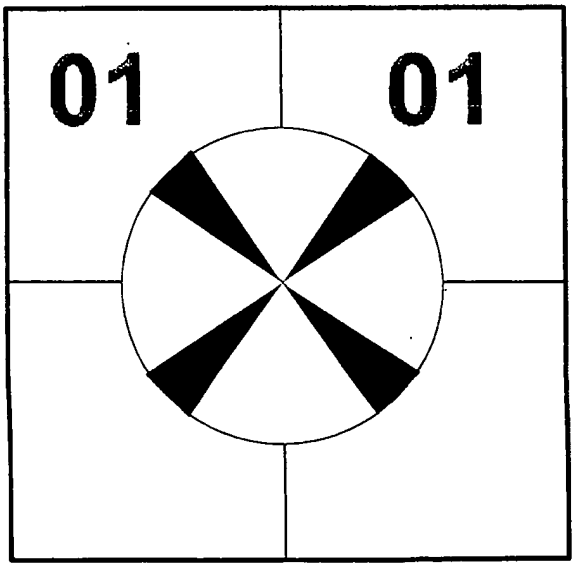


FIG. 5

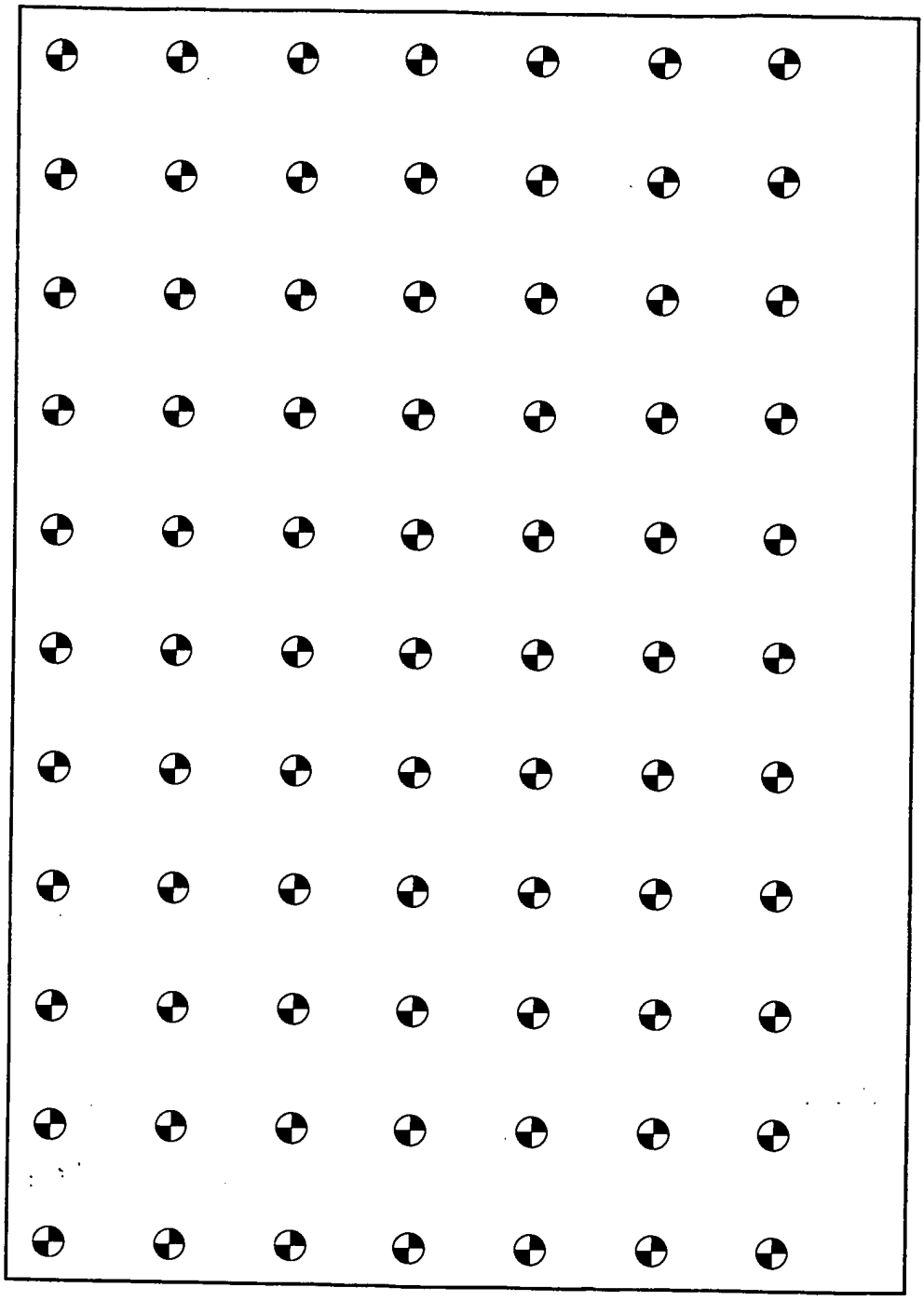
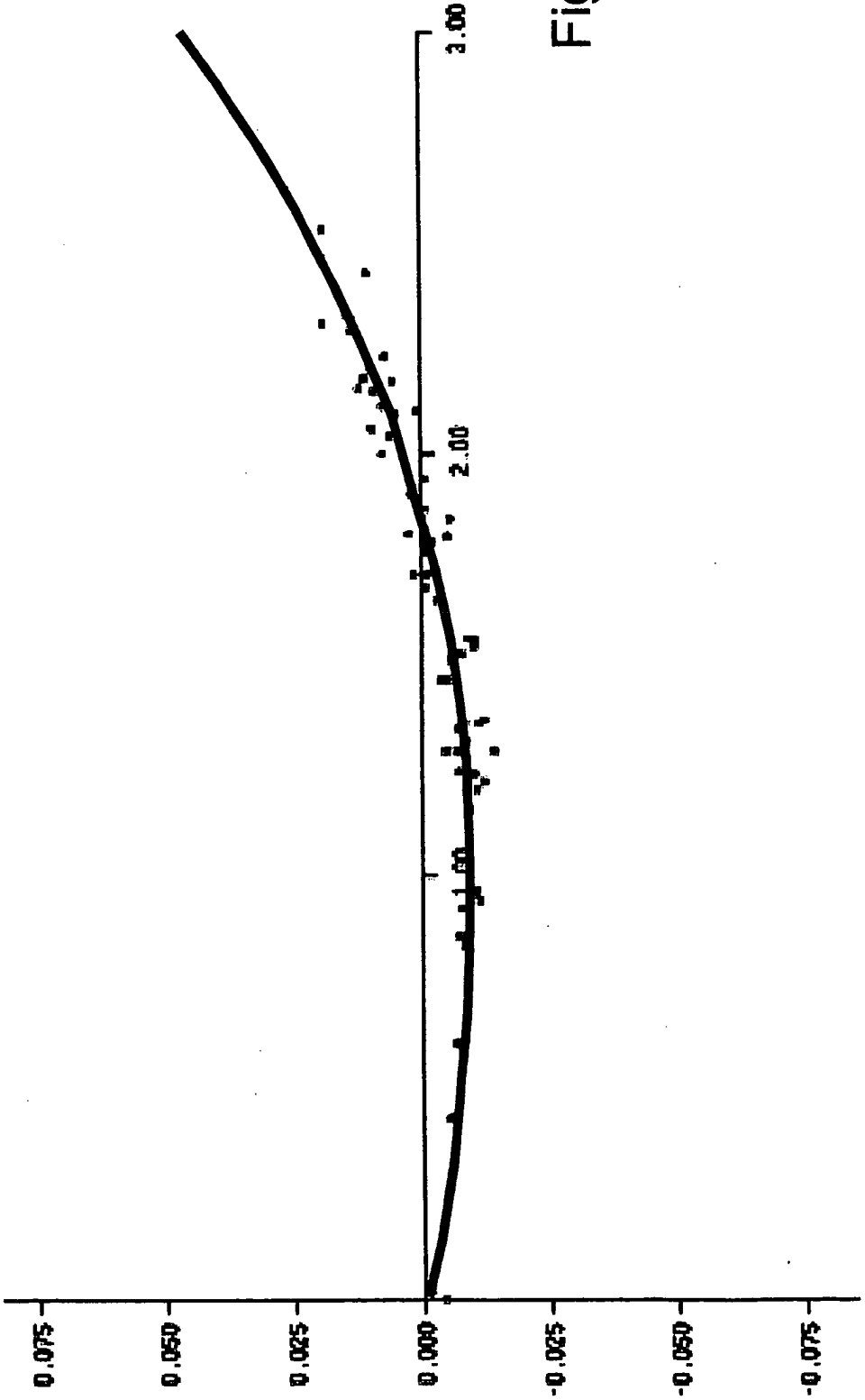


FIG. 6

Fig. 7



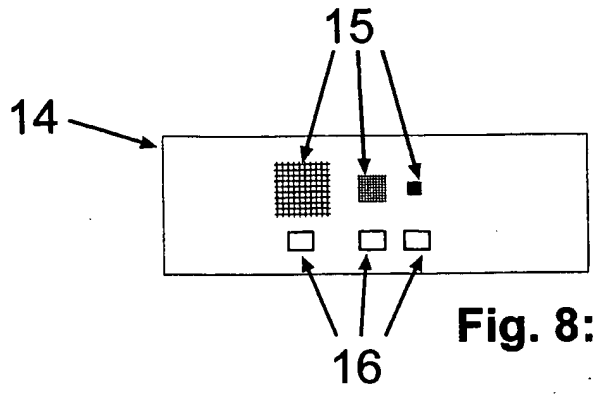


Fig. 8:

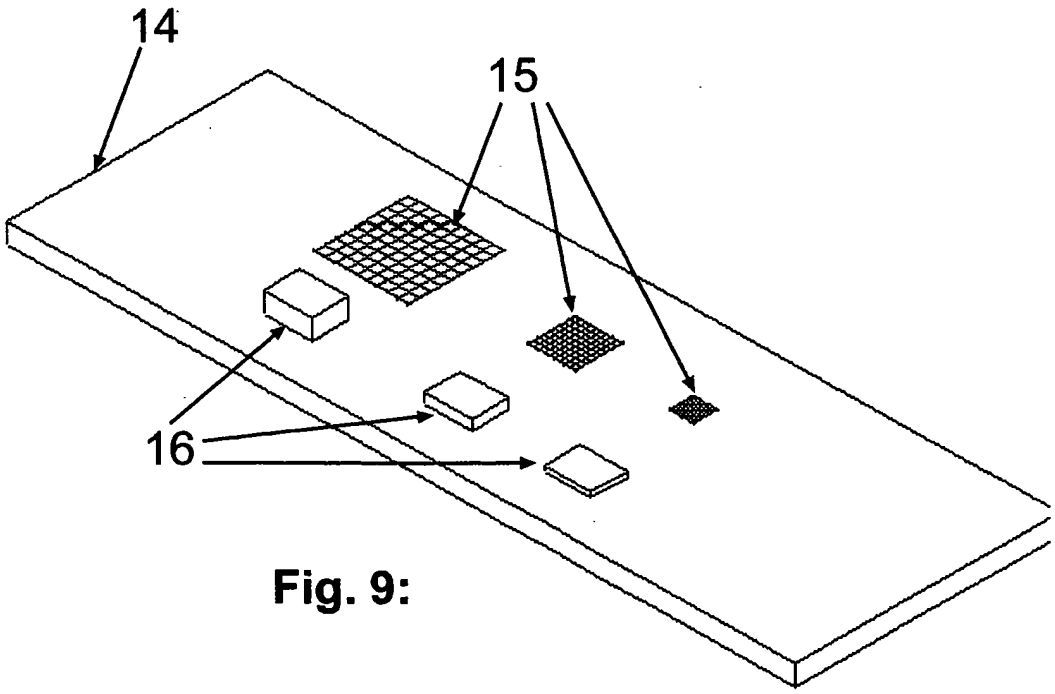


Fig. 9:

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

PCT

(43) Internationales Veröffentlichungsdatum
29. Dezember 2005 (29.12.2005)

(10) Internationale Veröffentlichungsnummer
WO 2005/124276 A3

(51) Internationale Patentklassifikation[7]: G01B 11/00, G02B 21/04

(21) Internationales Aktenzeichen: PCT/DE2005/001048

(22) Internationales Anmeldedatum:
11. Juni 2005 (11.06.2005)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
10 2004 028 635.3 15. Juni 2004 (15.06.2004) DE

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(74) Anwälte: **JUNIUS, Elisabeth** usw.; Wolfstrasse 24, 30519 Hannover (DE).

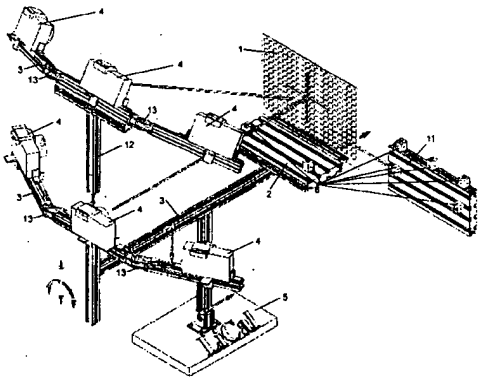
(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU,

[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD FOR THE MEASUREMENT OF OBJECTS WITH THE AID OF A CAMERA, AND CALIBRATION MEANS

(54) Bezeichnung: VERFAHREN ZUR VERMESSUNG VON GEGENSTÄNDEN MIT EINER KAMERA UND KALIBRIERMITTELN



(57) Abstract: The invention relates to a method for measuring objects with the aid of a camera by recording and later evaluating a series of pictures of said object taken from at least two directions as well as calibration/measuring means for carrying out said method. The aim of the invention is to make it possible to take measurements from the ground (close range photogrammetry) as well as from the air (aerial photogrammetry) with simple means, using commercial cameras that are not calibrated at the factory end and are available everywhere for private use at low cost while dispensing with the need for expensive special evaluation devices for evaluating the measurement pictures. Said aim is achieved by using at least one conventional (digital) camera comprising a vario lens or zoom lens as a recording system, simultaneously or successively recording the object in a series of pictures using a control point coordinate system as a measuring volume with the aid of said recording system, determining the focal length, the lens distortion, and the main point position of the image from said defined series of pictures, and measuring the object that is to be measured by taking into account the determined focal length, the lens distortion, and the main point position of the image, also in a 3D video.

(57) Zusammenfassung: Die Erfindung betrifft ein Verfahren zur Vermessung von Gegenständen mit einer Kamera durch Aufnahme und späterer Auswertung einer Serie von Objektaufnahmen aus mindestens zwei verschiedenen Richtungen und Kalibrier-/messmittel durch Durchführung dieses Verfahrens. Es ist die Aufgabe der Erfindung, mit einfachen Mitteln eine Möglichkeit zu schaffen, die Vermessung vom Boden (Nahbereichsphotogrammetrie) und aus der Luft (Luftbildphotogrammetrie) mit

[Fortsetzung auf der nächsten Seite]

WO 2005/124276 A3

TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Veröffentlicht:
— *mit internationalem Recherchenbericht*

(88) Veröffentlichungsdatum des internationalen Recherchenberichts: 27. April 2006

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

handelsüblichen, nicht werksseitig kalibrierten Kameras durchzuführen, wie sie derzeit für den Privatbedarf überall zu niedrigen Preisen erhältlich sind. Zur Auswertung der Vermessungsaufnahmen sollen keine hochpreisigen Spezialauswertegeräte benötigt werden. Die Erfindung besteht darin, dass man mindestens eine herkömmliche (Digital-) Kamera mit Vario- bzw. Zoomobjektiv als Aufnahmesystem ver wendet, dass man mit diesem Aufnahmesystem das Objekt gleichzeitig oder nacheinander. mit einem Passpunktkoordinatensystem als Messvolumen in einer Aufnahmeserie aufnimmt, dass man die Ermittlung der Brennweite, der Objektiwerzeichnung und der Bildhauptpunktlage aus dieser definierten Aufnahmeserie vornimmt und dass man unter Berücksichtigung der ermittelten Brennweite, der Objektiwerzeichnung und der Bildhauptpunktlage das zu vermessende Objekt vermisst, ebenso im 3D-Video.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DE2005/001048

A. CLASSIFICATION OF SUBJECT MATTER
G01B11/00 G01B21/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, INSPEC, PAJ, WPI Data, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 852 672 A (LU ET AL) 22 December 1998 (1998-12-22) column 5, line 31 - column 7, line 25	1-3,5, 11-13, 15,16
A	figures 1-5	4,6-10, 14,17

Y	EP 1 174 681 A (FORD GLOBAL TECHNOLOGIES, INC) 23 January 2002 (2002-01-23) column 2, line 19 - column 11, line 3	1-3,13
A	figure 1	4-12, 14-17

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 October 2005	26. 01. 2006

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kunz, L

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/DE2005/001048

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	HEIKKILA J ET AL: "Calibration procedure for short focal length off-the-shelf CCD cameras" PROCEEDINGS OF THE 13TH INTERNATIONAL CONFERENCE ON PATTERN RECOGNITION IEEE COMPUT. SOC. PRESS LOS ALAMITOS, CA, USA, vol. 1, 1996, pages 166-170 vol.1, XP002350077 ISBN: 0-8186-7282-X page 167	1-3,5, 11-13, 15,16
A	-----	7-10,14
A	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 12, 5 December 2003 (2003-12-05) -& JP 2003 329423 A (SANYO ELECTRIC CO LTD), 19 November 2003 (2003-11-19) abstract; figure 3	1-17

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DE2005/001048

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see the Supplemental Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

see Annex

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1992)

International application No.
PCT/DE2005/001048

The International Searching Authority has found that the international application contains multiple (groups of) inventions, as follows:

1. Claims: 1 to 17

   Method for measuring objects with the aid of a camera, whose focal length, lens distortion and principal point position of the image are determined by means of a control coordinate system.

   ---

2. Claims: 18 to 21

   Calibration measuring table for microscopy with an arrangement of grids and bodies for the third spatial dimension.

   ---

3. Claims: 22 to 25

   Calibrating table on a dimensionally stable board with targets.

   ---

4. Claim: 26

   Measuring-mark table with special measuring marks.

   ---

5. Claims: 27 to 29

   Three-dimensional coordinate frame.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/DE2005/001048

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5852672 A	22-12-1998	NONE	
EP 1174681 A	23-01-2002	NONE	
JP 2003329423 A	19-11-2003	JP 3685772 B2	24-08-2005

Form PCT/ISA/210 (patent family annex) (January 2004)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE2005/001048

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
G01B11/00 G01B21/04

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
G01B

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, INSPEC, PAJ, WPI Data, COMPENDEX, IBM-TDB

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
Y	US 5 852 672 A (LU ET AL) 22. Dezember 1998 (1998-12-22) Spalte 5, Zeile 31 - Spalte 7, Zeile 25	1-3,5, 11-13, 15,16
A	Abbildungen 1-5	4,6-10, 14,17

Y	EP 1 174 681 A (FORD GLOBAL TECHNOLOGIES, INC) 23. Januar 2002 (2002-01-23) Spalte 2, Zeile 19 - Spalte 11, Zeile 3	1-3,13
A	Abbildung 1	4-12, 14-17

	-/--	

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

° Besondere Kategorien von angegebenen Veröffentlichungen :
"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist
"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist
"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)
"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht
"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist
"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist
"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann allein aufgrund dieser Veröffentlichung nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden
"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist
"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
20. Oktober 2005	26. 01. 2006

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kunz, L

Formblatt PCT/ISA/210 (Blatt 2) (Januar 2004)

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/DE2005/001048

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
Y	HEIKKILA J ET AL: "Calibration procedure for short focal length off-the-shelf CCD cameras" PROCEEDINGS OF THE 13TH INTERNATIONAL CONFERENCE ON PATTERN RECOGNITION IEEE COMPUT. SOC. PRESS LOS ALAMITOS, CA, USA, Bd. 1, 1996, Seiten 166-170 vol.1, XP002350077 ISBN: 0-8186-7282-X Seite 167	1-3,5, 11-13, 15,16
A	-----	7-10,14
A	PATENT ABSTRACTS OF JAPAN Bd. 2003, Nr. 12, 5. Dezember 2003 (2003-12-05) -& JP 2003 329423 A (SANYO ELECTRIC CO LTD), 19. November 2003 (2003-11-19) Zusammenfassung; Abbildung 3 -----	1-17

Formblatt PCT/ISA/210 (Fortsetzung von Blatt 2) (Januar 2004)

INTERNATIONALER RECHERCHENBERICHT

nationales Aktenzeichen
PCT/DE2005/001048

Feld II Bemerkungen zu den Ansprüchen, die sich als nicht recherchierbar erwiesen haben (Fortsetzung von Punkt 2 auf Blatt 1)

Gemäß Artikel 17(2)a) wurde aus folgenden Gründen für bestimmte Ansprüche kein Recherchenbericht erstellt:

1. ☐ Ansprüche Nr.
weil sie sich auf Gegenstände beziehen, zu deren Recherche die Behörde nicht verpflichtet ist, nämlich

2. ☐ Ansprüche Nr.
weil sie sich auf Teile der internationalen Anmeldung beziehen, die den vorgeschriebenen Anforderungen so wenig entsprechen, daß eine sinnvolle internationale Recherche nicht durchgeführt werden kann, nämlich

3. ☐ Ansprüche Nr.
weil es sich dabei um abhängige Ansprüche handelt, die nicht entsprechend Satz 2 und 3 der Regel 6.4 a) abgefaßt sind.

Feld III Bemerkungen bei mangelnder Einheitlichkeit der Erfindung (Fortsetzung von Punkt 3 auf Blatt 1)

Die internationale Recherchenbehörde hat festgestellt, daß diese internationale Anmeldung mehrere Erfindungen enthält:

siehe Zusatzblatt

1. ☐ Da der Anmelder alle erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht auf alle recherchierbaren Ansprüche.

2. ☐ Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der eine zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Behörde nicht zur Zahlung einer solchen Gebühr aufgefordert.

3. ☐ Da der Anmelder nur einige der erforderlichen zusätzlichen Recherchengebühren rechtzeitig entrichtet hat, erstreckt sich dieser internationale Recherchenbericht nur auf die Ansprüche, für die Gebühren entrichtet worden sind, nämlich auf die Ansprüche Nr.

4. ☒ Der Anmelder hat die erforderlichen zusätzlichen Recherchengebühren nicht rechtzeitig entrichtet. Der internationale Recherchenbericht beschränkt sich daher auf die in den Ansprüchen zuerst erwähnte Erfindung; diese ist in folgenden Ansprüchen erfaßt:
see Annex

Bemerkungen hinsichtlich eines Widerspruchs

☐ Die zusätzlichen Gebühren wurden vom Anmelder unter Widerspruch gezahlt.

☐ Die Zahlung zusätzlicher Recherchengebühren erfolgte ohne Widerspruch.

Roofr Exhibit 1002, Page 264

WEITERE ANGABEN PCT/ISA/ 210

Die internationale Recherchenbehörde hat festgestellt, dass diese internationale Anmeldung mehrere (Gruppen von) Erfindungen enthält, nämlich:

1. Anspruch: 1 bis 17

   Verfahren zum Vermessen von Gegenständen mittels einer Kamera, deren Brennweite, Objektivverzeichnung und Bildhauptpunktlage mittels eines Passpunktkoordinatensystems ermittelt werden.

   ---

2. Anspruch: 18 bis 21

   Kalibriermesstafel für Mikroskopie mit Raster und Körper für die dritte Raumrichtung

   ---

3. Anspruch: 22 bis 25

   Kalibriertafel auf steifer Platte mit Zielmarken

   ---

4. Anspruch: 26

   Messmarkentafel mit speziellen Messmarken

   ---

5. Anspruch: 27 bis 29

   Dreidimensionales Koordinatengestell

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen die zur selben Patentfamilie gehören

Internationales Aktenzeichen
PCT/DE2005/001048

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
US 5852672	A	22-12-1998	KEINE		
EP 1174681	A	23-01-2002	KEINE		
JP 2003329423	A	19-11-2003	JP	3685772 B2	24-08-2005

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 April 2006 (20.04.2006)

PCT

(10) International Publication Number
WO 2006/040775 A2

(51) International Patent Classification:
H04N 7/18 (2006.01)

(21) International Application Number:
PCT/IL2005/001095

(22) International Filing Date: 16 October 2005 (16.10.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/618,578 15 October 2004 (15.10.2004) US
60/659,084 8 March 2005 (08.03.2005) US

(71) Applicant *(for all designated States except US)*: **OFEK AERIAL PHOTOGRAPHY LTD.** [IL/IL]; P.O.Box 8065, 42170 Netanya (IL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **FRIEDLANDER, Ilan** [IL/IL]; P.O.Box 8065, 42170 Netanya (IL). **SHOHAM, Haim** [IL/IL]; P.O.Box 8065, 42170 Netanya (IL).

(74) Agent: **FRIEDMAN, Mark**; 7 Jabotinsky St., 52520 Ramat Gan (IL).

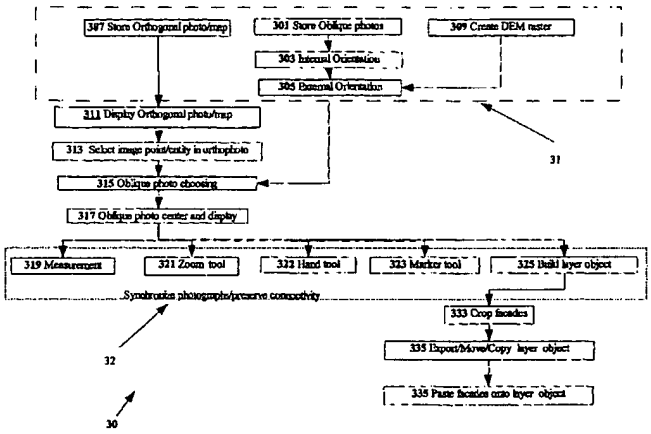
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: COMPUTATIONAL SOLUTION OF AN BUILDING OF THREE DIMENSIONAL VIRTUAL MODELS FROM AERIAL PHOTOGRAPHS



(57) **Abstract:** A method for processing in a computer a plurality of digital images stored in the computer. The digital images are from respective photographs of a geographic region. The photographs were taken from different directions. The method includes displaying the images and upon selecting an image point in an oblique image, synchronizing a corresponding image point in the digital images so that the selected image point in the first image and the corresponding synchronized image point in other images have substantially identical world coordinates. The method is useful for performing a geographic measurements on an oblique by selecting an image ground point below a first image point; calculating world coordinates in a vertical line segment which extends vertically from the image ground point, and upon selecting the first image point on the vertical line segment, calculating world coordinates at the first image point based on the world coordinate in the vertical line segment. The method is further used to display a three dimensional object, crop facades from the images and paste facades onto the object.

WO 2006/040775 A2

COMPUTATIONAL SOLUTION OF AND BUILDING OF THREE DIMENSIONAL VIRTUAL MODELS FROM AERIAL PHOTOGRAPHS

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to using photogrammetric techniques for providing measurements on two dimensional oblique photographs and three dimensional models based on two dimensional oblique photographs.

Conventionally, mapping of land is achieved with the use of orthogonal photography, with the camera pointing orthogonally downward towards the ground. Orthogonal photographs are easily scaled to provide horizontal distance measurements. However, orthogonal photographs are not sufficient for topographical measurements or measurements of heights since sufficient elevation information is not available. Additional methods are used for attaining elevation information such as radar, or surveying in combination with orthogonal photography. Height information is typically stored in a computer as a digital terrain model. The combination of a elevation measurements with orthogonal aerial photography is conventionally used to build a topographical map. Representative prior art references in the field of mapping land include US patent 4,686,474 and US patent 5,247,356.

Photogrammetry is a measurement technology in which the three-dimensional coordinates of points on a three dimensional physical object are determined by measurements made in one or more photographic images. The technique is used in different fields, such as topographic mapping, architecture, engineering, police investigation, geology and medical surgery. Photogrammetric techniques require that photogrammetric images be taken at an oblique angle to provide elevation information. The challenge of photogrammetry arises from the fact that oblique photographs are not easily scaled. For instance, images of buildings in the foreground of an oblique photograph appear to be much larger than similar buildings in the background of the the same image.

Reference is now made to Figure 1 a prior art drawing showing coordinate axes **10** in a photogrammetric calculation. Coordinates *X* and *Y* represent geographic coordinates, *e.g.* distances on the horizontal plane parallel to the ground. Coordinate

Z for represents elevation, for instance above sea level (z=0). A camera is located in position (X_c, Y_c, Z_c). Angular coordinates of the camera are given by angles of rotation Omega [Ω], Phi [ϕ], and Kappa [K or k]. Omega [Ω] is the angle of rotation about the X axis, Phi [ϕ] is the angle of rotation about the Y axis Kappa [K] is the angle of rotation about the Z axis. The term "camera coordinates" as used herein includes both the position coordinates (X_c, Y_c, Z_c) and the three angles of rotation. Ray **103a** is a light ray which emanates from Point P(X,Y,Z) located on a physical object **105.** Ray **103a** enters the camera and is imaged on image plane **107** at a point P'($x_p y_p$). The focal length of the camera is typically known. Typically, photogrammetric cameras have low photographic distortion, and the distortion is known and is removed during subsequent calculation. Typically, aerial photography is performed at varying angles, usually between 20° and 70°, under the wing of the aircraft.

Photography can be carried out with a digital or analog metric camera, or a video camera or a simple camera which is not designed for photogrammetric measurements. In the case of a camera, using film, the photographs are scanned with an accurate photogrammetric scanner. In the case of a video camera, a video frame or an average of identical video frames are used for the photograph. The term "interior orientation" is used herein to denote the 2D affine coordinate transformation between two-axis systems, the photograph coordinate system (for instance measured in millimeters on the film) to the digital image coordinate system (in picture elements of known size) subsequent to scanning. The "interior orientation" is calculated as follows for film photography. For video other types of photography, the interior orientation is analogous:

We look for coefficients a_0, a_1, a_2 b_0, b_1, b_2 such that

$x_p = a_0 \cdot x_i + a_1 \cdot y_1 + a_2$, $y_p = b_0 \cdot x_i + b_1 \cdot y_1 + b_2$ where x_i, y_i is image coordinate, and x_p, y_p is matching photograph coordinate

The operator marks at least three fiducial marks on the image, and inputs the corresponding coordinates of the photograph coordinate system. If there are more then three fiducial marks, a least square adjustment may be used. The operator integrates

the calibration report including the camera lens distortion with the orientation solution.

The term "exterior orientation" is used to solve the camera coordinates, the camera position (X_c, Y_c, Z_c) and the three orientation angles Omega, Phi and Kappa of the camera when the photograph was taken. The operator inputs the focal length of the camera f. The operator selects at least three ground control points on the oblique digital image, and corresponding ground control points typically on a scaled orthogonal photograph or map for which world coordinates are known. Alternatively, the world coordinates of the three control points are provided by surveying. For each control point j selected, geoographic coordinates Xt_j, Yt_j are typically obtained from the orthogonal photograph or map, and elevation Zt_j from a digital terrain model previously stored in the computer.

We need to solve the collinearity (CE) equations :

$$x_p = x_0 - f\frac{m_{11}(Xt - X_c) + m_{12}(Yt - Y_c) + m_{13}(Zt - Z_c)}{m_{31}(Xt - X_c) + m_{32}(Yt - Y_c) + m_{33}(Zt - Z_c)}$$

$$y_p = y_0 - f\frac{m_{21}(Xt - X_c) + m_{22}(Yt - Y_c) + m_{23}(Zt - Z_c)}{m_{31}(Xt - X_c) + m_{32}(Yt - Y_c) + m_{33}(Zt - Z_c)}$$

$x_p y_p$ is photograph coordinate, Xt, Yt is physical object coordinate in world space.

x_0, y_0 is taken from camera calibration report , or calculated by fiducials coordinates.

And M is matrix:

$$m_{11} = \cos\phi\cos k$$

$$m_{12} = \sin\Omega\sin\phi\cos k + \cos\Omega\sin k$$

$$m_{13} = -\cos\Omega\sin\phi\cos k + \sin\Omega\sin k$$

$$m_{21} = -\cos\phi \sin k$$

$$m_{22} = -\sin\Omega \sin\phi \sin k + \cos\Omega \cos k$$

$$m_{23} = \cos\Omega \sin\phi \sin k + \sin\Omega \cos k$$

$$m_{31} = \sin\phi$$

$$m_{32} = -\sin\Omega \cos\phi$$

$$m_{33} = \cos\Omega \cos\phi$$

There are six unknown parameters or camera coordinates to solve, each time the operator selects a ground control point on the oblique image and on the orthogonal photograph two equations are formed, thus three ground control points are required to solve for all the unknown parameters.

The calculation proceeds with a linearization of the equations using a Taylor expansion, first guessing initial values for the six unknowns and iteratively solving the linearized equations using a least square adjustment, trying to improve the results for the 6 unknown parameters until a previously defined threshold is reached. After a solution is reached, the solution is typically checked by the accuracy report (residuals), changing/sampling of additional control points and physically checking of several points chosen at random, in order to check orientation accuracy by pointing to the orthogonal photograph and checking the accuracy of the pointing on the oblique photograph.

Prior art photogrammetric solutions using oblique aerial photography used digital terrain models (DTM) based on a Triangulated Irregular Network (TIN) model. The TIN model was developed in the early 1970's as a simple way to build a surface from a set of irregularly spaced points. The irregularly spaced sample points can be adapted to the terrain, with more points in areas of rough terrain and fewer in smooth terrain. An irregularly spaced sample is therefore more efficient at representing a surface. In a TIN model, the sample points are connected by lines to form triangles. Within each triangle the surface is usually represented by a plane. By using triangles each piece of the mosaic surface will fit with neighboring pieces. The surface will be continuous, as each triangle's surface would be defined by the elevations of the three corner point.

Another type of digital terrain model is a raster digital terrain model The raster DTM is typically a rectangular grid over a certain area and resolution. Each pixel in

the raster "covers" an area of $r \times r\ [m^2]$ in world space, and has a gray value that represents the height of the terrain in the middle of this square.

In prior art photogrammetric solutions for oblique aerial photography, after the camera coordinates are determined an operator is able to select geographic coordinates on the orthogonal map or photograph and obtain the corresponding image coordinates or photograph coordinates by solving the CE equations with a single query to the stored TIN DEM .

Measurement capability in prior art photogrammetric solutions for oblique aerial photography is limited. Reference is now made to Figure 2 which illustrates a horizontal distance measurement of the prior art. In Figure 2, selecting an image point **201** on an entity **203** , *e.g.* image of building determines and calculates a ray **103** from camera position **101** to the physical point corresponding to image point **201.** The geographic coordinates used for the measurement (and for obtaining elevation from the DTM) are from point **205** where ray **103** intersects the terrain. For oblique angles, close to orthogonal, this method of calculation is reasonably accurate. However, for other angles, prior art methods introduce errors. For instance for measuring a horizontal measurement along the roof of a building, ray **103** intersects the ground several meters from the foot of the building. The measured horizontal distance H is based on the ground distance where ray **103** intersects the ground and the measurement is in error due to perspective distortion and to actual differences in elevation between the real point where ray **103** strikes the ground and the foot of the building .

There is thus a need for, and it would be highly advantageous to have a method of for more accurately measuring distances on oblique images than is provided for in the prior art. Furthermore, it would be advantageous to have a method which references world coordinates from one oblique photographs to other photographs including oblique photographs taken of the same region but from different directions. Moreover, there is a need for and it would be advantageous to have a method for building three dimensional objects based on accurate metrological techniques so that the three dimensional objects are viewed and manipulated in a separate display window and/or exported to other computer applications in a standard format. Furthermore, there is a need for and it would be advantageous to have a method for cropping facades from oblique photographs and incorporating the facades

with the three dimensional objects as virtual three dimensional models of physical objects.

REFERENCES:

http://en.wikipedia.org/wiki/Photogrammetry

The term "geographic coordinates" as used herein refers to a pair of coordinates, position coordinates or angular coordinates, *e.g.* latitude and longitude, which determine a geographic location, typically on the surface of the planet Earth. The term "geographic region" or "region" as used herein includes man-made physical objects, such as buildings and roads. Similarly the term "geographic measurements" includes measurements of man-made physical objects as well as natural terrain. The term "world coordinates" or "three-dimensional coordinates" as used herein refers to geographic coordinates and a third coordinate, *e.g.* elevation, which determine a position on or above the surface of the Earth or any other world. The term "oblique" as used herein refers to a direction which is not a principal axis of a physical object being photographed, typically not orthogonal nor parallel to the ground. The term "physical object" refers to an object in real space such as a building. The term "object" or "three-dimensional object" as used hereinafter refers to a virtual object such as a data structure *e.g.* vector object which overlays in part an image of a physical object. The term "entity" or "three dimensional entity" is used herein to refer to at least a portion of an image of a physical object. The term "below" as used herein refers to a projection to lower elevation. For example, a point (X,Y,0) is below (X,Y,Z). The term "display over an image" as used herein refers to display as a layer over a digital image. In the present invention an "object" is displayed as a layer over an entity. The term "photography" or "photograph" as used herein includes any type of photography used in the art including film, digital photography, *e.g.* CCD, and video photography. The terms "digital terrain model" and "digital elevation model" are used herein interchangeably.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method for processing in a computer digital images stored in the computer. The digital images are derived from respective photographs of a geographic region. The photographs were photographed from a number of directions. A first image is displayed which

corresponds to a first photograph which was photographed at an oblique angle. Another digital image is simultaneously displayed of the same region. Upon selecting an image point in the first image, a corresponding image point is synchronized in the other digital image. The selected image point in the first image and the corresponding synchronized image point in the other image have identical world coordinates. Preferably, prior to the synchronization for at least one of the respective digital images, camera coordinates are calculated of the photographs based on three or more control points in the respective digital images. The geographic coordinates of control points are previously known Alternatively, world coordinates are simultaneously calculated for the image point and the corresponding image point. Preferably, an exportable object is created by selecting other image points in one or more of the displayed digital images. Preferably, synchronizing includes iteratively estimating geographic coordinates of the selected image point, an estimated elevation value is received from a digital elevation model of the region based on the estimated geographic coordinates. The digital elevation model is previously stored in memory of the computer, and respective camera coordinates of the first photograph and the other photograph are previously determined. Preferably, a raster digital elevation model is stored in memory of the computer. Upon inputting any geographic coordinates to the raster digital elevation model, the raster digital elevation model returns a corresponding elevation value. Preferably, prior to the synchronization of one of the digital images, three or more control points are selected in the digital images, and respective geographic coordinates of the control points are previously determined. Respective elevation values are obtained from the raster digital elevation model. Camera coordinates are calculated of the camera which photographed the photographs based on the control points. Preferably, a photograph direction is determined of one or more digital images, the photograph direction is determined by a vector between a camera position of the digital image to the selected image point; and digital images are chosen based on comparing a geographic direction to the photograph direction. Preferably, a a measurement is performed in one or more displayed images between a first image point and a second image point, by selecting an image ground point below the first image point; calculating at least one world coordinate in a vertical line segment, and the vertical line segment extends vertically from the image ground point. Upon selecting the first image point on the vertical line segment, a world coordinate is calculated at the first image point based on world coordinate in the

vertical line segment. Preferably, when the measurement is a horizontal distance measurement, the second image point is selected to calculate geographic coordinates of the second image point. Preferably, when the measurement is a vertical distance measurement, the second image point is selected to calculate an elevation of the second image point. Preferably, when the selected image point is on a three dimensional entity at least partially visible in the first image, and different views from different directions of the three dimensional entity are displayed, image points are selected on the three dimensional entity in the different views, thereby synchronizing the other image points in the displayed images, and a three dimensional object is displayed.

According to the present invention, there is provided a method for performing a measurement related to an image point in a digital image using a computer which stores and displays the digital image. The digital image was derived from a photograph taken at an oblique angle. An image ground point below the first image point is selected and one or more world coordinates are calculated in a vertical line segment which extends vertically from the image ground point. Upon selecting the first image point on the vertical line segment, at least one world coordinate is calculated at the first image point based on the world coordinate in the vertical line segment. Preferably, the vertical line segment is displayed over the displayed image. Preferably, the calculation includes iteratively estimating geographic coordinates, an estimated elevation value is received from a digital elevation model based on the estimated geographic coordinates, the digital elevation model is previously stored in memory of the computer, and respective camera coordinates of the photograph are previously determined. Preferably, upon selecting a second image point related to the measurement, at least one world coordinate is calculated of the second image point.

According to the present invention there is provided a method for building three dimensional models in a computer, wherein digital images are stored in the computer. The digital images are derived from respective photographs of a geographic region. from a number of directions. Displayed digital images are chosen from the stored digital images and simultaneously displayed. The displayed digital images each include at least a partial view from a different direction of a three dimensional entity. Image points are selected on the three dimensional entity in one or more of the displayed digital images thereby synchronizing other image points in other displayed digital images, and a three dimensional object is displayed. Preferably, the image

points are vertices of facades of the three dimensional object, the three dimensional object is built while preserving connectivity of the facades from two or more of the displayed digital images. Preferably, the image points include a plurality of vertices of the facades of the three dimensional entity. The facade are cropped as respective polygons with the vertices, by calculating world coordinates respectively of the vertices. The facades are pasted onto the three dimensional object to incorporate the facade in the three dimensional object. Preferably. the three dimensional object is exported to a new display window, another application of the computer or to a standard format. Preferably, for at least one of the image points, an image ground point is selected below the image point, a world coordinate is calculated in a vertical line segment which extends vertically from the image ground point. Upon selecting the image point on the vertical line segment, a world coordinate is calculated at the image point based on the world coordinate in the vertical line segment. Preferably, for at least one of the image points, geographic coordinates are iteratively estimated , an estimated elevation value is received from a digital elevation model of the region based on the estimated geographic coordinates, the digital elevation model is previously stored in memory of the computer, and respective camera coordinates of said photographs are previously determined.

According to the present invention there is provided, a program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform a method for performing the methods as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a prior art drawing of coordinate systems used in photogrammetric calculations

FIG. 2 is an illustration of a prior art measurement method.

FIG 3 is a flow diagram of a method according to embodiments of the present invention;

FIG 4a is a simplified drawing of an image an orthogonal map as displayed on a computer display;

FIG 4b is a second view of the computer display after oblique images are selected, according to an embodiment of the present invention;

FIG 5 illustrates a method for choosing oblique photographs, according to an embodiment of the present invention;

FIG 6 is a simplified view of a computer display illustrating a method for building three dimensional models and cropping facades, according to an embodiment of the present invention; and

FIG 7 is an illustration of a cropped facade, according to an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a system and method for providing measurements and three dimensional models based on two dimensional oblique photographs. Specifically, the system and method includes a photogrammetric computational solution combined preferably with a raster digital elevation model. The use of a raster digital elevation model as opposed to a TIN model, for instance, allows retrieving of elevation values rapidly without undue computational overhead making it possible to rapidly reference world coordinates from one oblique photograph to another of the same region. Once different views of the same region are registered together on the same display, the operator may build three dimensional virtual models of the entities visible in the oblique images.

It should be noted, that although the discussion herein relates to typically to photography of resolution of about 1 meter and digital terrain models of resolution of tens of meters, the present invention may, by non-limiting example, alternatively be configured as well using a different range, a higher or a lower range of resolutions.

Before explaining embodiments of the invention in detail, it is to be understood that the invention is not limited in its application to the details of design and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

By way of introduction, principal intentions of the present invention are: to provide a computerized method of choosing oblique digital images of a single

geographic region from a large number of digital images of many typically adjacent and overlapping geographic regions stored in a memory of the computer. Once appropriate oblique photographs are chosen, another intention of the present invention is to provide a method for selecting a point in one of the displayed two dimensional oblique digital images and synchronize, in other displayed digital images, image points with the same world coordinates. Another intention of the present invention is to provide accurate measurement methods for horizontal, vertical, and air distance measurements on oblique digital images. Another intention of the present invention is to allow the operator to build virtual exportable objects of scaled dimensions which correspond accurately to the dimensions of the entities of interest in the oblique digital images. Another intention of the present invention is to crop facades from two or more of the oblique digital images and incorporate the facades with the three dimensional objects to build functional three dimensional virtual models of the physical objects originally photographed.

The present invention is applicable in many fields including tax assessment and building code violations, urban and infrastructure planning, land registry and management, military security, anti-terror and special forces operations, emergency and first response of emergency workers, critical infrastructure management such as of airports, seaports, mass transit terminals, power plants and government installations.

The principles and operation of a system and method of providing measurements and three dimensional modeling based on two dimensional oblique photographs, according to the present invention, may be better understood with reference to the drawings and the accompanying description.

Referring now to the drawings, Figure 3 is a flow diagram of a process **30** illustrating several embodiments of the present invention. Process **30** begins with storing oblique photographs (step **301**) in memory of a computer. Typically, the number of stored oblique photographs may exceed several hundred thousand. A digital elevation model (DEM) is stored (step **309**). Preferably, the DEM is a raster DEM. Typically, a conventional map or orthogonal photographs of the same geographic region is also stored (step **307**) in the computer. The oblique photographs, whether generated using traditional film photography or using digital photography are internally oriented (step **303**) and externally oriented (step **305**) for instance as previously described. Steps **301-309** are included as part of pre-processing (step **31**)

required for embodiments of the present invention. Reference is now also made to Figures 4a and 4b, which illustrate embodiments of the present invention. Once pre-processing **31** is complete, an operator using an application, preferably installed on the computer using a program storage device, displays (step **311**) on a computer display attached to the computer, a portion of map or orthogonal photograph **40** of interest. The operator is interested in a point **401** of orthogonal photograph **40** and the operator selects point **401** using an input device attached to the computer, *e.g.* a mouse click. Particular oblique digital images **42N,42S, 42E** and **42W** derived originally from oblique aerial photographs are chosen (step **315**) from among the many, *e.g* 100,000 stored oblique images and displayed (step **317**) preferably each in an individual display window on the computer display. Typically, digital images **42** are positioned (step **317**) in the respective windows so that entities **44** with world coordinates corresponding to point **401** are in the center of the windows. Similarly orthogonal photograph **40** is preferably centered around point **401.** The user may manipulate images **42** using a zoom (step **321**) hand tool (step **322**) and/or marker tool (step **323**) . Zoom (step **321**) magnifies the image within the window and the hand tool (step **322**) shifts image **42** within the window. Marker tool (step **323**) is used, for instance, by dragging mouse over one image **42** and synchronous changes occur in other images **42** that are displayed in the other windows.

According to embodiments of the present invention, an image point is selected in one of the displayed oblique images **42** and the application is required to synchronize, for instance to mark (step **323**) corresponding image points in the other displayed images with the same world coordinates as the selected image point. Synchronization from oblique image **42** requires an inverse solution of the collinearity equations. The inverse solution is typically performed iteratively. When an image point is selected in oblique image **42,** the interior orientation is used to obtain photograph coordinates (x_p, y_p). The photograph coordinates are used as a basis to estimate initial values for entity geographic coordinates (X_t, Y_t) in world space. The estimated geographic coordinates are used to obtain an elevation value Z_t from the stored DEM raster (step **309**). The elevation value obtained from the DEM is then used to obtain a next iteration for geographic coordinates. Since the inverse solution process is iterative, there is an advantage to use a DEM raster, rather than for instance a DEM based on a TIN model, because using the TIN model requires interpolations to

find each new elevation value and therefore the computation with a TIN based DEM is more time consuming. Since the TIN model is based on irregular points and for any particular set of geographic coordinates, considerable time is required to find the correct triangle that should be used to calculate the elevation coordinate.

Digital Elevation Model (DEM) Raster (step **309**)

The DEM Raster image is used to calculate the elevation (*Z*) value of a given (*X,Y*) geographic coordinate, according to embodiments of the present invention. The raster dimensions depend on the desired geographic region and on the resolution desired by the operator. Each pixel in the raster "covers" an area of $r \times r\ [m^2]$ in world space, and has a gray value that represents the height of the terrain in the middle of this square, When the gray value is lower, the shade is lighter and the elevation higher. The gray scale is chosen by the minimum and maximum elevations of the known terrain points. When there is a need to calculate the *Z* value for a specific *X,Y* coordinate, three pixels from the raster are chosen, in such a way that *X,Y* falls inside the triangle formed by the three pixels and these three pixels are the closest available points to *X,Y*. The elevation (Z) values of the three points are calculated from the respective gray values. Using the three points in 3D world space, namely $x_1, y_1, z_1\ x_2, y_2, z_2\ x_3, y_3, z_3$ a plane is determined. Two vectors are chosen between the points to form two vectors. A cross product computes the normal to the plane, and the elevation value of the requested (X,Y) is determined.

The DEM raster is created (step **309**) based on a collection of known world coordinates, for example in ASCII file. The first step in the creation of the raster is to determine the raster borders and the desired resolution. The dimensions of the raster are then determined and an array in memory is allocated. .

By iterating over the pixels in the raster, each pixel j,i is given a gray value based on the known points in the following way:

x,y world coordinate for the pixel is calculated by linear transformation using the width, height and resolution of the raster. The XY plane is divided into a number of pieces, for instance, eight pieces, and n closest points in each piece are determined,

Good results are typically achieved by choosing n > 3. Each point found is weighted with respect to its distance from point x, y and the weighted average is computed for obtain a z value. The z value is assigned to a value in gray scale and assigned to pixel j, i in the raster. An example of a weight function can be $\frac{1}{e^{d/50}}$, where d is the distance to x, y.

Image model:

The format of the stored digital information used is preferably Enhanced Compressed Wavelet (ECW), an image format that allows compression of imagery up to 50:1 with minimal visual loss of information. One of the main issues with ECW (and similar products) is the length of the time period between requesting a portion of image **42** and receiving the requested image portion. There are certain situations when new information is rapidly needed from the ECW file including when the zoom tool (step **321**) or mouse wheel is used to change zoom level, when the hand tool (step **322**) is used and/or the marker tool (step **323**). The software holds in memory the last view displayed from ECW per window j.

This image, I_j, is modified each time new information arrives from the ECW file, and its size is the same as the size of the window. The software also holds a copy of the full image with decreased resolution,usually, it is loaded from the jpeg file, but if the jpeg file is is missing, the image is calculated from the ECW file.

Zoom tool (step **321**):

When using the mouse wheel to zoom, the center of the image displayed will remain, In order to react quickly to a user action, the application will request the correct portion with the correct zoom to be displayed., but until this information arrives, the application preferably calculates sub image from I, to be displayed.

In the case of zooming in, the application takes I and enlarges it to fill the entire window. In the case of zooming out, the application takes I and calculates a smaller view of it to be displayed. In this case, the borders of the view are missing. When new information arrives the new information is displayed in the window. If another zoom action, *e.g.* mouse wheel is turned, before ECW information arrival, the earlier request is aborted, a new request is processed and displayed from I.

Hand tool (step **322**):

When a user "drags" the view, a portion of the image I is copied and displayed in the right location, while waiting for ECW information. Again if, another interaction with the tool is done by user, the old request will abort a new request will be initialized and another calculation form I will be carried and displayed.

Marker tool (step **323**):

When using marker tool (step **323**) on one window, all other windows choose (step **315**) an image **42** to be displayed, and display (step **317**) a respective images **42** in the windows according to current zoom level and window size. Preferably, images **42** of all windows are synchronized so that entity **44** is seen from different images **42** in all the windows. The user can use marker tool (step **323**) for instance by either clicking on a window, or by moving the mouse in the window while the left button is held pressed. Both cases are the same in the manner, that the user needs to click on the mouse left button and then move the mouse (zero movement in the second case) and release the mouse button. When user clicks on the mouse button and as long as there is mouse movement, the software displays a decreased resolution version of the images. Finally when the user releases mouse button the software will request the information from the ECW files and display (step **317**) What we gain by doing this is the speed in which the software reacts to using the tool, Of course, quality of the displayed view is less, which is more noticeable as zoom level increases. Preferably, if user holds the mouse button pressed, but does not move the mouse for short period of time, a request to ECW file is made, so the ECW is displayed.

Image Choosing (step **315**) **and centering** (step **317**) :

When using marker tool **323,** in one of the display windows, all the other display windows choose appropriate digital images **42** in each of the other display windows. Digital images are chosen (step **315**) based on zoom level, and display window size.

According to embodiments of the present invention, all windows are synchronized so that the same entities **44** are visible from different digital images **42**

in all the windows. Preferably, digital images **42** are chosen (step **315**) to include all available views from different directions.

Reference is now made to Figure 5, which illustrates a method of choosing (step **315**) digital images **42**, according to an embodiment of the present invention. Let n be the number of oblique windows,(n=4 in the example shown in Figure 4b). The XY plane is virtually split into n pie pieces **501** and each piece **501** is fit to one of the display windows. The goal is to display images **42** in window i, such that images **42** were photographed from a camera direction P that falls into the ith piece **501** in the pie. Camera direction P is the direction from camera X_c, Y_c to entity **44** of interest displayed in the center of the window, positioned in world coordinate X_t, Y_t. In Figure 5, six camera directions P1-P6 are shown for different stored oblique photographs. Only three of the four pie pieces **501** have appropriate directions. When using marker tool **323** on orthogonal image **40**, the X,Y world coordinate is calculated by, a simple linear transformation, from mouse position, with respect to the current view, image portion, and current size of window. Our main concerns here are how to choose different oblique image **42** for each window, and for a given image and window calculate which image point should be displayed at the center of the window. When using marker tool **323** on oblique windows, first we need to find the image point to which the mouse cursor is pointing, this again is done by a simple transformation from mouse coordinate to image coordinate X_i, Y_i. Then given X_i, Y_i we need to find the matching terrain coordinate X_t, Y_t. Once we have this, the process of choosing images **42** for other windows, and centering them is similar to the case of using marker tool **323** on orthogonal photograph **40**. Assume that we have X_t, Y_t geographic coordinate and wish to choose oblique images **42** to be displayed in a certain window. For each oblique image **42** in memory, the direction from camera position is calculated, X_c, Y_c to X_t, Y_t. If the camera direction suits the defined window direction than the distance from camera X_c, Y_c, Z_c to physical object X_t, Y_t, Z_t is calculated. Among all images **42**, chosen image **42** will be the one with minimum distance. Once an image **42** is chosen, a center image coordinate X_i, Y_i to is centered in the window by using the collinear equations to receive photograph

coordinate X_i, Y_i, and the interior orientation with X_p, Y_p to receive image coordinate X_i, Y_i The only remaining problem now is how to find terrain coordinate, X_t, Y_t by giving an oblique image coordinate X_i, Y_i. To solve this problem, we do the following: The average elevation of the DEM, Z_m, is calculated in advance (in raster creation step **309**) X_p, Y_p is calculated by interior orientation from X_i, Y_i. We calculate Xt_1, Yt_1 by using Z_m, X_p, Y_p in the collinear equations. By using the raster we calculate Zt_1 from Xt_1, Yt_1. If the absolute value of $Zt_1 - Z_m$ is smaller than a certain threshold than Xt_1, Yt_1, Zt_1 is used. Otherwise we iteratively repeat the process with Zt_1, X_p, Y_p this time receiving Xt_2, Yt_2, Zt_2 and checking the absolute value of $Zt_2 - Zt_1$ and so on. The process usually converges after 4-5 iterations.

According to another embodiment of the present invention, image choosing (step **315**) is performed using a special data base which is set up during pre-processing **31.** For each oblique photograph stored in memory, a specific area in the shape of a trapezoid is covered on the stored orthogonal photographs/map. The trapezoidal shape arises from the perspective distortion of oblique images. An efficient data base structure is set up so that for a specific query including geographic coordinates *X,Y,* the data base returns the specific trapezoids that include *X,Y.*

Layer model:

According to embodiments of the present invention, the application maintains layers of information over images **40** and/or **42.** A layer of information is overlaid and optionally displayed over oblique images **42.** When a layer object is initialized, the object receives as a parameter the size of the underlying image **40** or **42.** Each layer object currently can include for instance, lines, *e.g.* vectors, points and/or text. Preferably, layer data is read and displayed over a portion of the oblique image **42** using a minimum of processor time because the user frequently changes the viewed portion of image **42.**

Each line in the system can be segmented or not segmented over the image. When segmented a vector is composed by n image lines where each image line has coordinates $Xi_j, Yi_j, Xi_{j+1}, Yi_{j+1}$ in image space, where $1 \le j \le n$. The vector is

segmented to n world lines, each such line (except the last) Xw_j, Yw_j, Zw_j , $Xw_{j+1}, Yw_{j+1}, Zw_{j+1}$ has an air distance of 1m, (this number can be changed to other values for different segmentation resolution) and transformed to Xi_j, Yi_j , Xi_{j+1}, Yi_{j+1} by using exterior and interior orientations. Zw_j, Zw_{j+1} are either taken from DEM or calculated from the line equation defined by line Xw_1, Yw_1, Zw_1 , $Xw_{n+1}, Yw_{n+1}, Zw_{n+1}$ depending on need. Image **42** is segmented by itself to 2D blocks and each image line is mapped to one or more blocks depending on its location in image space. If the image line falls in more than one block the image line is segmented to blocks by simply segmenting the image line to few pieces for matching blocks.

Displaying a portion of layer information, is performed by calculating and displaying blocks which are fully or partly visible on the current view. In this way, image lines that are referenced usually also need to be drawn. As the current zoom level is increased fewer blocks need to be drawn (fewer lines in the view) which gives high responsiveness to user requests to change the portion of image viewed. As zoom level decreases more blocks need to be drawn and when the view holds the entire image **42**, all blocks should be drawn. In such a case many or all lines in the layer should be displayed and therefore responsiveness to user actions can suffer, depending on number of visible image lines. Preferably, to mitigate this problem when the application notices a user action with only a portion of image **42** viewed, while in the process of drawing a layer, the layer drawing process is aborted, and drawing of image **42** is processed instead. When zoom level is relatively high, aborting is not necessary, since the drawing is performed relatively quickly.

Alternatively, a relatively small raster image is be transparent in background and opaque with image lines. When the zoom level is relatively low, this raster can be drawn quickly over another image This method improves greatly the responsiveness to user actions, because drawing time does not longer depend on the number of lines in the layer. Notice that since the zoom level is low, accuracy of image lines coordinates is of less importance. A disadvantage to this method is the fact that this raster must be updated when layer information is changed. For example when user deletes/adds line from/to the layer.

Layers organization:

Layers are organized in blocks. Each block contains one or more layers.

The blocks are ordered, and also layers inside each block are ordered When image **42** is loaded, image **42** is initialized to hold only one block, a system layer that cannot be deleted by the user. Preferably, the user is able to import and associate one or more dxf files with image **42.** When the dxf file is imported all layers in the file are loaded to a new block. This method of layers organization enables easy manipulation of the following features: Hiding/Displaying all layers of certain block, changing the painting order of blocks and layers inside blocks, removing a layer or a complete block of layers, exporting blocks of layers to a file, removing a certain block.

For example, to achieve changing the painting order, we need only to change the order in which blocks of layers are organized in memory.

Layers painting:

When new information arrives from ECW file, layers information is preferably displayed over image information, and then displayed in the display window. The process of painting is performed in the following manner: The ECW information arrives and painted to a bitmap B_0. Each layer i, in turn, is painted over bitmap B_{i-1} .

When the user uses the hand tool or the zoom tool, new information is requested from the ECW file. In the time between the request and the arrival of image information, the image model described above is used to paint the window with a temporary image that is constructed from the last information that arrived from the ECW file

Assume new information is arriving with a specific zoom level; this information is at least a portion of the full image. The upper left coordinate on the arriving image portion is taken from the full image at coordinate tlx,tly and the bottom left is taken from coordinate brx,bry these coordinates with certain zoom level were requested from ECW previously.

In order to be react quickly to user requests for instance while the user is rapidly using the hand tool, layers should be painted quickly. If layers information is large and zoom level is low considerable time is required.

A number of techniques are used to reduce this time delay and to improve reaction to user requests:

-Layer painting is performed according to blocks that are visible in the requested view. This means that most objects that are going through iteration when the layer is in painting process, are actually objects that should be painted eventually. Exceptions to this rule are objects that fall in partially visible image blocks.

-When the view requested occupies a relatively big portion of the complete image (i.e $brx - tlx > c_1, bry - tly > c_2$) and the user interacts with the tools above, layer painting process is stopped , and the view is painted with layers that were painted so far.

-When the view requested occupies relatively small portion of the complete image, (i.e $brx - tlx < c_1, bry - tly < c_2$) usually only small amount of layers information is needed, therefore painting is processed quickly and stopping the painting process is not necessary.

-In order to achieve even better results (from a user point of view) another raster image per image should be maintained to hold a complete drawing of the layer. This raster image should be relatively small in size (one way is to use the jpeg size), and should be constantly edited when the layer is behind edited - an object is added , deleted or edited.

Each layer can use its raster for painting instead of iterating through many image blocks, which potentially might contain many objects. The raster image should be with transparent background, so painting such an image over another image will paint only the entities.

System layers for measuring tools (step 319) :

The following measurements (step **319**) are performed according to embodiments of the present invention each in a different layer: horizontal measurements, vertical measurements, vertical rectangle measurements, terrain segmented measurements, air distance – horizontal and diagonal measurements. For each of the layers, there is a specific tool that is used to insert new lines to the respective layer. Reference is now made again to Figure 4b. The user wishes to perform a horizontal measurement between image points **403** and **405,** according to an embodiment of the present invention. Three selections, *e.g.* mouse clicks are performed to achieve the horizontal measurement. A ground point **407** is selected on the ground below the image point **403.** The second mouse click is on image point **403,**

and the third mouse click is on image point **405.** The first click is used to determine the terrain coordinates X_1, Y_1, Z_1 on ground point **407** below the image point **403.** When the first click is performed, a vertical line **409** preferably appears that begins from the X_1, Y_1, Z_1 and extends vertically upward. Since X_1, Y_1 is known after first click, calculating vertical line **409** is performed by using the collinear equations n times, each time with X_1, Y_1, Z_i where $Z_i = Z_1 + \Delta z \cdot i$, to receive Xp_i, Yp_i (Δz is a small constant) The second click is on vertical line **409**. When clicked we have the image coordinates Xi_2, Yi_2, which are transformed to Xp_2, Yp_2 by using the interior orientation. Now we use Xp_2, Yp_2 and X_1, Y_1 in C.E to receive Z_2 (the height of the image point **403**). Now we have X_1, Y_1, Z_2 which are the world coordinates of image point **403.** The third click is on image point **405** and gives us Xi_3, Yi_3. Again using interior orientation we receive Xp_3, Yp_3. we use Xp_3, Yp_3 and Z_2 with C.E to receive the world coordinates X_3, Y_3, Z_2 of image point **405.** Notice that we use Z_2 on the second measured coordinate. This is a good assumption when we deal with small distances that are known to be horizontal.

A vertical measurement, according to an embodiment of the present invention is performed similarly to the horizontal measurement. The user wishes to vertically measure between image point **413** and image point **415.** The user first selects, *e.g.* by mouse click on an image point **411** on the ground vertically below image points **413** and **415.** The world coordinates of ground point **411** are calculated using the collinearity equations. Vertical line **409** is displayed in a layer over image **42S.** The user then selects image point **413** followed by image point **415.** The X,Y world coordinate is the same for all 3 clicks , and in the second and third click, we calculate only elevations from this coordinate (in similar manner to the horizontal tool)

A vertical rectangle measuring tool is used to measure small rectangles that are known to be vertical to the terrain (*e.g* measuring street signs) Four image point selections are required with the first selection on the ground. The three first selections are the same as in the vertical measurement The first click on the ground brings up vertical line **409** and second and third click are on vertical line **409** for instance on corners of a street sign. The fourth click, for instance on another corner of the street sign calculates all the world coordinates of the street sign.

A terrain measuring tool is used to measure terrain distances. Two selections are on two image points on the terrain. Terrain coordinates X_1,Y_1,Z_1 , X_2,Y_2,Z_2 are calculated. A new line is inserted into the layer with segmentation over the terrain, the distance of each segment is calculated summed up to find the length of the path.

An air distance measure tool is used to calculate air distances between two coordinates. Two image point selections are used. Terrain coordinates X_1,Y_1,Z_1 , X_2,Y_2,Z_2 are calculated for the selections. Air distance X_1,Y_1-X_2,Y_2 is calculated for the horizontal air layer and the distance X_1,Y_1,Z_1-X_2,Y_2,Z_2 is calculated for the diagonal air layer.

According to embodiments of the present invention, world coordinates are accurately obtained by selecting on different images **42** synchronized image points which have the same world coordinates, and calculating simultaneously using the two or more sets of collinearity equations, for the world coordinates. For example, referring again to Figure 4b, the user selects the point of the cone on entity **44S** and **44W.** Two sets of collinearity equations are solved simultaneously to accurately determine the world coordinates of the point of the cone.

Build layer object (step **325)**

After the process of the orientations, i.e. 3D photogrammetric model is complete we can use the model for measuring facades and building layer objects (step **325)** in the photograph, by defining a discrete function from world coordinates to the matching image coordinates.

Reference is now made to Figure 6 which shows a simplified example of building (step **325)** a layer object **60,** according to an embodiment of the present invention. Preferably, the window showing the orthogonal photograph **40** is closed or placed in the background. A new display window **61** is opened. Window **61** is scaled according to geographic coordinates. Different facades of entity **44** are labeled with letters A-E. A layer object such as a rectangle is displayed obliquely over each facade. When the layered rectangle coincides with the facade, the layered rectangle is copied to window **61.** By repeating for all facades A-E, layered object **60** is built (step **325).**

Cropping facades (step **333)**

The cropping of facades is available, since the facade polygon in world coordinates is mapped into a polygon in image space. The polygon may be be cropped if the world coordinates of the vertices of the polygon are known. In Figure 6, facade A is cropped (step **333**) and pasted (step **335**) onto layer object **60.**

Figure 7 shows an example of a cropped facade taken from an oblique image. Points A and B are vertices with known world coordinates, and since this facade is a rectangle in the real world, knowing A,B is sufficient for knowing the entire facade location. The cropped facade is saved to an image file such as bitmap (bmp) , jpeg (jpg) or tiff. Together with the image file the world coordinates of the vertices are saved creating the facade.

Handling a single facade is relatively straightforward, but what about cropping (step **333**) the facades of entire building? What is a building? A building is a group of facades connected together. For any given photograph, some of the facades of some buildings are occluded by others. Therefore for a complete model, multiple photographs are required from all directions of the buildings. Assuming we have all the required images from all directions with the orientations known. One can measure facades in each of the images and crop the "best" facade from each image or direction.

In real life not everything is exact, in our case there could be small errors in orientations and positions between images **42**. Moreover, even if the orientations are exact, ability to measure facades with high accuracy is limited due to photograph quality, resolution and even mouse click errors. A mouse click error of one pixel of the image can represent a significant area in the real world. If the user measures facades from different photographs the facades will often not connect to each other. There will be gaps between each two neighboring facades. In order to avoid gaps in the virtual model, it is preferable, to build (step **325**) layer object **60** prior to cropping facades (step **333**) by *preserving connectivity* between all the facades that are connected in the building. In this way, systematic and/or random errors in process **30** are averaged out or minimized as best as possible.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

As such, those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

WHAT IS CLAIMED IS:

1. A method for processing in a computer a plurality of digital images stored in the computer, the digital images being derived from a plurality of respective photographs of a geographic region, wherein the photographs were photographed from a plurality of directions, the method comprising the steps of:

(a) displaying a first image of said digital images, said first image corresponding to a first photograph of the photographs; wherein said first photograph was photographed at an oblique angle;

(b) simultaneously displaying at least one other of the digital images corresponding to at least one other of the photographs; and

(c) upon selecting an image point in said first image, synchronizing a corresponding image point in at least one other of the digital images, wherein said selected image point in said first image and said corresponding synchronized image point in said at least one other image have substantially identical world coordinates.

2. The method, according to claim 1, further comprising the step of, prior to said selecting and said synchronizing, for at least one of the respective digital images:

(d) calculating camera coordinates of said at least one photograph based on at least three control points in said at least one respective digital image, wherein geographic coordinates of said at least three control points are previously known.

3. The method, according to claim 1, further comprising the step of:

(d) simultaneously calculating said world coordinates for said image point and said corresponding image point.

4. The method, according to claim 1, further comprising the step of:

(d) creating an exportable object by selecting at least one other image point in at least one of said displayed digital images.

5. The method, according to claim 1, wherein said selecting and said synchronizing include the step of iteratively estimating geographic coordinates of said selected image

point, wherein an estimated elevation value is received from a digital elevation model of the region based on said estimated geographic coordinates, wherein said digital elevation model is previously stored in memory of the computer, wherein respective camera coordinates of said first photograph and said at least one other photograph are previously determined.

6. The method, according to claim 1, further comprising the step of:

(d) storing a raster digital elevation model in memory of said computer, wherein upon inputting any geographic coordinates to said raster digital elevation model, said raster digital elevation model returns a corresponding elevation value.

7. The method, according to claim 6, further comprising the steps of, prior to said selecting and said synchronizing, for at least one of the digital images and at least one of the respective photographs:

(e) selecting at least three control points in said at least one digital image, wherein respective geographic coordinates of said at least three control points are previously determined and respective elevation values are obtained from said raster digital elevation model; and

(f) calculating camera coordinates of the camera which photographed said at least one photograph based on said at least three control points.

8. The method, according to claim 1, further comprising the steps of:

(f) determining a photograph direction of at least one of the digital images, wherein said photograph direction is substantially determined by a vector between a camera position of said at least one digital image to said selected image point; and

(e) choosing from the plurality of digital images at least one of the digital images wherein said choosing is based on comparing a geographic direction to said photograph direction.

9. The method, according to claim 1, further comprising the step of:

(d) performing a measurement in at least one of said displayed images between a first image point and a second image point, wherein said performing includes the sub-steps of:

(i) selecting an image ground point below said first image point;

(ii) calculating at least one world coordinate in a vertical line segment, wherein said vertical line segment extends vertically from said image ground point; and

(iii) upon selecting said first image point on said vertical line segment, calculating at least one world coordinate at said first image point based on said at least one world coordinate in said vertical line segment.

10. The method, according to claim 9, wherein said measurement is a horizontal distance measurement, said performing further includes the sub step of:

(iv) upon selecting said second image point, calculating geographic coordinates of said second image point.

11. The method, according to claim 9, wherein said measurement is a vertical distance measurement, said performing further includes the sub step of:

(iv) upon selecting said second image point, calculating an elevation of said second image point.

12. The method, according to claim 1, wherein said selected image point is on a three dimensional entity at least partially visible in said first image, wherein said displaying and said simultaneously displaying show a plurality of different views from different directions of said three dimensional entity, the method further comprising the step of:

(d) selecting in at least one of said displayed images a plurality of other image points on said three dimensional entity, thereby synchronizing said other image points in said at least one displayed image, and displaying a three dimensional object over said three dimensional entity.

13. A method for performing a measurement related to an image point in a digital image using a computer which stores and displays the digital image, the digital image

being derived from a photograph taken at an oblique angle, the method comprising the steps of:

(a) selecting an image ground point below said first image point;

(b) calculating at least one world coordinate in a vertical line segment, wherein said vertical line segment extends vertically from said image ground point; and

(c) upon selecting said first image point on said vertical line segment, calculating at least one world coordinate at said first image point based on said at least one world coordinate in said vertical line segment.

14. The method, according to claim 13, further comprising the step of:

(d) displaying said vertical line segment over said one displayed image.

15. The method, according to claim 13, wherein said calculating includes iteratively estimating geographic coordinates, wherein an estimated elevation value is received from a digital elevation model based on said estimated geographic coordinates, wherein said digital elevation model is previously stored in memory of the computer, wherein respective camera coordinates of said photograph are previously determined.

16. The method, according to claim 13, further comprising the step of

(d) upon selecting a second image point related to the measurement, calculating at least one world coordinate of said second image point.

17. A method for building three dimensional models in a computer, wherein a plurality of digital images are stored in the computer, the digital images being derived from a plurality of respective photographs of a geographic region, wherein the photographs were photographed from a plurality of directions, the method comprising the steps of:

(a) choosing from the plurality of stored digital images a plurality of displayed digital images and simultaneously displaying said displayed digital images each including at least a partial view from a different direction of a three dimensional entity;

(b) selecting in at least one of said displayed digital images a plurality of image points on said three dimensional entity, thereby synchronizing other image points in at least one other said displayed digital image, and thereby displaying a three dimensional object.

18. The method, according to claim 17, wherein said image points include a plurality of vertices of a plurality of facades of said three dimensional object, further comprising the step of:

(c) building said three dimensional object while preserving connectivity of at least two said facades displayed in at least two said displayed digital images.

19. The method, according to claim 17, wherein said image points include a plurality of vertices of a plurality of facades of said three dimensional entity, further comprising the step of:

(c) cropping said facades as respective polygons with said vertices, by calculating at least one world coordinate respectively of said vertices;

(d) pasting at least one said facade onto said three dimensional object, thereby incorporating said facade in said three dimensional object.

20. The method, according to claim 17, further comprising the steps of:

(c) exporting said three dimensional object to selectably either a new display window or another application of the computer.
[or another standard format.]

21. The method, according to claim 17, wherein for at least one said image point, further comprising the steps of:

(c) selecting an image ground point below said at least one image point;

(d) calculating at least one world coordinate in a vertical line segment, wherein said vertical line segment extends vertically from said image ground point; and

(e) upon selecting said at least one image point on said vertical line segment, calculating at least one world coordinate at said at least one image point based on said at least one world coordinate in said vertical line segment.

22. The method, according to claim 17, wherein for at least one said image point, further comprising the step of:

(c) iteratively estimating geographic coordinates of said at least one image point, wherein an estimated elevation value is received from a digital elevation model of the region based on said estimated geographic coordinates, wherein said digital elevation model is previously stored in memory of the computer, wherein respective camera coordinates of said photographs are previously determined.

23. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform a method for processing in a computer a plurality of digital images stored in the computer, the digital images being derived from a plurality of respective photographs of a geographic region, wherein the photographs were photographed from a plurality of directions, the method comprising the steps of:

(a) displaying a first image of said digital images, said first image corresponding to a first photograph of the photographs; wherein said first photograph was photographed at an oblique angle;

(b) simultaneously displaying at least one other of the digital images corresponding to at least one other of the photographs; and

(c) upon selecting an image point in said first image, synchronizing a corresponding image point in at least one other of the digital images, wherein said selected image point in said first image and said corresponding synchronized image point in said at least one other image have substantially identical world coordinates.

24. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform a method, for performing a measurement related to an image point in a digital image using a computer which stores and displays the digital image, the digital image being derived from a photograph taken at an oblique angle, the method comprising the steps of:

(a) selecting an image ground point below said first image point;

(b) calculating at least one world coordinate in a vertical line segment, wherein said vertical line segment extends vertically from said image ground point; and

(c) upon selecting said first image point on said vertical line segment, calculating at least one world coordinate at said first image point based on said at least one world coordinate in said vertical line segment.

25. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform a method for building three dimensional models in a computer, wherein a plurality of digital images are stored in the computer, the digital images being derived from a plurality of respective photographs of a geographic region, wherein the photographs were photographed from a plurality of directions, the method comprising the steps of:

(a) choosing from the plurality of stored digital images a plurality of displayed digital images and simultaneously displaying said displayed digital images each including at least a partial view from a different direction of a three dimensional entity;

(b) selecting in at least one of said displayed digital images a plurality of image points on said three dimensional entity, thereby synchronizing other image points in at least one other said displayed digital image, and thereby displaying a three dimensional object.

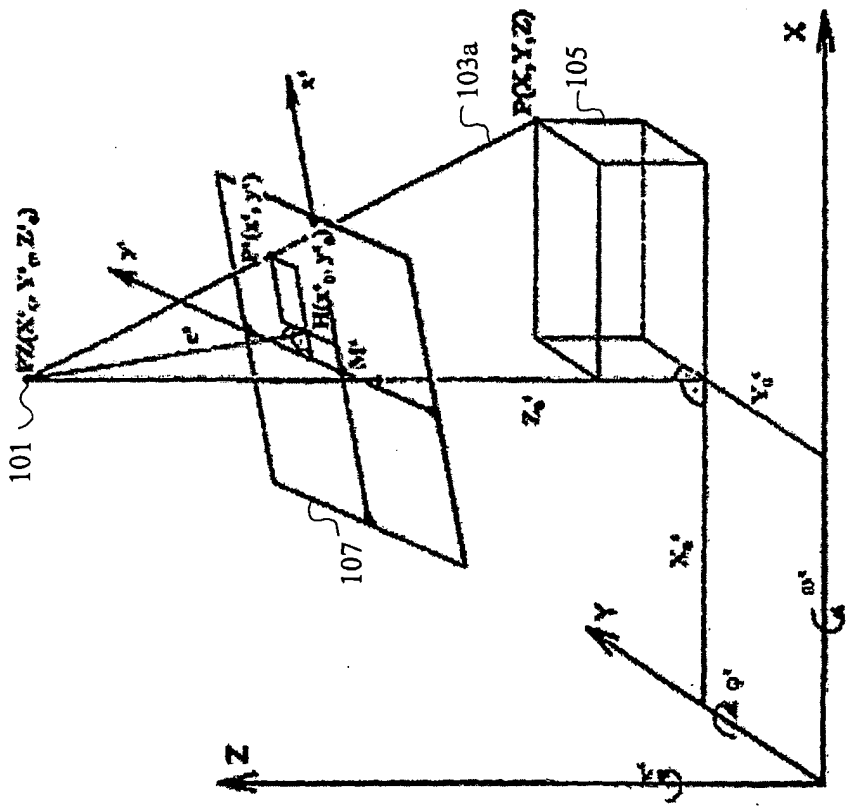


FIG. 1
PRIOR ART

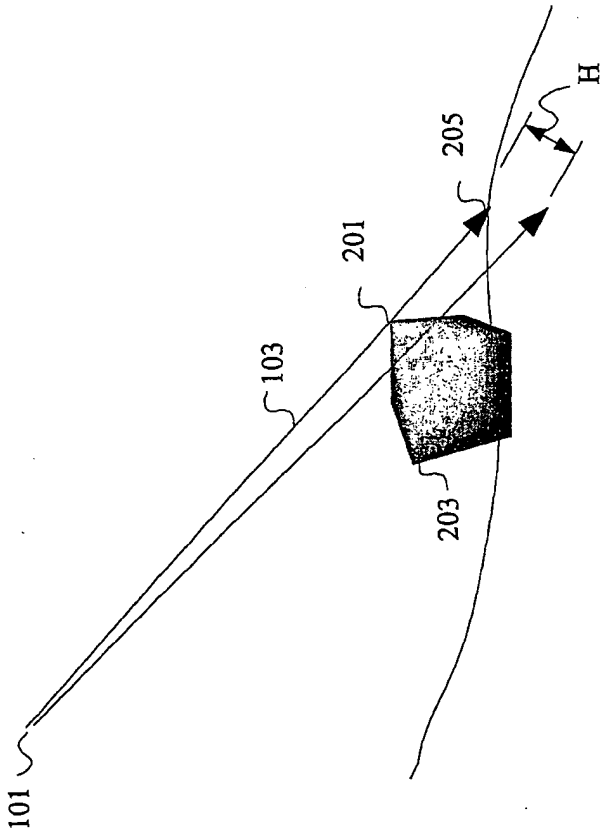


FIG.2
PRIOR ART

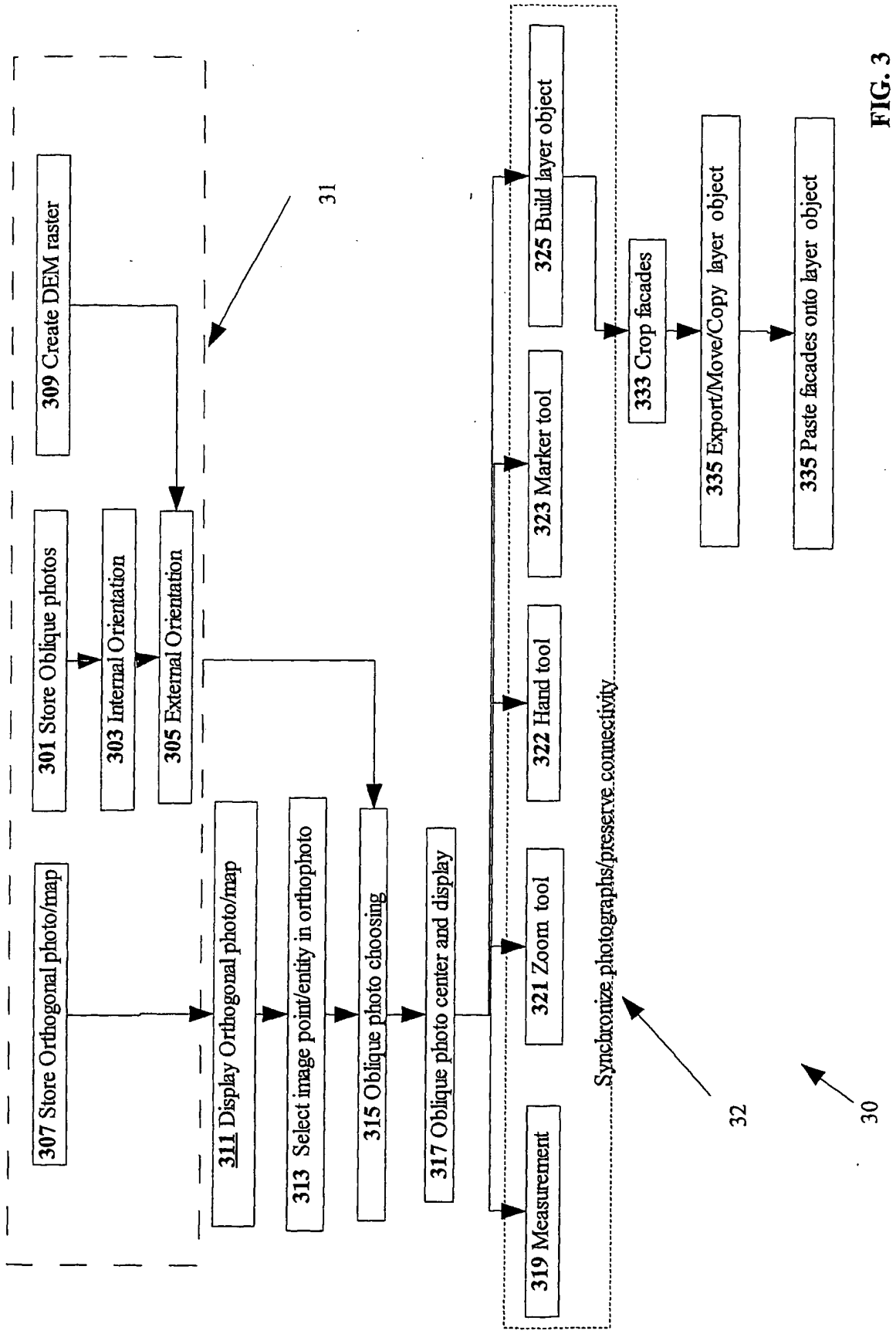

307 Store Orthogonal photo/map
301 Store Oblique photos
309 Create DEM raster
303 Internal Orientation
305 External Orientation
31
311 Display Orthogonal photo/map
313 Select image point/entity in orthophoto
315 Oblique photo choosing
317 Oblique photo center and display
319 Measurement
321 Zoom tool
322 Hand tool
323 Marker tool
325 Build layer object
333 Crop facades
335 Export/Move/Copy layer object
335 Paste facades onto layer object
Synchronize photographs/preserve connectivity
32
30

FIG. 3

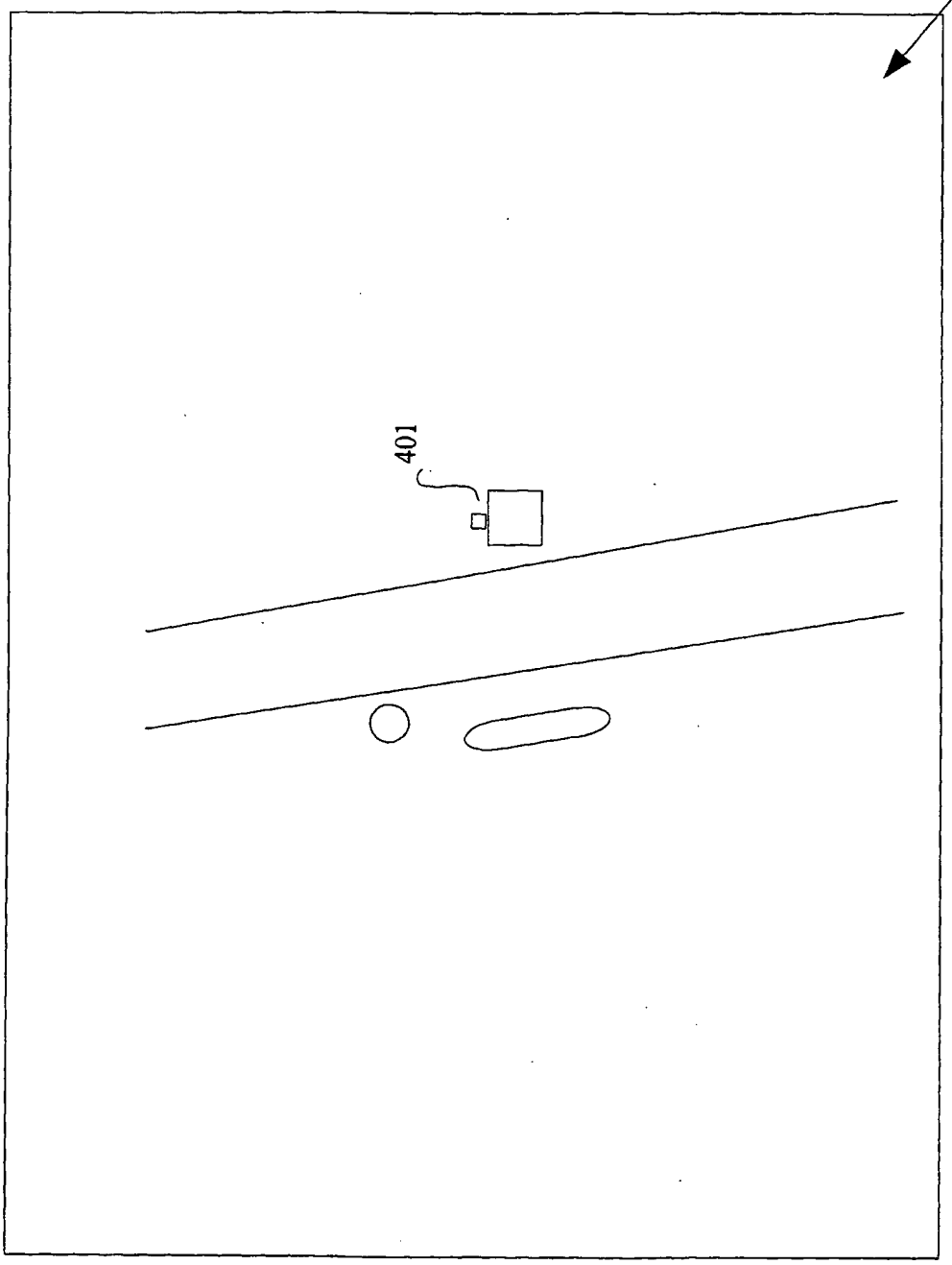


FIG. 4a

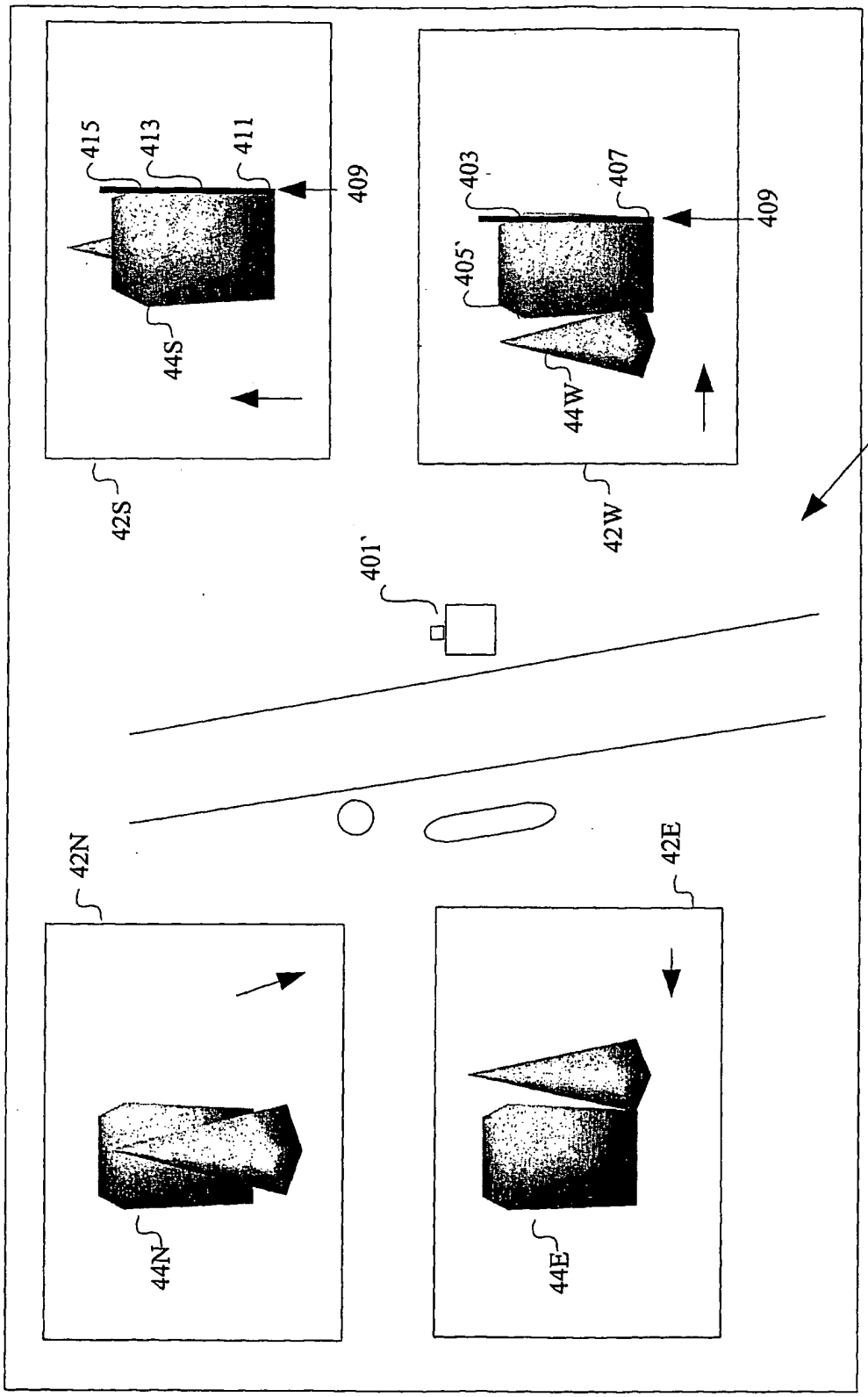
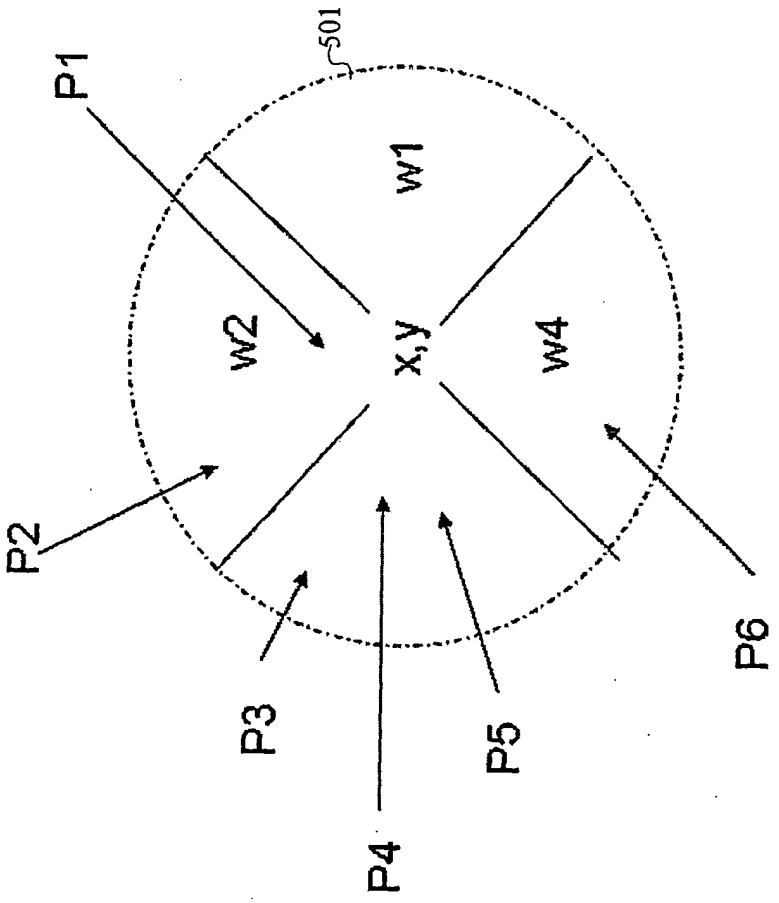

415
413
411
409
44S
42S
403
407
409
405'
44W
42W
40
401'
42N
42E
44N
44E

FIG. 4b

FIG. 5



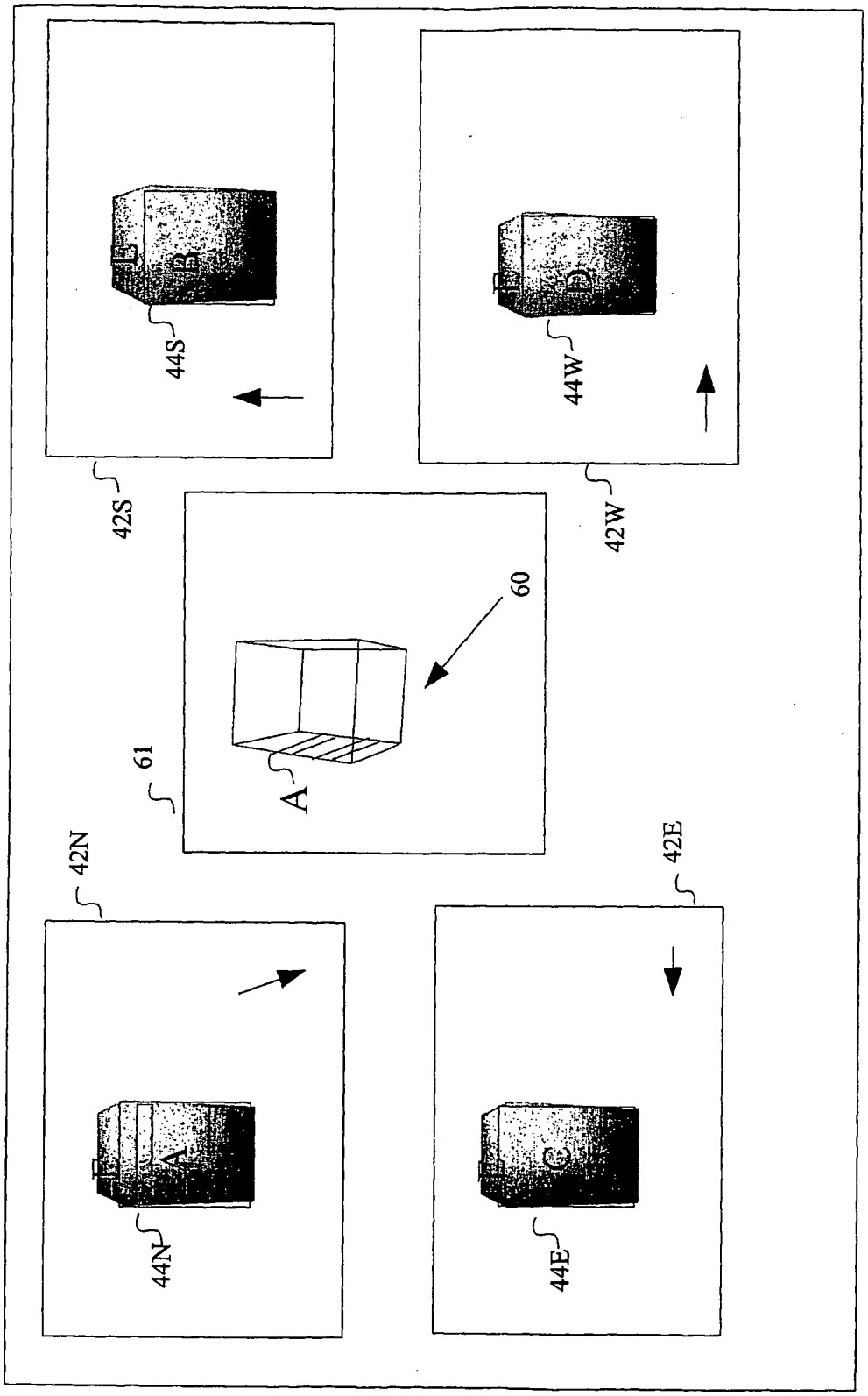
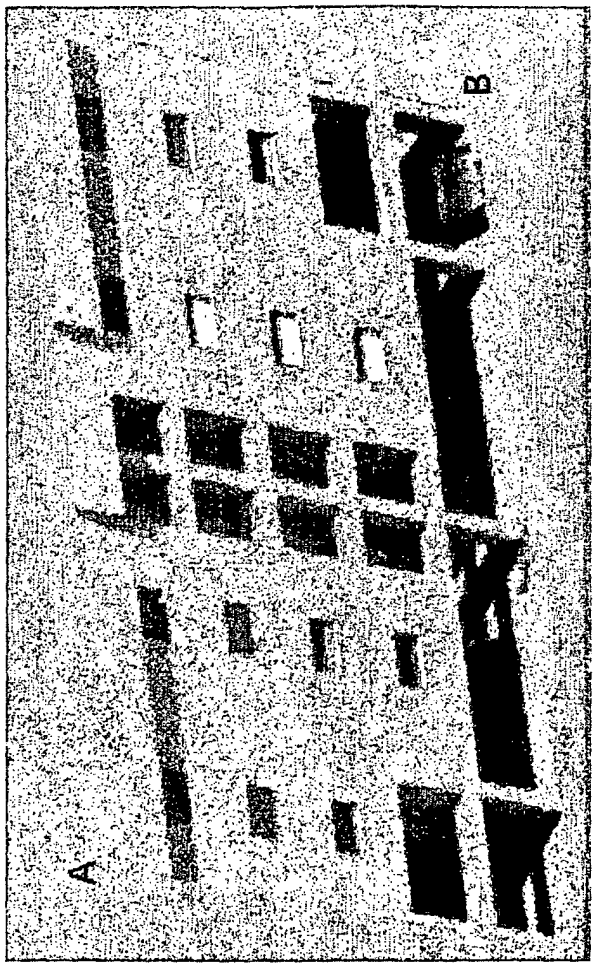


FIG. 6

FIG.7



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 April 2006 (20.04.2006)

PCT

(10) International Publication Number
WO 2006/040775 A3

(51) International Patent Classification:
H04N 7/18 (2006.01)

(21) International Application Number:
PCT/IL2005/001095

(22) International Filing Date: 16 October 2005 (16.10.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/618,578 15 October 2004 (15.10.2004) US
60/659,084 8 March 2005 (08.03.2005) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

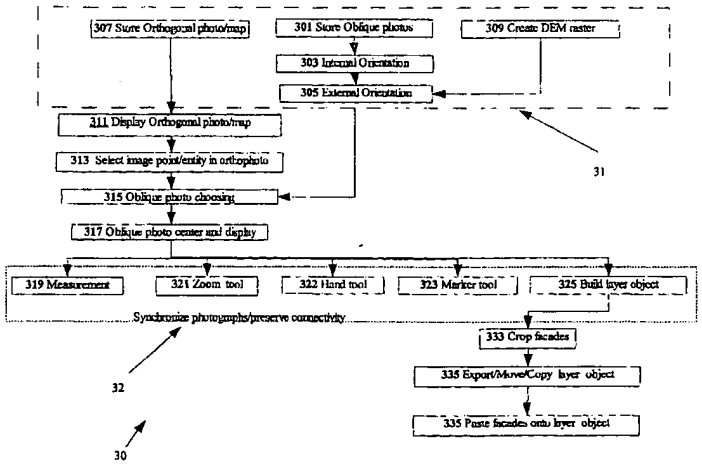
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
10 August 2006

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: COMPUTATIONAL SOLUTION OF AND BUILDING OF THREE DIMENSIONAL VIRTUAL MODELS FROM AERIAL PHOTOGRAPHS



(57) Abstract: A method for processing in a computer a plurality of digital images stored in the computer. The digital images are from respective photographs (301) of a geographic region. The photographs were taken from different directions. The method includes displaying the images (311) and upon selecting an image point in an oblique image, synchronizing a corresponding image point in the digital images so that the selected image point in the first image and the corresponding synchronized image point in other images have substantially identical world coordinates. The method is useful for performing a geographic measurement (319) on an oblique by selecting an image ground point below a first image point; calculating world coordinates in a vertical line segment which extends vertically from the image ground, and upon selecting the first image point on the vertical line segment, calculating world coordinates at the first image point based on the world coordinate in the vertical line segment.

WO 2006/040775 A3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL05/01095

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **H04N 7/18**(2006.01)

USPC: 348/144
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 348/144

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,694,064 B1 (BENKELMAN) 17 February 2004, Figures 1, 3-6, columns 1-2, column 3, lines 20-55, column 4, lines 8-12, lines 34-40, column 5, lines 10-18, column 6, line 35 to column 7, line 50, column 12, line 48 to column 13, line 50, column 14, lines 18-42.	1-25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
21 April 2006 (21.04.2006)

Date of mailing of the international search report
09 JUN 2006

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US
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Form PCT/ISA/210 (second sheet) (April 2005)

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

PCT

(43) International Publication Date
31 August 2006 (31.08.2006)

(10) International Publication Number
WO 2006/090132 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/GB2006/000598

(22) International Filing Date: 2 February 2006 (02.02.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0504077.9 28 February 2005 (28.02.2005) GB

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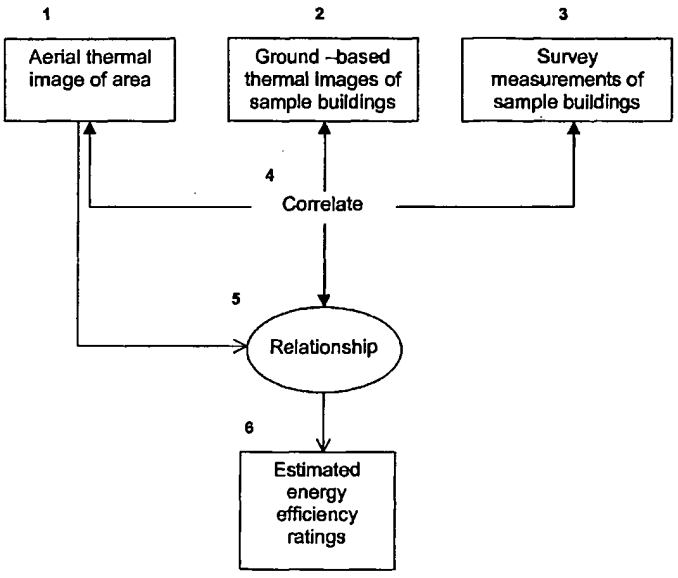
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Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD OF ASSESSING ENERGY EFFICIENCY OF BUILDINGS



(57) Abstract: A method of identifying, from an aerial thermal image (1) of a plurality of buildings within a predetermined area, those buildings having relatively low thermal efficiency, comprises performing ground-based measurements (2, 3) indicative of the thermal efficiency of a sample of the buildings; correlating (4) the ground-based measurements (2, 3) with the aerial thermal image (1) and estimating (6), on the basis of the correlation (5), which ones of the buildings, other than those of the sample, have relatively low thermal efficiency.

WO 2006/090132 A2

Method of Assessing Energy Efficiency of Buildings

Field of the Invention

[0001] The present invention relates to a method of assessing the energy efficiency of buildings, particularly but not exclusively for identifying buildings of low thermal efficiency.

Background of the Invention

[0002] As the cost of energy for heating rises, and awareness increases of the environmental impact of wasted energy, it has become desirable to survey an area for buildings that are poorly insulated or otherwise using energy inefficiently.

[0003] Internationally, the Kyoto Protocol requires signatory states to implement policies to enhance energy efficiency. Within the UK, the Home Energy Conservation Act 1995 imposes a duty on local authorities to identify energy inefficient buildings and to take remedial steps. A Housing Health and Safety Rating System (HHSRS) has been devised for the assessment of buildings, including an assessment of their thermal performance. The recommended thermal rating system is the Standard Assessment Procedure (SAP), which quantifies the energy efficiency of a building on a scale of 1-100. Other ratings systems, such as the National Home Energy Rating (NHER) system, may also be used.

[0004] To rate the thermal efficiency of a building using either SAP or NHER requires a detailed survey of the building, including a floor plan, elevations, details of the construction of walls, roof, doors and windows, and details of the heating system. It is not practicable for a local authority, with responsibility for 10,000 – 100,000 buildings or more, to survey each one. Instead, in a conventional method of attempting to identify thermally inefficient buildings, a representative sample of buildings is surveyed, and the results extrapolated to other buildings within the area of responsibility. Additional information on the unsurveyed buildings may be gathered from mail shots or electoral registers, for example. However, this additional information is often inconclusive and may be inaccurate.

[0005] As a general method of surveying thermal losses from buildings, it is known to obtain an aerial thermal image of an area, which is inspected visually for signs of excessive heat loss. The image may be compared with a map of the area, to identify the building from which the heat loss emanates. For example, a paper entitled 'Monitoring Building Heat Loss – Airborne Thermal Infrared', by Paul Gray, available on 22 February 2005 at http://www.infoterra-global.com/pdfs/thermal_gg.pdf describes how an aerial thermal image may be cross-referenced to other data sources such as geographical information or energy

ratings, to identify buildings having the worst heat loss problems. This paper acknowledges that anomalies may occur when interpreting aerial thermal images. For example, a building that appears relatively cool in the image may be either well heated but well insulated, or under-heated and badly insulated. The paper concludes that such anomalies are unavoidable, but should not detract from the overall value of the aerial thermal image for heat-loss detection. However, under-heated and badly insulated buildings are precisely those buildings that the local authority is required to identify and remedy.

[0006] Thus, there remains a need to identify more reliably those buildings that have low thermal insulation characteristics.

Statement of the Invention

[0007] According to one aspect of the present invention, there is provided a method of identifying buildings having relatively low thermal efficiency, the method comprising: obtaining aerial thermal images of a set of buildings; performing ground-based measurements of a subset of the buildings; correlating the ground-based measurements of the subset with the corresponding aerial images; and estimating, on the basis of the correlation, ones of the buildings, other than those of the subset, have relatively low thermal efficiency.

[0008] Preferably, the correlating and/or estimating steps involve the use of a geostatistical technique dependent on the spatial distribution and variation of the measured subset. The geostatistical technique may be a Kriging technique, such as Ordinary Kriging (OK) or Indicator Kriging (IK).

[0009] The ground-based measurements may include a thermal efficiency rating and/or a ground-based thermal image. The ground-based thermal image provides information on the thermal performance of buildings, which is not apparent from aerial thermal images alone. However, there is some overlap between the information obtained from aerial and ground-based thermal imaging. This overlap may be used to correlate the ground-based measurements with the aerial measurements. This correlation may be used to estimate the thermal properties of those buildings that have not been surveyed from the ground.

[0010] The thermal efficiency rating of the subset of buildings may be derived using physical measurements and/or historical data of the construction of those buildings. The thermal efficiency may be quantified by an objective rating. The thermal efficiency of the unsurveyed buildings may also be estimated using the same rating.

[0011] The method may involve using a geographical database identifying the geographical location of the buildings, so that the buildings estimated to have low thermal efficiency are identified by location.

[0012] The method is preferably implemented by a computer system, which takes as its input the aerial thermal images, the ground-based measurements and optionally, the geographical database. The computer system correlates the aerial thermal images of the subset with their ground-based measurements to derive a relationship, which is then applied to the aerial thermal images of the buildings not within the subset, so as to output a estimated thermal rating of those buildings. The output may comprise a database of estimated thermal efficiency ratings for specific ones of those buildings, or of groups of those buildings. The estimated thermal efficiency ratings may be displayed on a map of the area, to assist a user in identifying buildings estimated to have a low thermal efficiency rating. Embodiments of the present invention include a computer program comprising program code arranged to implement the above system and method, a computer system for executing the program code, and a medium for carrying the computer program.

Brief Description of the Drawings

[0013] Specific embodiments of the present invention will now be illustrated with reference to the accompanying drawings, in which:

[0014] Figure 1 is a schematic diagram of a method in an embodiment of the invention;

[0015] Figure 2 is a composite aerial thermal image of an area;

[0016] Figure 3 is an enlarged section of the aerial thermal image of Figure 3;

[0017] Figure 4 is a processed image showing temperature differences in the aerial thermal image; and

[0018] Figure 5 is a ground-level thermal image of a building located within the area.

Detailed Description of the Embodiments

Aerial Thermal Image

[0019] A method according to an embodiment of the invention is illustrated in Figure 1. According to this method, an aerial thermal image 1 is taken of an area containing buildings for which the thermal efficiency is to be estimated. The aerial thermal image 1 is taken under conditions selected so as to emphasize thermal effects caused by internal heating and heat loss from buildings, and to minimize the effect of solar heating. Preferably, the aerial thermal image is taken in cold weather conditions at a time when the interiors of the buildings are

likely to have been heated to their normal temperature by internal heating systems, but the effect of solar heating is minimal; for example, 8 to 10 pm and/or the early hours in the morning.

[0020] The aerial thermal image 1 is preferably taken using a digital infrared camera mounted on an aircraft overflying the area at a substantially constant altitude. If the desired area cannot be imaged by one pass of the aircraft, then images of sections (normally strips in the case of fixed wing aircraft) of the area are taken, and spliced together using image processing software.

[0021] An example of a composite aerial thermal image 1 is shown in Figure 2, which is an image of the area of the Borough of Spelthorne, composed of many small thermal images taken over a two-day period and normalised for ambient temperature. Darker parts of the image represent cooler parts of the area. Some parts were not imaged, as shown by the blank strips in the image. Figure 3 shows an enlarged section of the image.

[0022] The aerial thermal image 1 may converted to a standardized form indicative of temperature differences between the buildings or between the buildings and the mean outside temperature. Standardized thermal images of this type are commonly generated as colourized images, to highlight areas of high heat loss. Figure 4 shows a standardized version of the image of Figure 3. Cooler roads can be distinguished from warmer buildings and cars in the image. The large building highlighted with a dashed circle is a metal-framed warehouse showing warm patches, and therefore high heat loss.

Ground-Based Thermal Images

[0023] Ground-based thermal images 2 are obtained from a sample of the buildings shown in the aerial thermal image 1. The sample of buildings is preferably chosen so as to cover a wide range of different types of building, at varying locations. The ground-based thermal images 2 may be taken using an infrared camera mounted on or near the ground (for example, on a crane). From the ground-level thermal images 2, it is possible to distinguish between well-heated, well-insulated buildings and poorly heated, poorly insulated buildings, which may appear similar from the aerial thermal image 1. For example, thermal images of side elevations will show the effect of the variation in thermal insulation between windows and external walls, and therefore indicate the level of internal heating within the building. An example of such a thermal image is shown in Figure 5, which is an infrared image of the East

entrance to the Spelthorne Borough Council offices. The warmer windows are contrasted with the cooler exterior walls, illustrating their different thermal insulation properties.

[0024] The ground-based thermal images 2 are processed to derive values for standardized parameters, so that different thermal images 2 may be compared quantitatively.

Survey Measurements

[0025] Measurements 3 are obtained by surveying some or all of the sample of buildings from which ground-based thermal images were taken. The measurements 3 are indicative of the thermal efficiency of the buildings, including the surface area of elevations and roofs, and/or historical data such as the type of construction of the buildings. For example, historical records may show that a building is of British Iron and Steel Foundation (BISF) modular type; this data could also be obtained by invasive measurement techniques.

[0026] Preferably, the survey measurements 3 are processed to derive an energy efficiency rating for that building, representing an overall objective measurement of the thermal efficiency of the building on a standard scale. The scale may be an SAP or NHER scale.

Geographical Information

[0027] The method may use geographical information identifying the known locations of buildings within the area covered by the aerial thermal image. The geographical information may identify the addresses and/or postal codes of buildings at specified geographical locations. The geographical information may be used to correlate the ground-based measurements with the corresponding areas of the aerial thermal image 1.

Correlation of Ground Survey Data and Aerial Thermal Properties

[0028] As described above, there is available for the sample of buildings an aerial thermal image 1, ground-based thermal images 2, and survey measurements 3. The method correlates 4 these three sets of data for the sampled buildings so as to derive a general relationship 5 between properties of the aerial image 1, properties of the ground-based thermal images 2 and the survey measurements 3 of the sampled buildings. The relationship 5 may be a statistical model dependent on the locations of the sampled buildings.

[0029] In one example, the relationship 5 is a geostatistical model. A preferred geostatistical model uses a linear unbiased estimator, such as a Kriging technique. Either Ordinary Kriging (OK) or Indicator Kriging (IK) may be used. Kriging techniques are described for example in 'An Introduction to Applied Geostatistics', Isaaks E H and Srivastava R M, Oxford

University Press 1989. Alternative techniques, such as fuzzy logic, may be used to construct the relationship 5.

Estimation of Thermal Efficiencies of Unsampled Buildings

[0030] The properties of the aerial thermal image 1 for the unsampled buildings are then converted to estimated thermal efficiency ratings 6 of the unsampled buildings, using the relationship 5. For example, the aerial thermal image 1 may be input to the geostatistical model together with the geographical information indicating the location of the unsampled buildings. The model may generate as output the corresponding estimated thermal efficiency ratings 6 of the unsampled buildings.

[0031] The estimated thermal efficiency ratings 6 may be output in the form of a digital map representing the location and estimated efficiency ratings 6 of the buildings within the area. The map helps the user to identify areas of estimated low thermal efficiency within the area.

[0032] Additionally or alternatively, the method may apply a threshold to the estimated efficiency ratings 6, and output a list of buildings having estimated efficiency ratings below the threshold. For example, the user may wish to identify all buildings estimated to have a SAP rating below the national average of 44-46. The user inputs the desired threshold and the method outputs a list of buildings with estimated SAP ratings below that threshold. The buildings may be identified by address, location and/or postal code, derived from the geographical information.

[0033] The method may provide good estimations of thermal efficiency of unsampled buildings, and may therefore reduce the need to conduct full ground surveys of buildings within the area. If these estimations are followed by remedial action to improve the thermal efficiency of those buildings identified as having poor thermal efficiency, then heat loss from buildings within the area may be significantly improved, resulting in lower consumption of fuel for heating and a consequent saving in carbon dioxide emissions.

Updating the Relationship

[0034] The relationship 5 may be updated by providing additional ground-based thermal images 2 and/or survey measurements 3 as input. For example, the buildings estimated as having the lowest thermal efficiency may be surveyed to generate ground-based thermal images 2 and measurement data 3, which are provided as input to update the relationship 5 to fit the new data. The aerial images 1 of the unsampled buildings are then reprocessed using the updated relationship 5 so as to obtain an improved estimate of their thermal efficiency. In

other words, the relationship 5 is updated recursively so as to improve its estimations of buildings with the lowest thermal efficiency.

Computer System, Program and Medium

[0035] The method is preferably implemented by a computer system executing a program to perform the method shown in Figure 1. The computer system may comprise a computer having access to the aerial thermal image 1 and the relationship 5, so as to estimate the energy efficiency ratings 6. The aerial thermal image 1, the ground-based thermal images 2 and the survey measurements 3 may be pre-processed by another computer or computers to derive the relationship 5.

[0036] The computer program may be recorded on a program carrier or medium, such as a removable or fixed disk or solid-state memory, or incorporated in a signal.

Alternative Embodiments

[0037] The embodiments described above are illustrative of rather than limiting to the present invention. Alternative embodiments apparent on reading the above description may nevertheless fall within the scope of the invention. For example, it is not necessary to estimate the thermal efficiency of all buildings within the area, if it is desired only to identify those buildings having a low estimated thermal efficiency.

Claims

1. A computer-implemented method of estimating the thermal efficiency of a specified building within a predetermined area, comprising the steps of:

    a. accessing aerial measurements of thermal properties of buildings within the area, including the specified building;

    b. accessing data representing ground-based measurements of a subset of the buildings, excluding the specified building;

    c. deriving a relationship between the aerial measurements and the ground-based measurements of the subset; and

    d. applying the relationship to the aerial thermal measurement of the specified building so as to estimate the thermal efficiency of the specified building.

2. The method of claim 1, wherein the relationship is a geostatistical model dependent on the spatial distribution of the subset of the buildings.

3. The method of claim 2, wherein the geostatistical model uses a linear unbiased estimator.

4. The method of any preceding claim, wherein the ground-based measurements of the subset of the buildings include ground-based thermal measurements.

5. The method of any preceding claim, wherein the ground-based measurements of the subset of the buildings include measurements indicative of thermal efficiency.

6. The method of any preceding claim, wherein the aerial measurements of the thermal properties of the buildings are derived from an aerial thermal image.

7. The method of any preceding claim, including determining whether the specified building has an estimated thermal efficiency below a predetermined level.

8. The method of claim 7, further including, if the specified building is estimated to have a thermal efficiency below the predetermined level, updating the relationship so as to include ground-based measurements of the specified building.

9. A computer-implemented method of identifying, from a set of buildings within an area, one or more buildings likely to have a low thermal efficiency, comprising the steps of:

a. performing ground-based measurements indicative of the thermal efficiencies of a subset of the buildings;

b. obtaining an aerial thermal image of the area;

c. correlating the ground-based measurements with the aerial thermal image to derive a relationship therebetween; and

d. applying the relationship to the aerial thermal image to identify the one or more buildings likely to have a low thermal efficiency.

10. A computer program including program code arranged to perform the method of any preceding claim.

11. A computer system arranged to execute the computer program of claim 10.

12. A program carrier incorporating the computer program of claim 10.

13. A method substantially as herein described with reference to the accompanying drawings.

14. A computer program substantially as herein described with reference to the accompanying drawings.

Fig. 1

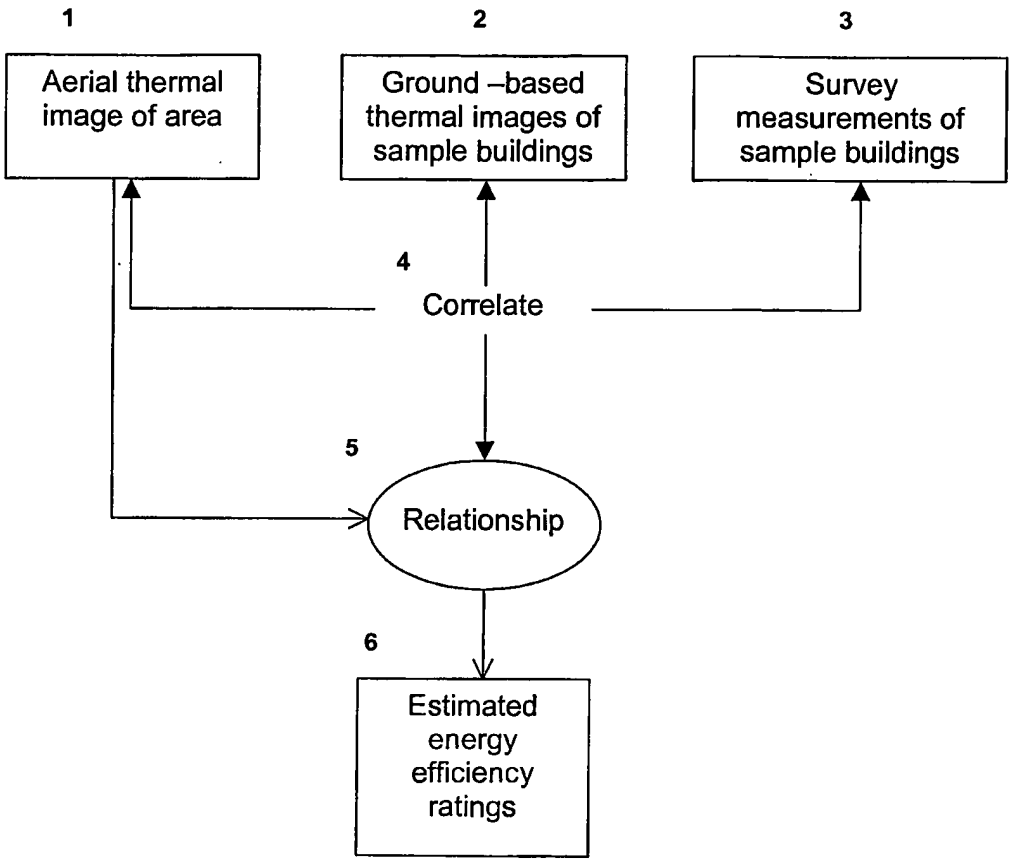

1
2
3
Aerial thermal image of area
Ground –based thermal images of sample buildings
Survey measurements of sample buildings
4
Correlate
5
Relationship
6
Estimated energy efficiency ratings

Fig. 2

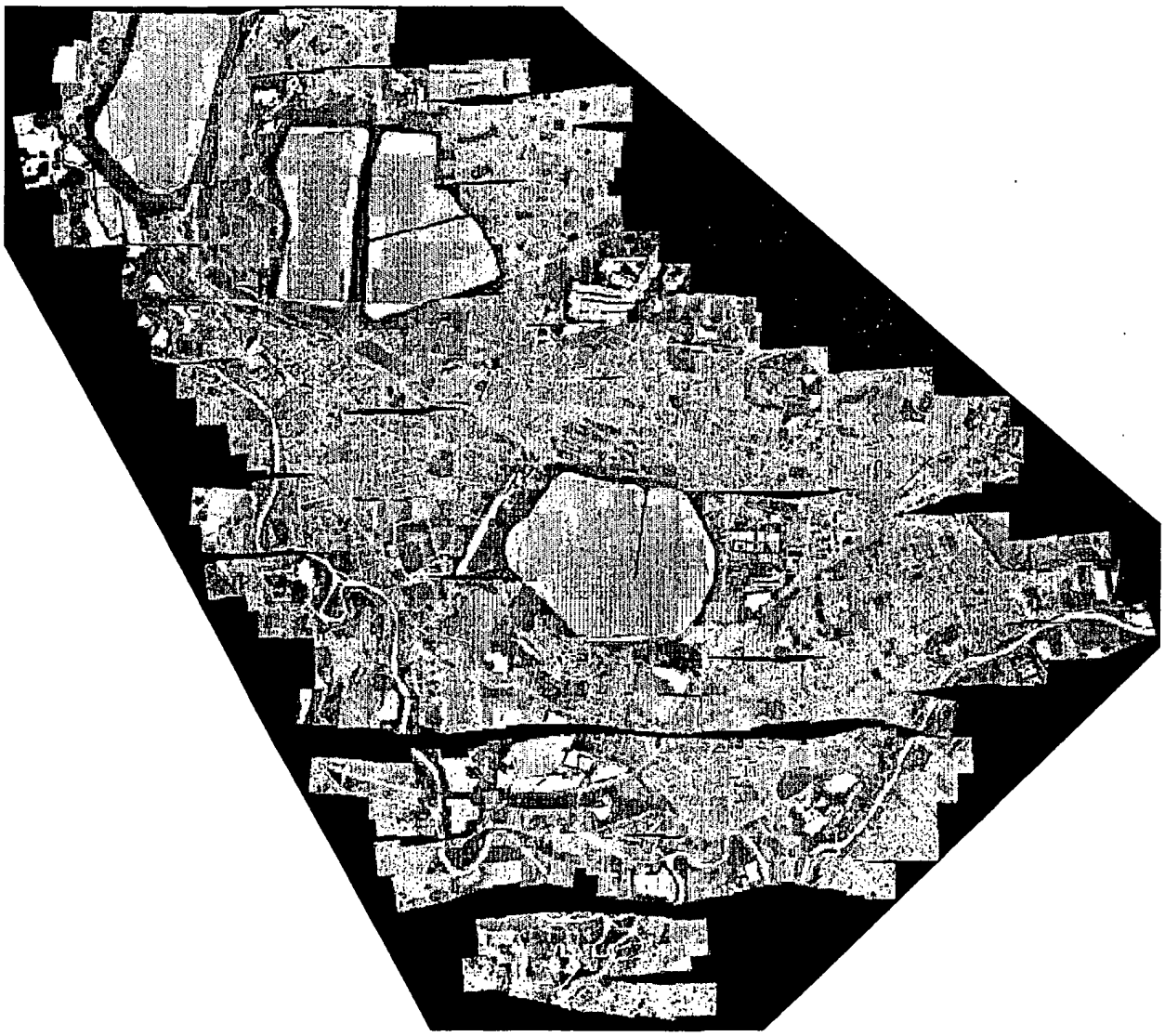


Fig. 3

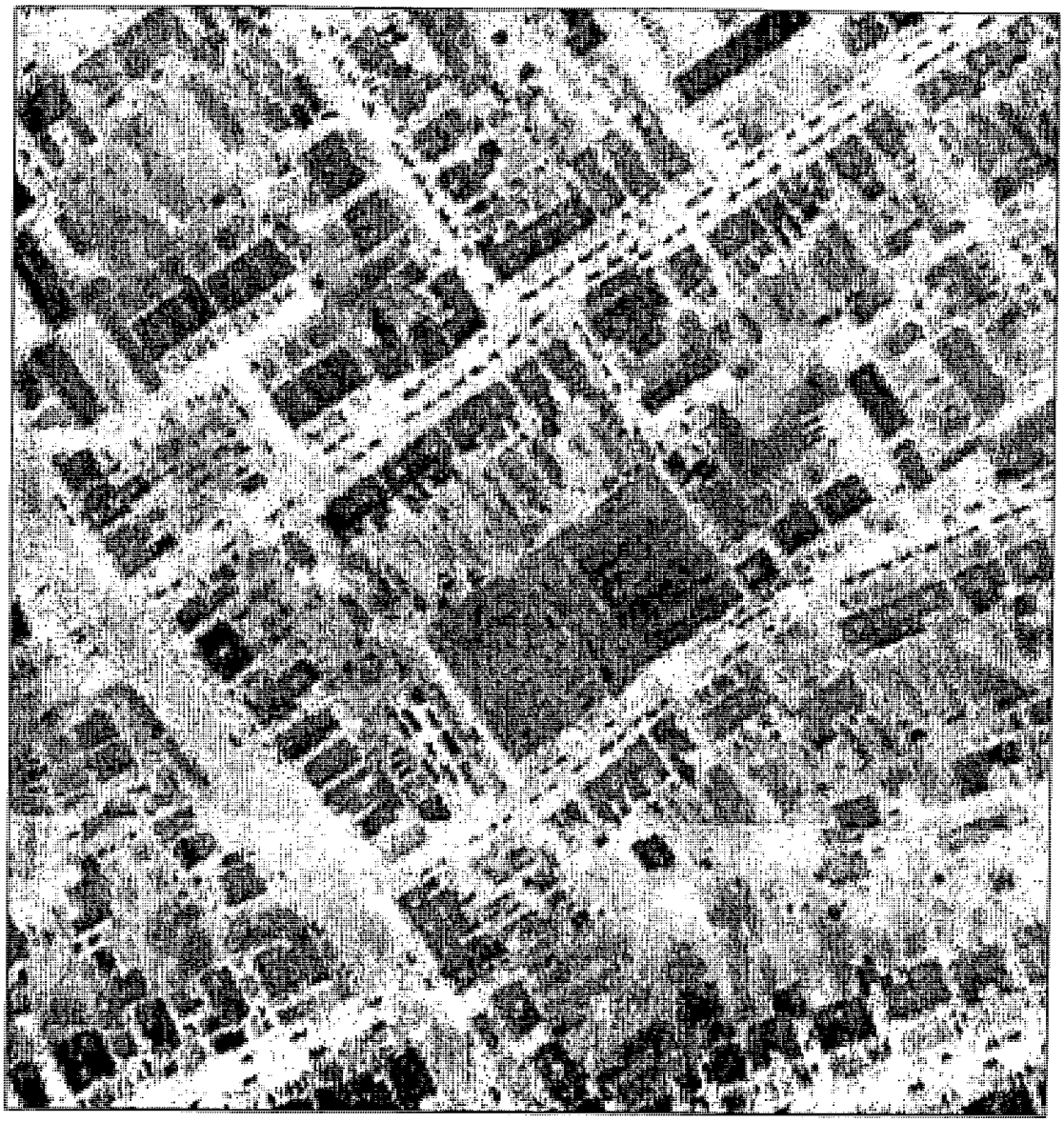
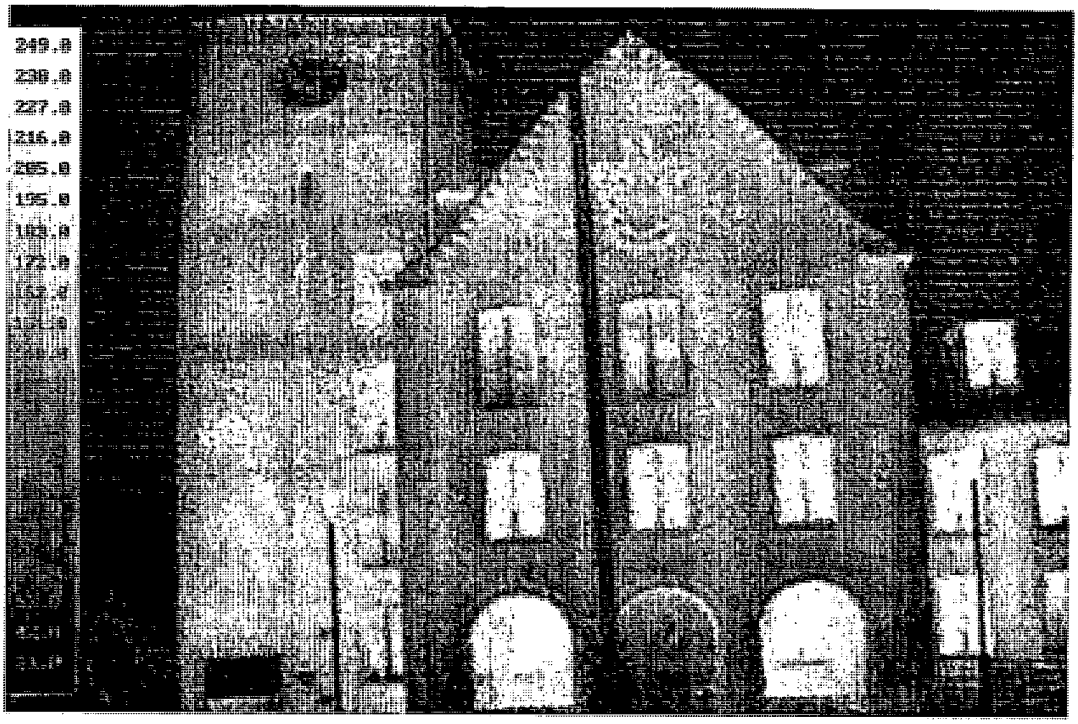


Fig. 4



Fig. 5



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 August 2006 (31.08.2006)

PCT

(10) International Publication Number
WO 2006/090132 A3

(51) International Patent Classification:
G01N 25/00 (2006.01)

(21) International Application Number:
PCT/GB2006/000598

(22) International Filing Date: 2 February 2006 (02.02.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0504077.9 28 February 2005 (28.02.2005) GB

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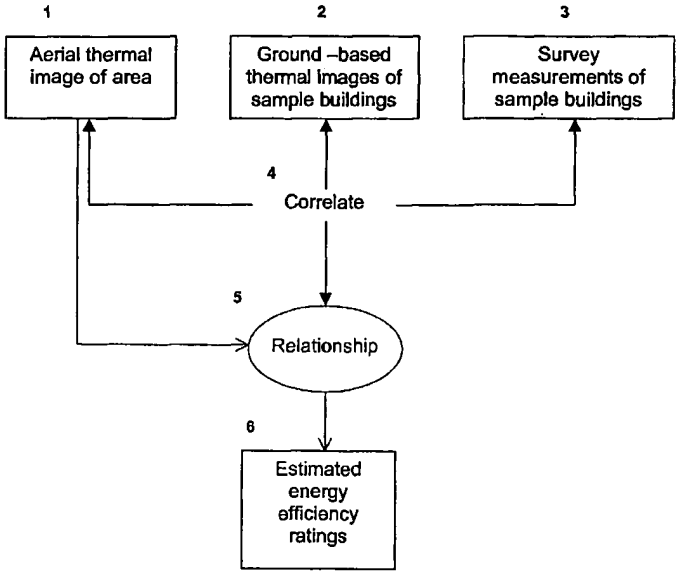
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Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
23 November 2006

[Continued on next page]

(54) Title: METHOD OF ASSESSING ENERGY EFFICIENCY OF BUILDINGS



(57) Abstract: A method of identifying, from an aerial thermal image (1) of a plurality of buildings within a predetermined area, those buildings having relatively low thermal efficiency, comprises performing ground-based measurements (2, 3) indicative of the thermal efficiency of a sample of the buildings; correlating (4) the ground-based measurements (2, 3) with the aerial thermal image (1) and estimating (6), on the basis of the correlation (5), which ones of the buildings, other than those of the sample, have relatively low thermal efficiency.

WO 2006/090132 A3

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000598

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01N G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 203 673 A (THE DOW CHEMICAL COMPANY) 3 December 1986 (1986-12-03) the whole document	1-14
A	US 4 896 281 A (MACK ET AL) 23 January 1990 (1990-01-23) the whole document	1-13
A	BASILI, PETRA ET AL.: "Retrieving Atmospheric Temperature Profiles by Microwave Radiometry Using a priori Information on Atmospheric Spatial-Temporal Evolution" IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, vol. 39, no. 9, September 2001 (2001-09), pages 1896-1905, XP002397889 the whole document	1-14

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 September 2006	21/09/2006

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Thomte, Peter

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	PARK ET AL: "The application of the CFD and Kriging method to an optimization of heat sink" INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, PERGAMON PRESS, GB, vol. 49, no. 19-20, September 2006 (2006-09), pages 3439-3447, XP005526672 ISSN: 0017-9310 the whole document	1-14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2006/000598

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0203673 A	03-12-1986	NONE	
US 4896281 A	23-01-1990	NONE	

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 August 2006 (31.08.2006)

PCT

(10) International Publication Number
WO 2006/090132 A3

(51) International Patent Classification:
G01N 25/00 (2006.01)

(21) International Application Number:
PCT/GB2006/000598

(22) International Filing Date:
21 February 2006 (21.02.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0504077.9 28 February 2005 (28.02.2005) GB

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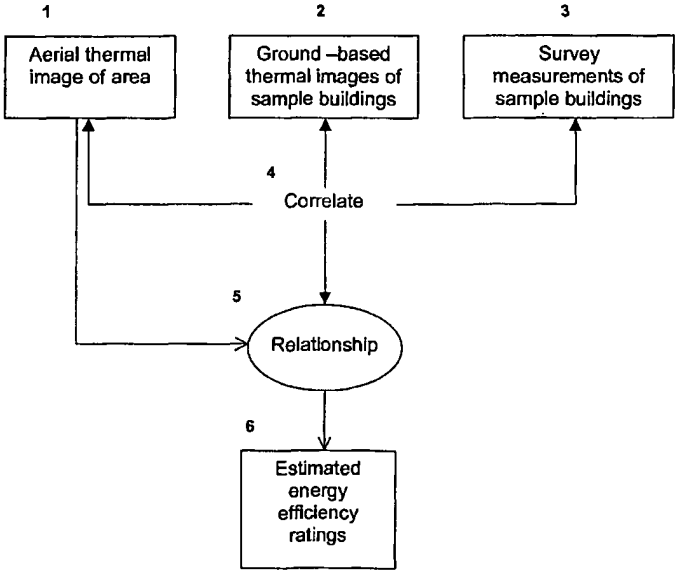
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

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WO 2006/090132 A3

(88) Date of publication of the international search report:
23 November 2006

(48) Date of publication of this corrected version:
18 October 2007

(15) Information about Correction:
see PCT Gazette No. 42/2007 of 18 October 2007

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERA

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 August 2011 (04.08.2011)

PCT

(10) International Publication Number
WO 2011/094760 A2

(51) International Patent Classification:
G06T 17/00 (2006.01)

(21) International Application Number:
PCT/US2011/023408

(22) International Filing Date:
1 February 2011 (01.02.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/300,414 1 February 2010 (01.02.2010) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: GEOMETRIC CORRECTION OF ROUGH WIREFRAME MODELS DERIVED FROM PHOTOGRAPHS

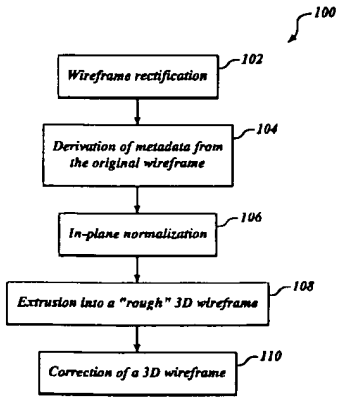


FIG.1A

(57) **Abstract**: Geometric correction of rough wireframe models derived from photographs may include rectification of either a 2D or 3D original wireframe model of a roof structure, derivation of metadata from the original wireframe, in-plane normalization of the wireframe, extrusion into a "rough" 3D wireframe based on the normalized wireframe, and correction of the "rough" 3D wireframe. The correction and normalization may be an iterative process based on initial pitch values, metadata derived from the original or corrected wireframe models and defined constraints regarding relationships between roof portions or segments. The iterative process may repeat adjusting the wireframe model until the adjusting converges to a stable state according to the various defined constraints.

Roofr Exhibit 1002, Page 331

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GEOMETRIC CORRECTION OF ROUGH WIREFRAME MODELS DERIVED FROM PHOTOGRAPHS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application No. 61/300,414, filed on February 1, 2010, which is incorporated herein by reference in its entirety.

BACKGROUND

Technical Field

This invention is in the field of computer modeling of physical objects and, in particular, the generation of a three-dimensional model using one or more two-dimensional photographs as a starting data set.

Description of the Related Art

Several methods can be employed to generate a three-dimensional computer model of a roof in the form of a wire-frame using one or more overhead photographs.

A first method is to trace the image in the photograph with or without user input. Using this tracing method on a photograph that provides a nearly top-down view of the structure of interest, a computer-aided design (CAD) tool allows lines and polygons to be drawn over the background image. The resulting wireframe model reflects the lines and contours of interest in the locations they are observed in the photograph.

While this method has the advantage that it is fast and compatible with many off-the-shelf CAD and drawing tools that do not require much training, there are a number of disadvantages. One disadvantage is that incorrect line lengths on sloped roof facets will result when the image is not taken from directly overhead, resulting in a "lean" of the roof within the image.

Another disadvantage is that there is a poor ability to correctly determine pitches on sloped roof facets.

Other problems are a poor determination of layered or underhanging roof sections. This first method requires a user to have previous knowledge of the roof facet pitches to obtain a wireframe without errors.

A second method is for a user to select and align roof 'primitives' over a photograph.

Like the previous method, an overhead photograph is selected as a backdrop starting point for a CAD tool. However, rather than tracing lines and polygons, the CAD tool allows the user to overlay, resize, and connect common geometric roof forms stored as primitives. Gables and hips are examples of commonly found primitive forms used in roof designs. The photograph provides a visual reference for the selection and placement by the user of these higher-level objects.

While this method has the advantage that a skilled operator can produce geometrically correct models, it has the disadvantage that it is harder to create from an image and it becomes more time consuming with increasing roof complexity.

In addition, complex user interface software is required, which requires greater training.

This second method also requires subjective technician judgments by the user to compensate for lean artifacts due to lean and shadows in images.

The user must also have previous knowledge of the roof facet pitches to correctly size the roof.

A third method is for a user to obtain and work with one or more photographs of the same roof taken from different angles in order to trace a 3D wire model of the roof.

This method starts with a set of photographs that are analyzed to derive a virtual 3D volume that is geometrically consistent with all the

supplied viewpoints of the target roof. The line segments comprising the wireframe are then drawn in 3D-space and projected back onto the set of photographs to assess the correct placement within the derived 3D volume. The details of this method are described in prior U.S. Patent Applications owned by the assignee, EagleView Technologies, and bearing U.S. Patent Application Serial Numbers 12/148,439; 12/253,092; 12/590,131; 12/467,244; and 12/467,250.

The advantage of this third method is that it does not require previous knowledge of roof facet pitches, rather, pitches are derived from the content of the photograph(s). It also produces geometrically correct models. Unfortunately, the detailed 3D model made this way cannot be easily imported to some widely used home construction CAD software programs.

The disadvantages of this third method are that greater training is required as compared to the first method and it becomes harder and more time consuming with increasing roof complexity without further processing or touch-up of the model to meet import requirements of the 3rd party software. To summarize, the first method provides a fast and simple means of generating a wire frame model of a roof at the expense of decreased accuracy and a dependence on having previous knowledge of the roof facet pitches to complete the model.

The second method sacrifices some speed and ease of use in exchange for a more consistent model and a dependency on having previous knowledge of the roof facet pitches to complete the model.

The third method also sacrifices speed and requires more user skill than the first method, but the resulting model is a very accurate reflection of the correct geometric form of the house in the photograph and does not depend on previous knowledge of the roof facet pitches.

SUMMARY OF THE INVENTION

The present invention provides a method of forming both a 2D and a 3D wireframe model in computer software that are accurate and

geometrically correct. Further, the technique does not require prior knowledge of the roof facet pitches. The produced model can be easily converted into formats compatible with import into 3rd party CAD software.

Five technology components have been developed as part of the inventive solution:

1) Wireframe rectification, either 2D or 3D;
2) Derivation of metadata from the original wireframe;
3) In-plane normalization;
4) Extrusion into a "rough" 3D wireframe; and
5) Correction of a 3D wireframe.

While each of the five components contributes to the overall solution, each can be used independently or in various combinations to yield improvements in obtaining a 2D or 3D wire model as discussed below.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1A is a flow chart showing an example process of geometric correction of rough wireframe models derived from photographs, according to one embodiment of the present invention.

Figure 1B shows a top side 2D view of wireframe correction according to one embodiment of the present invention.

Figure 2A illustrates a precursor step of deriving metadata from a proposed wireframe according to principles of the present invention.

Figure 2B is a top side view illustrating the membership of various roof facets within geometric primitives identified from the metadata for the roof of Figure 2A.

Figure 3 illustrates the hierarchy operations in deriving the primitives of Figure 2B.

Figure 4 illustrates the correction of a "rough" 3D wireframe from a normalized 2D wireframe using rules from the metadata.

Figure 5 illustrates a 3D wireframe model of the roof of Figure 2A according to one embodiment.

Figure 6 illustrates a plurality of geometrical objects representing the state of the correction algorithm during the process of correcting the spatial location of a point in the wireframe model of Figure 5.

Figure 7 shows a fully normalized and corrected 2D wireframe model.

Figures 8A and 8B illustrate the finalized 3D wireframe model superimposed back onto the photograph of the original home.

Figure 9 is a schematic diagram of a computing environment in which geometric correction of rough wireframe models derived from photographs may be implemented or of which it may be a part.

DETAILED DESCRIPTION

Figure 1A is a flow chart showing an example process 100 of geometric correction of rough wireframe models derived from photographs, according to one embodiment. In particular, Figure 1A illustrates process 100 that may be performed or implemented by, for example, one or more software modules or components or any combination of suitable hardware, firmware or software components or devices including those that are a part of or configure the computing environment of Figure 7.

While each of the steps shown in Figure 1A contributes to the overall solution, each can be used independently or in various combinations to yield improvements in obtaining a 2D or 3D wire model as discussed below. Below is an overview of each step in the process, which will be followed by a more detailed discussion of each step.

At 102, the process performs wireframe rectification. This is a pre-cursor step that can optionally be used within or as a precursor to each of the other four steps that follow. The algorithm can work with either a 2D or 3D wireframe as an input. The wireframe comes into this step as a set of connected points forming a set of closed polygons shown as roof 10 in Figure 1B. From this set of points, some basic geometric flaws are identified and corrected.

At 104, the process derives metadata from the original wireframe. A series of analysis steps are made to derive contextual information that becomes metadata for the wireframe. Each step of the analysis yields an additional layer of metadata derived from the wireframe and previous layers of derived metadata. This combined set of metadata provides valuable context for later processing steps.

At 106, the process performs in-plane normalization which takes as input a "rough" wireframe (2D or 3D) generated by a manual or automated process and then performs an 'in-plane' normalization of the wireframe to yield a new wireframe. Any elevation or 'z' coordinate values of the input wireframe are ignored during this normalization step. Therefore, while this step is typically processes 2D wireframes, it remains compatible with a wireframe input that already contains elevation data.

At 108, extrusion into a "rough" 3D wireframe is performed by transforming output of the in-plane normalization of step 106 to a "rough" 3D wireframe suitable for import into a subsequent 3D wireframe correction algorithm. Extrusion of a normalized 2D or 3D wireframe is performed to produce a "rough" 3D form using a set of rules combined with metadata that the algorithm derived from the original wireframe in step 104.

At 110, correction of a 3D wireframe is performed. For example the correction step may take as an input the "rough" 3D wireframe generated by the output of the step 108, or directly from prior art Method 3 or any similar manual or automated method yielding a 3D wireframe. A new wireframe model is generated by correcting the original wireframe to satisfy a set of user-defined constraints and to remove geometric distortions/problems found in the original wireframe that are inconsistent with the selected constraints. This includes systematic processing of primitives, facet polygons, and line segments, which may be continued throughout the wireframe until the corrections converge to a final roof shape with no further changes.

Figure 1B shows a wireframe rectification of a 2D image of a roof. In particular, Figure 1B illustrates a roof 10 shown as a 2D top plan

view. This is the type of view that would be seen looking down on the top side of a roof from an overhead image. This view can be obtained from an aircraft that flies over the roof 10 and takes a picture using standard photographic equipment.

A number of potential difficulties arise when a photograph is taken from a top side view of a home of the type shown in Figure 1B. A first difficulty is that the camera mounted on the aircraft, satellite, or other aerial platform might not be directly over the roof 10 at the moment that the photograph is taken. If the camera is directly overhead, then an exact top plan view of the roof 10 is provided in the image which is created in the photograph. However, if the camera is off to one side, for example several degrees to the left or right of directly overhead, then the relative position of objects of different elevations (height) within the image of the roof 10 will appear to be shifted when compared to a truly top-down viewpoint. In some cases, presence of this 'lean' in the image can be observed as the ability to see the side of a vertical wall or chimney. It is difficult to correct for the amount of lean unless it is exactly known. In addition, the presence of lean may affect the perception of objects in the image differently depending on the pitch of the various roof faces and the orientation of the roof 10 with respect to the aircraft at the time the photograph was taken. A further problem is that the original images typically undergo a series of processing steps such as compression, resampling, and orthorectification before image is published into an image library. This processing may degrade details and/or introduce geometric distortions that were not present in the original image. Yet a third problem of the top side photograph is the difficulty in determining the pitch of the roof. The pitch is a measure of the slope of a roof facet. Typically, pitch is defined as the ratio change in height (in inches) for every 12 inches of of lateral movement in the direction of steepest descent. This may be reported as a ratio of 6/12 or simple as 6 with an implied denominator of 12 inches. A roof pitch of 0/12 represents a flat roof while a 9/12 pitch denotes a steeper slope than a 6/12 roof pitch. From a single top-side-only photograph,

determining the exact pitch is difficult and often not possible. Accordingly, the image of the roof 10 is rectified according to principles of the present invention as set forth herein.

Wireframe Rectification

Figure 1B shows wireframe rectification being performed. This is a pre-cursor step that can optionally be used within or as a precursor to each of the other four processing algorithms that follow. The algorithm can work with either a 2D or 3D wireframe as an input.

The wireframe comes into this algorithm as a set of connected points forming a set of closed polygons shown as roof 10 in Figure 1B.

From this set of points, a series of processing steps are to identify and correct some basic geometric flaws.

These steps may include:

a) Orientation / Rotation: Principal axes of the wireframe are determined to gain an understanding of the orientation of the structure represented by the wireframe. This orientation information can then be used to rotate the coordinate system of the wireframe to any desired orientation.

b) De-skew: The wireframe is analyzed to determine if a global 'skew' is present, namely, if the two principal axes of the structure are not orthogonal to each other. This type of distortion makes rectangular objects look like parallelograms. If detected, the set of points are transformed to move the lines to become orthogonal and thus remove the skew.

c) Rectify: Points in the wireframe are shifted in the plane as needed to straighten lines, square off corners, and adjust lines to be either parallel or perpendicular to other lines based on a set of rules using information regarding their proximity to each other, the relation of each major line, and their nearest neighbors. For example, according to one set of rules, long extending edges of the roof 10 on opposite sides are made parallel to each other while corners between connect lines that are very close to 90° are made to be exactly 90° square.

As can be seen in Figure 1B, the solid dark lines indicated by line 12 is one example of the fully corrected final lines of the roof, while the dashed lines 14 represent the position of the line in the original image. The rectified, solid line wireframe has been overlaid on top of the original photograph of wireframe 14 to better illustrate the corrections which have been made and the realignment to each of the lines. As can be seen, the line 12 did not require any changes from the photograph because it was properly aligned, however one more lines 14 required a deskew in order to align the principle axes of the structure with each other. In addition, some alignment was required of the two sides 16 and 18 to ensure that they were parallel with respect to each other. Other appropriate orientation and rotation was carried out in order to properly represent the roof 10 to obtain the rectified solid line pattern overlaid on the original dashed line pattern shown in Figure 1B.

Derivation of Metadata from the original wireframe

Figure 2 shows another pre-cursor step that can be made prior to each of the processing algorithms that follow. The wireframe of the roof 10 is input to this algorithm as a set of connected points forming a set of closed polygons. The algorithm is equally applicable to whether the original wireframe is flat 2D representation of the roof or a 3D representation of the roof.

From this set of connected points, a series of analysis steps are made to derive contextual information that becomes metadata for the wireframe. Each step of the analysis yields an additional layer of metadata derived from the wireframe and previous layers of derived metadata. This combined set of metadata provides valuable context for later processing steps.

Basic metadata includes a catalog of nearest neighbor points, nearest neighbor segments, segment membership in polygons, etc.

This basic metadata is then used to determine more abstract information such as whether segments are edges or ridges, groups of points

and/or line segments that will likely reside at the same elevation (Z coordinate) in the final model, and which points look like hip junctions, gable junctions, or corners on the perimeter of the structure, for example.

Additional metadata layers are then derived to identify the presence of common geometric forms, referred to herein as 'primitives,' that are components of many roof architectures. Examples of such 'primitives' include hips and gables. The identification of the primitives facilitates an association of individual roof facets with one or more primitive objects in standard root geometry.

Finally, an ordered hierarchy is established between these roof primitives that provides context regarding the spatial relationships that exist between the primitives. This hierarchy is used to establish an order of operations in later processing steps.

Figure 2A shows a first layer of analysis and labeling. The software has analyzed the wireframe and determined some base points and layers of metadata. Shown in this diagram of Figure 2A are gable origination points 20, large dark circles ●; hip origination points 22, open circles ○; edge segments 30, dark solid line —; ridge segments 33, dash-dot line —·—; hip segments 39, dash lines - - - -; junction and valley segments 36, dotted line ·····; corner points 24, closed black circles •; and 'complex' intersection points 26, triangles Δ. Of course, the various lines and points can be shown on a computer screen in different colors rather than as different sizes and styles of black to provide ease of use for an operator. For example, the gable origination points can be red, the hip points green or blues and the corner points yellow or black. Similarly, the various lines can be in solid colors, such as red lines for the ridge segments, green lines for the edge segments and magenta or blue or purple for the junction and valley segments. The different metadata are shown here with different black and white representation patterns for the patent application, but in some embodiments, different colors on the computer screen will be preferred.

In Figure 2B, the wireframe and metadata from Figure 2A are further processed to identify hip and gable primitives, as well as uncategorized geometric primitives. Facet polygons labeled with a 2 are members of the hip associated with the hip origination point 22 identified in Figure 2A. Facets labeled with 1, 3, 4, 5 are members of the respective gable primitives associated with the gable origination points 20 identified in Figure 2A. Facets labeled with 6 and 7 are identified as geometric primitives that are not hips, gables, or any other common geometric form recognized by the software. As seen in Figure 2B, the mapping of facet polygons to primitives is a one-to-many relationship – *e.g.*, a facet may be a member of more than one identified primitive. For example, the facet 38 is both a gable primitive 2 and a hip primitive 1, whereas facet 40 is only a gable primitive 5.

As shown in Figure 3, the metadata derived from the wireframe in previous steps represented by Figures 2A and 2B is analyzed further to determine hierarchy among the identified primitives. Information from this hierarchy can then be used by other algorithms to establish a preferred order of processing when progressing through the wireframe.

As seen in Figure 3, the algorithm determined the hierarchy of the connected hip and gable primitives. Primitive 2, the gable on the main ridge line of the entire home, was determined to be higher in the hierarchy than the subordinate (or child) primitives 1, 3, and 4. Multiple parentage is allowed during this process such that Primitive 3 is also identified as parent of Primitive 4. Algorithms consuming this hierarchy may choose to prune multiple parent linkages such that each child only has a one parent.

The uncategorized primitives 5, 6, 7 are shown without parents or children. For 5 and 7, this is due to the fact that the underlying polygons are physically disconnected from the main portion of the wireframe containing 1, 2, 3, 4. Primitive 6 is also shown as disconnected in the hierarchy even through it shares a line segment with the wireframe containing 1, 2, 3, 4. In this case, the software determined that pruning this primitive from the main hierarchy would result in a better order of operations for down-stream

processing. In other situations, the algorithm may have joined Primitive 6 to the main hierarchy as a child of 2 and 3.

The algorithm for the selection of hierarchy is based on a set of rules that evaluates the intersections between the identified primitives. These rules normally produce a hierarchy predicting a top-down elevation ordering of connected primitives. In this case, primitives 2 (associated with ridgeline 32) is ranked above the primitives 1, 3, and 4. This ranking is consistent with relative elevations of the ridglines observed in Figure 5 resulting from additional downstream processing steps.

In-Plane Normalization

Figure 4 shows in-plane normalization in which the algorithm takes as input a "rough" wireframe (2D or 3D) generated by the first technique of Figure 1B or by a manual process similar to Method 1 of the prior art, or by an automated process employing computer vision techniques, or by some other free-hand method that may or may not employ a photograph as a background image during the tracing process (*e.g.*, a hand-drawn sketch for example).

The algorithm then performs an 'in-plane' normalization of the wireframe to yield a new wireframe. As the name suggests, this algorithm ignores any elevation or 'z' coordinate values of the input wireframe during this normalization step.

Therefore, while this algorithm is typically used to process 2D wireframes, it remains compatible with a wireframe input that already contains elevation data.

A top-down view of the normalized result 48 shows a wireframe that has been corrected for lean effects and many other geometric distortions and imperfections that may be present in an original wireframe. Although the elevation values of the points within this wireframe may not have been adjusted yet, the shapes of the polygons have been modified to yield a true top-down viewpoint for each facet that is consistent with a set of initial pitch

values assigned to the roof facets. In another embodiment, a precursor step to the In-Plane Normalization may have made adjustments/corrections to the 'z' coordinate values (elevation values) of the points.

One great value of the removal of the lean and other distortions is realized when this normalized model is used as an input to the Extrusion and 3D -correction algorithms discussed later in this document. The errors associated with those lean artifacts and edge distortions would otherwise become amplified during the subsequent extrusion and correction steps and degrade the quality of the end result.

When the algorithms of the invention are used in this sequence, the speed and ease of use of prior art Method 1 provides a precursor model that can be further processed to yield a model that is equivalent in quality and accuracy to the output of prior art Method 3.

This algorithm provides several competitive benefits:

a) Significant reduction of manual drawing time, which was the primary benefit of prior art Method 1.

b) Minimal technician training time, another primary benefit of prior art Method 1.

c) Maintains all the benefits of prior art Method 3 – accuracy, consistent geometry, and no dependence on previous pitch knowledge.

d) Maintains compatibility with existing construction methods.

e) Supports and enhances models derived from automated computer vision methods.

Following are the in-plane normalization algorithm details:

a) Precursor steps: Wireframe metadata has been determined and the structure has been processed by the rectification algorithm as set forth in Figures 1B-3. The use of either or both of these techniques as a precursor step is preferred but not required.

b) Seeding of Pitch Values: An initial set of pitch values and orientations are assigned to each roof facet. The assignment could be via user assignment, by an algorithm that assigns a pitch based on metadata derived from the 2D or 3D wireframe, or by an algorithm that gleans pitch information from the existing "rough" 3D wireframe provided as an input.

c) Adjustment of ridgelines: A systematic pass is made through the wireframe to adjust the lateral position of the points associated with line segments identified as 'ridges'. The adjustments are made to accommodate pitch values associated with the polygons that share the ridge segment and/or the ridge segment's endpoints.

d) Correction of Junctions between Primitives: Line segments that have been identified as junctions or seams between adjacent primitives are likewise adjusted to accommodate the specified pitches and the adjusted positions of the ridgelines. An iterative loop repeats steps (c) and (d) until the repositioning of lines and points converges to a stable state. In an alternative embodiment, the loop repeats steps (b), (c), and (d) allowing flexibility in adapting the pitch of facets when converging to the final solution.

Figure 4 shows the result 48 of the In-Plane Normalization, shown by the solid lines in Figure 4, that is overlaid on the rectified wireframe of Figure 1B, which is shown by the dashed lines of Figure 4.

The shift of the line positions resulted from a repositioning of the hip and gable origination points 20 and 22 and junction line segments 32 to accommodate a set of pitch values that were assigned to each of the facets. This adjusts for lean and rotation that may have been present in the first image. In this example, the corrections have been made based on an assigned pitch of 7/12 for all facets except for the facet associated with primitive 6, which has been assigned a pitch of 9/12.

Extrusion into a "rough" 3D wireframe

Figure 5 shows the results of an algorithm as a transition step that transforms output of the in-plane normalization to a "rough" 3D wireframe suitable for import into a subsequent 3D wireframe correction algorithm.

This algorithm performs an extrusion of a normalized 2D or 3D wireframe to produce a "rough" 3D form using a set of rules combined with metadata that the algorithm derived from the original wireframe in Figures 2A and 2B and 4, for example.

The resulting "rough" 3D model may contain some geometric inconsistencies that were not anticipated or corrected during the in-plane normalization step or during the extrusion step.

The "rough" 3D model is then used as an input into the aforementioned 3D correction algorithm for further processing.

Extrusion algorithm details:

a) Precursor steps: Wireframe metadata has been determined and pitch values have been assigned to each of the facets. The structure has optionally been processed by the rectification algorithm and/or optionally has undergone an in-plane normalization step.

b) Extrusion of the wireframe into 3D: A systematic pass is made through the extruded wireframe to correct the locations of points in the wireframe to accommodate the desired pitches and facet orientations. Information from the primitive hierarchy provides context for the order of primitive processing. Combined with other derived metadata, the primitive hierarchy also provides contextual clues about the relative elevations between groups connected by primitives. If the input wireframe is already in a "rough" 3D form, elevation information from this model may optionally be used by the Extrusion algorithm to "seed" initial relative elevations of points, lines and/or primitives with respect to other points, lines, and/or primitives present in the mode. If the input wireframe is 2D, it does not contain elevation information. In such a case, metadata containing hints about relative elevations between objects in the model (such as a disconnected patio or bay window cover) can

be used to provide context for placing some objects above or below others in the extruded 3D output.

As shown in Figure 5, the in-plane optimized wireframe of Figure 3 has been extruded into a "rough" 3D wireframe.

Correction of 3D wireframes

Figure 6 shows algorithm that takes as an input the "rough" 3D wireframe generated by the output of the 'Extrusion' algorithm of Figure 5, or directly from prior art Method 3 or any similar manual or automated method yielding a 3D wireframe.

The algorithm then generates a new wireframe model by correcting the original wireframe to satisfy a set of user-defined constraints and to remove geometric distortions/problems found in the original wireframe that are inconsistent with the selected constraints. As can be seen in Figure 6, whole planes of the proper geometric shape are overlaid in an interest to assist in correction of prior possible error.

For example, an original wireframe originating from Method 3 may contain some erroneously shaped roof polygons due to errors made by an inexperienced technician or even by a highly experienced technician that can quickly create a "rough" model that may contain a series of small correctible defects. In another example, an automated computer vision process produces a wireframe that contains correctable defects resulting from the small statistical uncertainties in its ability to determine the exact location of poorly resolved boundaries. In a third example, the output from the 'Extrusion' algorithm of Figure 5 may contain defects resulting from complex intersection from several planes which require further normalization to correctly resolve.

In these situations, the correction algorithms process the "rough" input wireframe to yield a wireframe that is consistent with a set of selected constraints. Examples of such constraint may include:

- Preserving the footprint (*e.g.*, perimeter) of the original wireframe
- Correcting angles of intersection between line segments
- Straightening line segments
- Specifying a particular pitch for one or more facets
- Allowing the pitch of one or more facets to conform with other constraints
- Enforcing relationships between line segments and facets to satisfy symmetry requirements.
- Correcting of 'lean' artifacts that are identified in the original model

Additional constraints that have proved to be useful may include:

- Constraining groups of points and/or line segments to reside at the same elevation (elevation groups). For example, such line segments include the line segments (and points they contain) that are parallel and equidistant from a ridge line as measured by the perpendicular distance between the ridge and the line segments. See the two line segments 58 and 60, which meet these criteria for the ridge 20 in Figure 2A.
- Constraining two or more elevation groups to maintain a particular difference in elevation. For example, Group 1 is the ridge 20 in Figure 2A. Group 2 are the line segments identified in the above example of an elevation group.
- Enforcing symmetry between nearly symmetric objects in the model, such as between the left and right planes 5 in Figure 2B.

The constraints above are additional examples of the use of metadata derived from the input model and/or collected interactively from the user. Also, the constraints above may be followed according to an assigned priority. For example, if one constraint cannot be adhered to without violating another constraint, the constraint to adhere to may be decided based upon which constraint has a higher priority. The priorities may be assigned by a user to be followed automatically during the processes described herein or

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created dynamically during the process of 3D wireframe generation. The metadata used in the examples above derived from the input model and/or collected interactively from the user may also or instead be used in the process for extrusion into a "rough" 3D wireframe described above.

This algorithm provides several competitive benefits:

a) It automates small corrections that would otherwise require manual correction by quality control staff that review the work of other technicians.

b) It decrease the time spent drawing a 3D wireframe using manual processes. Technicians can be less precise when "roughing" out a 3D model. This time savings increases with the complexity of the roof model.

c) It reduces some skill and training time required for new technicians

d) It processes constraints specified to produce models that satisfy a set of conditions required by third party CAD applications that desire to import the model for further editing.

e) It provides mechanisms to "clean up" or adjust models generated from other processes or programs.

Some software used by insurance claim adjustments has a set of constraints for their CAD software that renders roof images. Some software tools have a specific set of requirements that must be satisfied in order to import a roof diagram into their CAD software tool. The ability to modify a model derived from a photograph image to conform to the software requirements of specific CAD software tools is provided by the features of this invention. This yields the advantage of compatibility across the industry, one of the benefits of the inventive techniques described herein.

3D correction algorithm details:

a) Precursor steps: Wireframe metadata has been determined and pitch values been assigned to facets. The pitch value assignment could be via user assignment, by an algorithm that automatically assigns a pitch based on metadata derived from the 2D or 3D wireframe, or

by an algorithm that derives or assesses pitch information from the existing "rough" 3D wireframe provided as an input. The structure has optionally been processed by the rectification algorithm and/or optionally has undergone an in-plane normalization step and/or has optionally undergone an extrusion step.

b) Assembly: The "rough" wireframe input and the associated metadata provide a prototype from which a new wireframe is assembled while enforcing a set of constraints on the wireframe. These constraints may include such things as: i) A requirement that the set of points in each identified roof facet are coplanar to within a specified tolerance. ii) The area footprint in the XY plane of the wireframe's perimeter remains within a specified tolerance of the original "rough" wireframe's footprint area. iii) ridgelines and eavelines remain parallel to the XY plane.

Figure 6 is a "rough" wireframe of the 3D frame shown in Figure 4 overlayed with several known geometric objects. This figure illustrates a snapshot of the processing being performed to correct the spatial location of one point within the "rough" 3D form of the wireframe. The large plane 52 highlights the facet polygon 39 from Figure 2B currently being corrected. The plane 54 highlights the adjoining planar facet sharing the currently processed line segment with the main plane 52. The line segment in this example originates from the ridgeline of Primitive 2 and terminates at the ridgeline of Primitive 4. The darker plane 56 is a plane orthogonal to the XY plane that intersects the ridgeline of Primitive 4. The coordinates of the terminal endpoint of his line segment are then calculated as the intersection of the plane 56 with the line segment computed from the intersection of the planes 54 and 52, respectively. In Figure 5, the various planes and geometric shapes are shown in different shades of gray; of course, on a computer screen, each of the geometric shapes or planes may be a different color to provide highlight for a user. For example, the plane 52 may be green, the plane 54 red, the polygon 39 blue and the darker plane 56 a brown or orange. This diagram serves to illustrate one of many similar internal processing steps

that are not typically displayed to the end user because they typically do not require user input. The systematic processing of primitives, facet polygons, and line segments is continued throughout the wireframe until the corrections converge to a final roof shape with no further changes. If convergence does not occur, the software may exit or produce a corresponding message or alert due to a non-convergence condition.

Typical Usage Scenarios:

In the "background" section of this document, three prior art methods were identified and discussed as the motivation for inventing new methods that leverage best efficiency and accuracy attributes of the present methods.

Various new technology components, such as, for example, those listed below as items 1-5 resulted from this effort:

1) Wireframe rectification
2) Derivation of metadata from the original wireframe
3) In-plane normalization
4) Extrusion into a "rough" 3D wireframe
5) Correction of a 3D wireframe

Although the above technology components can be used independently, there are a number of usage embodiments envisioned involving these various technology components in various scenarios. The following labels for each step in each scenario below are for ease of identification and recollection of common steps within the various scenarios for the sake of brevity and do not limit the content or activities in each step.

Scenario 1

In scenario 1 below, the output is a corrected 3D wireframe.

a) "Wireframe": A 2D or 3D wireframe is used as input along with (optional) registration information that enables the system to overlay,

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project, and/or map the points of the input 2D or 3D wire frame onto one or more photographs containing an image of the structure of interest.

b) "Rectify": Wireframe Rectification is optionally applied to the input 2D or 3D wire frame.

c) "Metadata": Metadata is derived from the input 2D or 3D wire frame and/or the output of (b).

d) "AssignPitch": Pitches are either assigned by algorithms that analyze neighboring polygons to infer relative pitch values or the pitches are assigned by the user.

e) "Normalize": The in-plane normalization algorithm is applied to the wireframe.

f) "Extrude": The Extrusion algorithm is applied.

g) "Correct 3D": The 3D correction algorithm is applied.

h) "Verify":

The following are example steps takes during the "Verify" process:

1. Validation: As assessment of the resulting wireframe is made to determine if the wireframe conforms to the above mentioned pitches and constraints to within a desired tolerance. If the model does not conform, the algorithm to returns to (d) or (e) until the wireframe is successfully validated or the algorithm determines that insufficient progress is being made toward converging to a valid model.

The following steps h(2) and h(3) may be optional since they depend on the result of the image registration process and could be omitted if the registration information is not provided as part of the input.

2. Projection: The validated wireframe is transformed and projected onto each of the photographs registered into the coordinate system determined provided in (a), as described in U.S. Patent Applications Serial Numbers 12/467,244 and 12/467,250.

3. Quality of Fit evaluation (shown in Figures 8A and 8B): The projected wireframes are evaluated for a quality of fit. This may be a

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combination of an automated quality of fit determination as well as a subjective visual assessment by a quality control technician. If quality of fit is not acceptable, the algorithm returns to step (b) following adjustments to the facet pitch values and/or edits to the wireframe.

Figure 7 shows the noncorrected 3D wireframe dark lines, overlaid onto the rectified wireframe of Figure 1B, shown by the dashed lines of Figure 7. Note that the top-down view of this final 3D wireframe in Figure 7 is not distinguishable from the output of the (2D) in-plane optimized wireframe in Figure 4. This is a desirable result for this simple roof example since it illustrates how the in-plane normalization produced a wireframe that correctly represented a top-down projection of what became the final 3D form. In situations of greater wireframe complexity, the correction in 3D may result in a repositioning of lines in the top-down projection that could not be predicted by the in-plane calculations.

Scenario 2

In scenario 2, the output is a corrected 2D wire frame instead of a 3D wire frame as in scenario 1 above. The sequence of steps is: "Wireframe", "Rectify", "Metadata", "AssignPitch", and "Normalize". The steps of scenario 2 correspond to those steps of scenario 1 having the same labels.

Scenario 3

In scenario 3, the output is a corrected 3D wire frame. Scenario 3 uses a "rough" 3D model input needing minor corrections, such as a model that was already extruded by using the new registration algorithm mentioned in this document above. The sequence of steps is: "Wireframe", "Rectify", "Metadata", "AssignPitch", "Normalize", "Extrude", "Correct3D", and "Verify". The steps of scenario 3 correspond to those steps of scenario 1 having the same labels. However, in the "AssignPitch" step of scenario 3, pitches are typically assigned by algorithms that generate a "rough" 3D wireframe. Also,

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the "Extrude" step of scenario 3 leverages existing elevation information to "seed" elevation placements of model points and/or lines, etc.

Scenario 4

Scenario 4 uses a "rough" 3D model input needing major corrections, such as a major pitch correction or after adding, removing, and/or changing major parts of the model. The sequence of steps is: "Wireframe", "Rectify", "Metadata", "AssignPitch", "Normalize", "Extrude", "Correct3D", and "Verify". The steps of scenario 4 correspond to those steps of scenario 1 having the same labels. However, in the "AssignPitch" step of scenario 4, pitches are typically assigned by algorithms that that generate a "rough" 3D wireframe and/or are overridden by a user. Also, the "Extrude" step of scenario 4 may ignore existing elevation "seed" information where needed to complete a successful extrusion.

Figures 8A and 8B shows the 3D wireframe of Figure 7 transformed and then projected back on the original source images. Note that the transformation process slightly distorts the appearance of overlayed wireframe to account for the 'lean' and other artifacts that were calculated to be in the original source photographs during the registration process. These distortions are most obvious at the gables of Primitive 1 and 3.

By mapping the distortions back into the wireframe, a quality of fit (QOF) metric can be applied to judge the alignment of the wireframe against the object(s) it represents in the original source image.

In one embodiment a wireframe is generated via prior art Method 2 or 3, then correction is done in 3D as shown in Figures 5-7.

This is an extension of Methods 2 and 3 whereby a "rough" 3D model resulting from a manual or automated wireframe generating process is optimized to a desired set of pitch and orientation constraints.

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In yet another embodiment, the system will generate a metadata and a rectified 2D model, then normalize in-plane to achieve a final 2D or 3D wireframe.

In some situations, the content of the photograph(s) are insufficient to complete a 3D model without previous knowledge of the pitches of some or all of the roof facets. Furthermore, it may be preferable in some situations to defer the final application of pitch values to selection by an operator at a later time. In such situations, only steps 1, 2, and 3 as set forth under the heading of "Typical Usage Scenarios" above are carried out or, alternatively, step 3 is carried out on the in-plane normalized wireframe traced via prior art Method 1.

Figure 9 is a schematic diagram of computing environment in which geometric correction of rough wireframe models derived from photographs may be implemented or of which it may be a part. For example, process 100 described above in conjunction with Figure 1A may be performed or implemented by, for example, one or more software modules or components or any combination of suitable hardware, firmware or software components or devices including those that are a part of, stored in, or configure the computing environment of Figure 9.

The computing environment 900 will at times be referred to in the singular herein, but this is not intended to limit the embodiments to a single device since in typical embodiments there may be more than one computer system or device involved. Unless described otherwise, the construction and operation of the various blocks shown in Figure 9 are of conventional design. As a result, such blocks need not be described in further detail herein, as they will be understood by those skilled in the relevant art.

The computing environment 900 may include one or more processing units 912a, 912b (collectively 912), a system memory 914 and a system bus 916 that couples various system components including the system memory 914 to the processing units 912. The processing units 912 may be any logic processing unit, such as one or more central processing

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units (CPUs) 912a, digital signal processors (DSPs) 912b, digital video or audio processing units such as coder-decoders (codecs) or compression-decompression units, application-specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), etc. The system bus 916 can employ any known bus structures or architectures, including a memory bus with memory controller, a peripheral bus, and a local bus. The system memory 914 includes read-only memory ("ROM") 918 and random access memory ("RAM") 920. A basic input/output system ("BIOS") 922, which can form part of the ROM 918, contains basic routines that help transfer information between elements within the computing environment 900, such as during start-up.

The computing environment 900 may include a hard disk drive 924 for reading from and writing to a hard disk 926 (including a solid state memory device), an optical disk drive 928 for reading from and writing to removable optical disks 932, and/or a magnetic disk drive 930 for reading from and writing to magnetic disks 934. The optical disk 932 can be a CD-ROM, while the magnetic disk 934 can be a magnetic floppy disk or diskette. The hard disk drive 924, optical disk drive 928 and magnetic disk drive 930 may communicate with the processing unit 912 via the system bus 916. The hard disk drive 924, optical disk drive 928 and magnetic disk drive 930 may include interfaces or controllers (not shown) coupled between such drives and the system bus 916, as is known by those skilled in the relevant art. The drives 924, 928 and 930, and their associated computer-readable storage media 926, 932, 934, may provide nonvolatile and non-transitory storage of computer readable instructions, data structures, program modules and other data for the computing environment 900. Although the depicted computing environment 900 is illustrated employing a hard disk 924, optical disk 928 and magnetic disk 930, those skilled in the relevant art will appreciate that other types of computer-readable storage media that can store data accessible by a computer may be employed, such as magnetic cassettes, flash memory, digital video disks ("DVD"), Bernoulli cartridges, RAMs, ROMs, smart cards,

etc. For example, computer-readable storage media may include, but is not limited to, random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory, compact disc ROM (CD-ROM), digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, solid state memory or any other medium which can be used to store the desired information and which may be accessed by processing unit 912a.

Program modules can be stored in the system memory 914, such as an operating system 936, one or more application programs 938, other programs or modules 940 and program data 942. Application programs 938 may include instructions that cause the processor(s) 912 to perform directional geometric correction of rough wireframe models derived from photographs, and store and display input images or images generated by geometric correction of rough wireframe models. Other program modules 940 may include instructions for handling security such as password or other access protection and communications encryption. The system memory 914 may also include communications programs, for example, a Web client or browser 944 for permitting the computing environment 900 to access and exchange data including digital images of structures with sources such as Web sites of the Internet, corporate intranets, extranets, or other networks and devices, as well as other server applications on server computing systems. The browser 944 in the depicted embodiment is markup language based, such as Hypertext Markup Language (HTML), Extensible Markup Language (XML) or Wireless Markup Language (WML), and operates with markup languages that use syntactically delimited characters added to the data of a document to represent the structure of the document. A number of Web clients or browsers are commercially available such as those from Mozilla, Google, and Microsoft of Redmond, Washington.

While shown in Figure 9 as being stored in the system memory 914, the operating system 936, application programs 938, other

programs/modules 940, program data 942 and browser 944 can be stored on the hard disk 926 of the hard disk drive 924, the optical disk 932 of the optical disk drive 928 and/or the magnetic disk 934 of the magnetic disk drive 930.

An operator can enter commands and information into the computing environment 900 through input devices such as a touch screen or keyboard 946 and/or a pointing device such as a mouse 948, and/or via a graphical user interface in order to receive, process, store and send data on which geometric correction of rough wireframe models derived from photographs has been or will be performed as described herein. Other input devices can include a microphone, joystick, game pad, tablet, scanner, etc. These and other input devices are connected to one or more of the processing units 912 through an interface 950 such as a serial port interface that couples to the system bus 916, although other interfaces such as a parallel port, a game port or a wireless interface or a universal serial bus ("USB") can be used. A monitor 952 or other display device is coupled to the system bus 916 via a video interface 954, such as a video adapter which may be configured to display images used by or generated by geometric correction of rough wireframe models derived from photographs. The computing environment 900 can include other output devices, such as speakers, printers, etc.

The computing environment 900 can operate in a networked environment using logical connections to one or more remote computers and/or devices. For example, the computing environment 900 can operate in a networked environment using logical connections to one or more other computing systems, mobile devices and other service providers or information servers that provide the digital images in various format or by other electronic delivery methods. Communications may be via a wired and/or wireless network architecture, for instance wired and wireless enterprise-wide computer networks, intranets, extranets, telecommunications networks, cellular networks, paging networks, and other mobile networks.

The various embodiments described above can be combined to provide further embodiments. All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet are incorporated herein by reference, in their entirety. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.

These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

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CLAIMS

1. A method comprising:

assigning an initial set of pitch values to a plurality of facets of a roof;

automatically adjusting lateral positions of points associated with one or more first line segments of the roof identified as one or more ridge segments to accommodate pitch values of the initial set of pitch values associated with facets that share the one or more ridge segments or share endpoints of the one or more roof segments; and

automatically adjusting lateral positions of points associated with one or more second line segments of the roof identified as a junction or seam between adjacent facets of the roof to accommodate pitch values of the initial set of pitch values associated with the adjacent facets.

2. The method according to claim 1 further comprising repeating the automatically adjusting lateral positions of points associated with the one or more first line segments until the adjusting of lateral positions of points converges to a stable state.

3. The method according to claim 2 further comprising automatically repeating the automatically adjusting lateral positions of points associated with the one or more second line segments until the adjusting of lateral positions of points converges to a stable state.

4. The method according to claim 3 further comprising repeating the assigning an initial set of pitch values before repeating the automatically adjusting lateral positions of points associated with the one or more first line segments and before repeating the automatically adjusting lateral positions of points associated with the one or more second line segments.

5. The method according to claim 1, further comprising assigning an initial set of orientations to the plurality of roof facets.

6. The method according to claim 1, further comprising automatically generating a first 3D wireframe of the roof based on the adjusted lateral positions of points associated with the one or more first line segments and the adjusted lateral positions of points associated with the one or more second line segments.

7. The method according to claim 6 wherein the automatically generating the first 3D wireframe is further based on and initial set of input roof elevation values.

8. The method according to claim 7 further comprising automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints.

9. The method according to claim 8 wherein the changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints includes one or more of the following: preserving a footprint of the first 3D wireframe; correcting angles of intersection between line segments of the first 3D wireframe; straightening line segments of the first 3D wireframe; specifying a particular pitch for one or more facets of the roof; allowing a pitch of one or more facets of the roof to conform with other constraints; enforcing relationships between line segments and facets of the first 3D wireframe to satisfy symmetry requirements; constraining groups of points or line segments of the first 3D wireframe to reside at a same elevation; constraining two or more different groups of points or line segments of the first 3D wireframe to maintain a particular difference in elevation; enforcing symmetry between nearly symmetric objects in the first 3D wireframe.

10. The method of claim 8 wherein the automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints includes using metadata regarding relationships between roof line segments and points.

11. The method according to claim 1, further comprising deriving metadata from an initial wireframe of the roof, the metadata including information regarding one or more of the following: nearest neighbor points of the points associated with the one or more first line segments, nearest neighbor line segments of the one or more first line segments, nearest neighbor points of the points associated with the one or more second line segments, nearest neighbor line segments of the one or more second line segments, roof line segment membership in polygons, whether line segments of the roof are edges or ridges, which points resemble roof hip junctions of the roof, which points resemble roof gable junctions of the roof, which points resemble roof corners on a perimeter of the roof, or identification of roof geometric shape primitives;

wherein the metadata is used in one or both of: the automatically adjusting lateral positions of points associated with one or more first line segments, and the automatically adjusting lateral positions of points associated with one or more second line segments.

12. The method according to claim 11 wherein the initial wireframe is a 2D wireframe.

13. The method according to claim 11 wherein the initial wireframe is a 3D wireframe.

14. The method according to claim 1 wherein the assigning an initial set of pitch values to a plurality of facets of a roof comprises

automatically analyzing neighboring polygons of the roof to infer relative pitch values.

15. The method according to claim 1 wherein the initial set of pitch values are automatically assigned based on received input pitch values from a user.

16. A method comprising:

generating metadata from a wireframe model of a roof;

moving a location of roof junction points from the wireframe model to a normalized roof outline based on the generated metadata;

modifying a shape of the roof facets of the wireframe model; and

outputting a revised wireframe model based on the moved junction points and modified shapes to more closely approximate the actual shape of the roof.

17. The method according to claim 16 wherein the modifying the shape of the roof facets of the wireframe model includes:

comparing the roof facets of the wireframe model to a database of roof geometric shape primitives; and

modifying the shape of at least one of the roof facets of the wireframe model to match the geometric shape of a previously stored primitive.

18. The method according to claim 17 where in one of the primitives is a hip or gable.

19. The method according to claim 16 wherein the modifying the shape of the roof facets of the wireframe model is based on the generated metadata.

Roofr Exhibit 1002, Page 363

20. The method according to claim 16 wherein the wireframe model is a 2D top view of the roof.

21. The method according to claim 20 further including:

generating a 3D wireframe of the roof based on the revised wireframe model.

22. A non-transitory computer readable medium having computer executable instructions thereon that, when executed, cause a computer processor to perform the following:

automatically adjusting lateral positions of points associated with one or more first line segments of a roof identified as one or more ridge segments to accommodate pitch values of an initial set of pitch values associated with facets that share the one or more ridge segments or share endpoints of the one or more roof segments; and

automatically adjusting lateral positions of points associated with one or more second line segments of the roof identified as a junction or seam between adjacent facets of the roof to accommodate pitch values of the initial set of pitch values associated with the adjacent facets.

23. The method according to claim 22 wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform automatically generating a first 3D wireframe of the roof based on the adjusted lateral positions of points associated with the one or more first line segments and the adjusted lateral positions of points associated with the one or more second line segments.

24. The method according to claim 23 wherein the generating the first 3D wireframe is further based on and initial set of input roof elevation values.

25. The method according to claim 23 wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints.

26. A non-transitory computer readable medium having computer executable instructions thereon that, when executed, cause a computer processor to perform the following:

generating metadata from a wireframe model of a roof, the wireframe model having roof junction points and roof facets;

moving a location of roof junction points from the wireframe model to a normalized roof outline based on the generated metadata;

modifying a shape of the roof facets of the wireframe model; and

outputting a revised wireframe model based on the moved junction points and modified shapes to more closely approximate the actual shape of the roof.

27. The non-transitory computer readable medium of claim 26 wherein the modifying the shape of the roof facets of the wireframe model includes:

comparing the roof facets of the wireframe model to a database of roof geometric shape primitives; and

modifying the shape of at least one of the roof facets of the wireframe model to match the geometric shape of a previously stored primitive.

28. The non-transitory computer readable medium of claim 26, wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform generating a 3D wireframe of the roof based on the revised wireframe model.

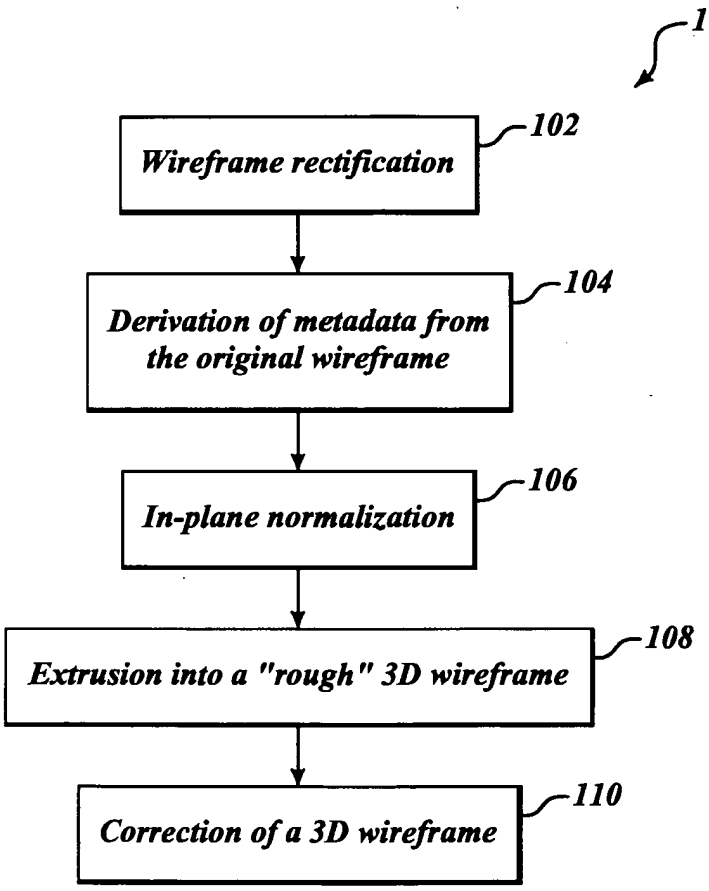

100
Wireframe rectification
102
Derivation of metadata from the original wireframe
104
In-plane normalization
106
Extrusion into a "rough" 3D wireframe
108
Correction of a 3D wireframe
110

FIG.1A

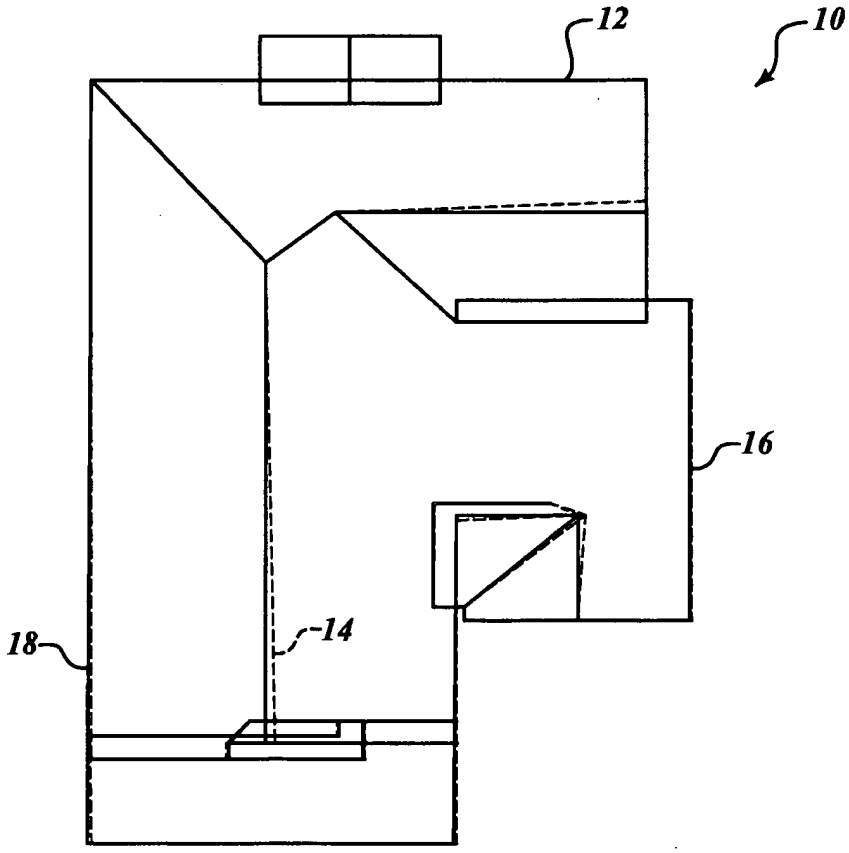


FIG.1B

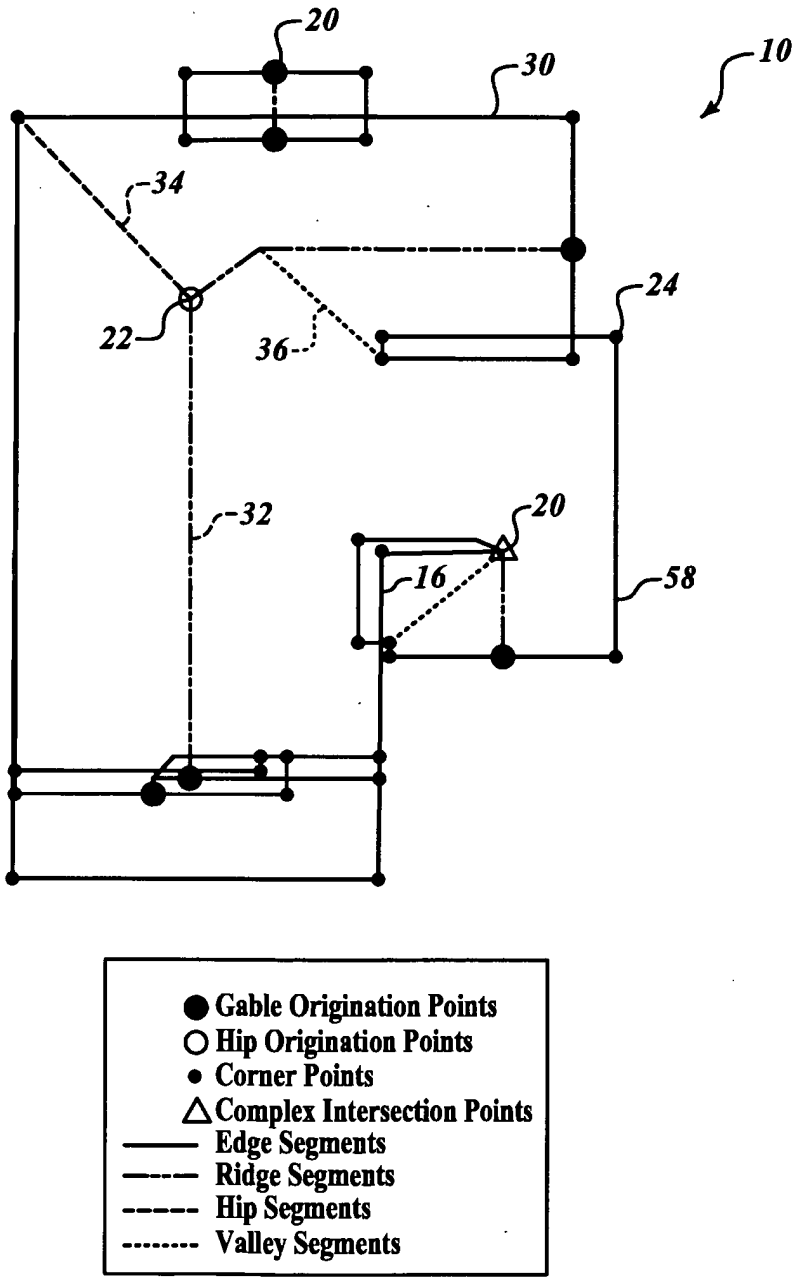

20
30
10
34
24
22
36
32
20
16
58
Gable Origination Points
Hip Origination Points
Corner Points
Complex Intersection Points
Edge Segments
Ridge Segments
Hip Segments
Valley Segments

FIG.2A

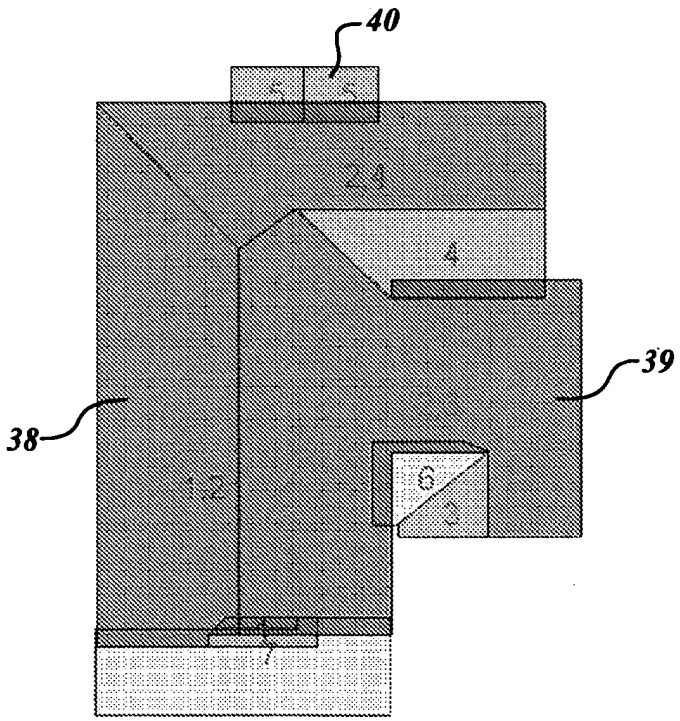


FIG.2B

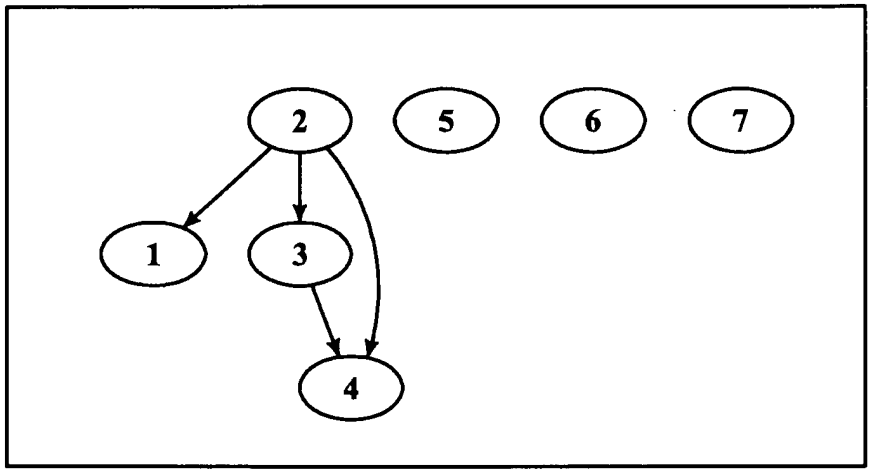


FIG.3

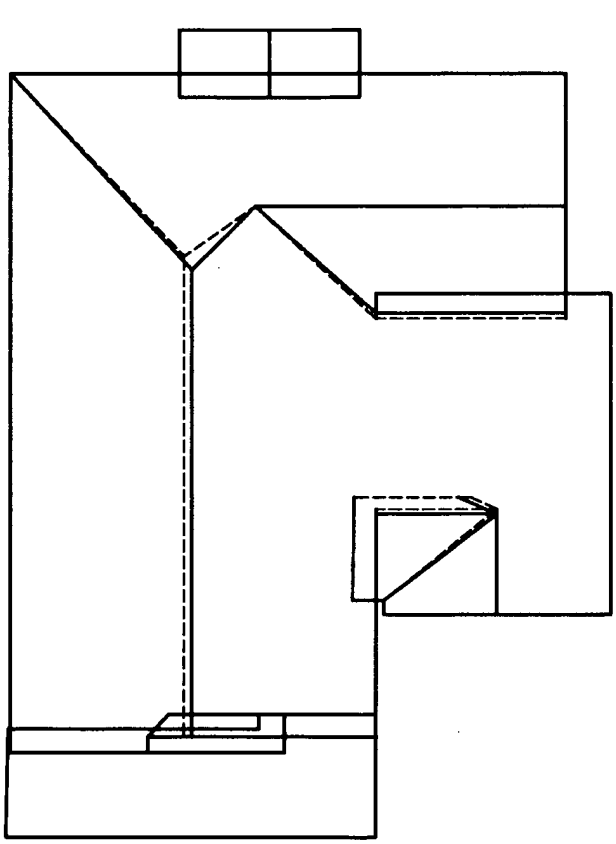


FIG.4

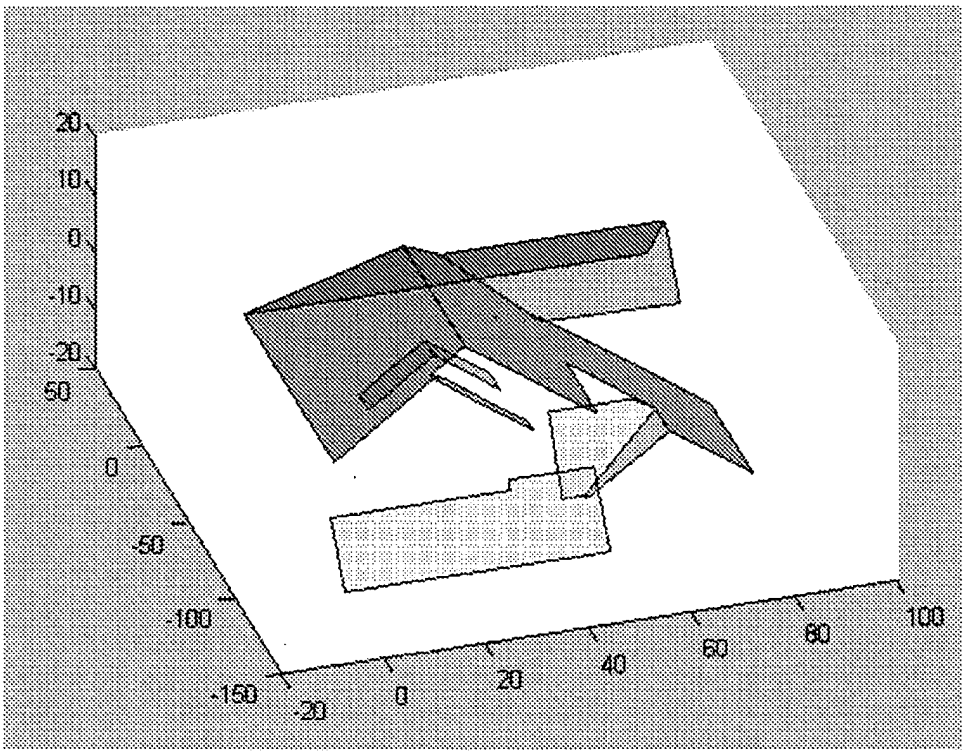


FIG.5

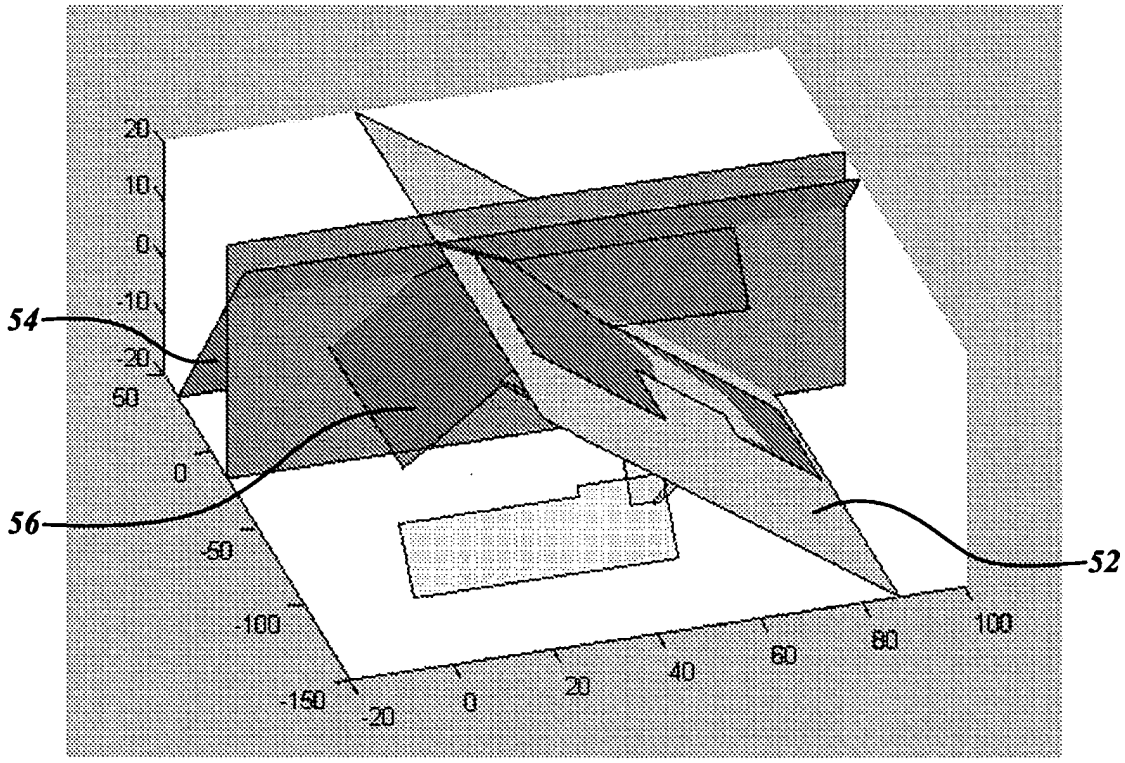


FIG.6

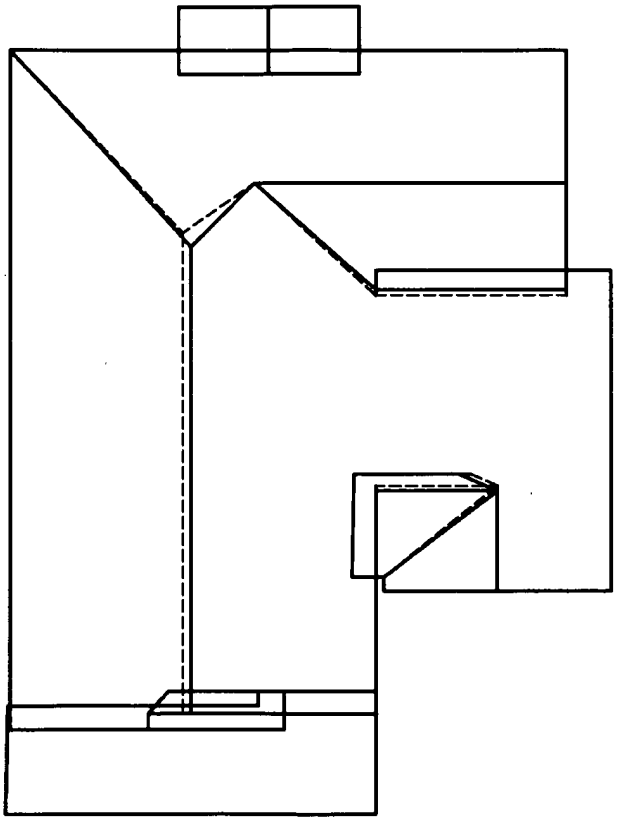


FIG. 7

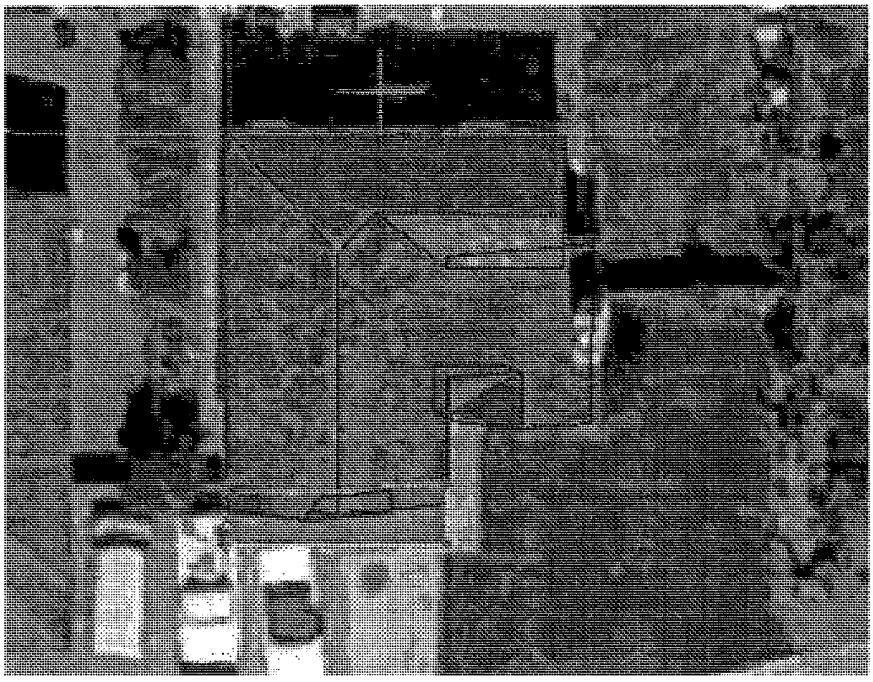


FIG.8A

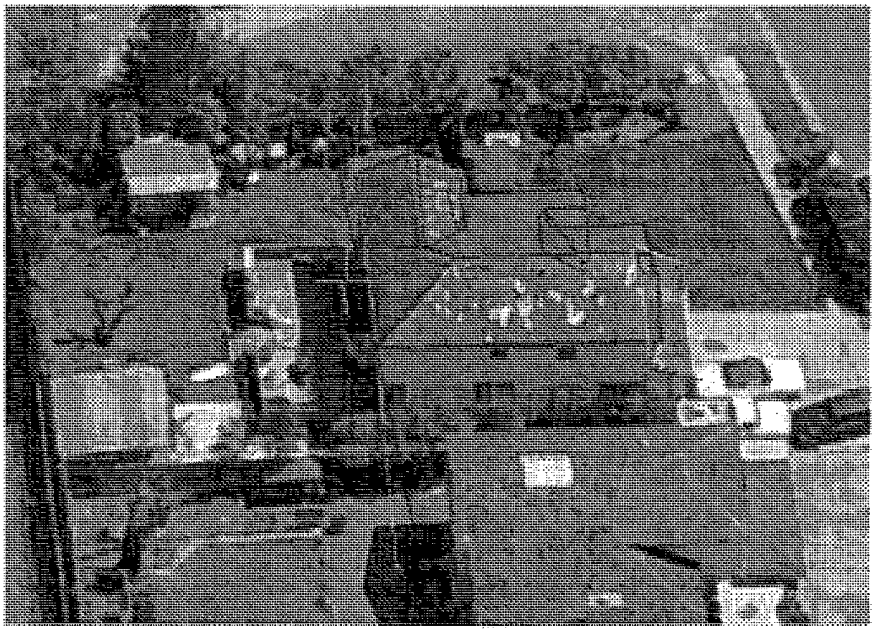


FIG.8B

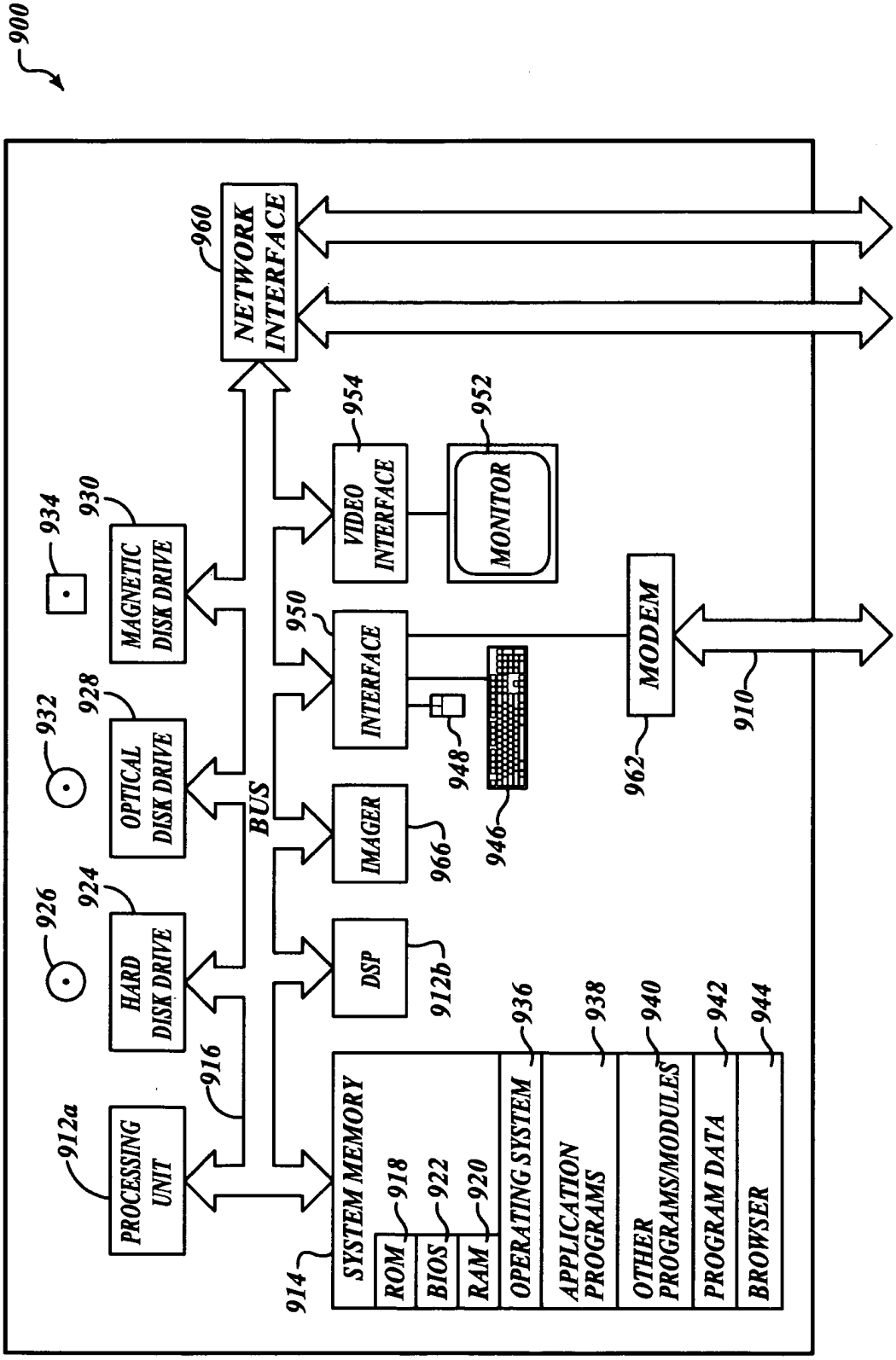

900
NETWORK INTERFACE
960
VIDEO INTERFACE
954
MONITOR
952
MAGNETIC DISK DRIVE
930
934
OPTICAL DISK DRIVE
928
932
HARD DISK DRIVE
924
926
BUS
950
INTERFACE
948
946
IMAGER
966
DSP
912b
MODEM
962
910
PROCESSING UNIT
912a
916
914
SYSTEM MEMORY
ROM
918
BIOS
922
RAM
920
OPERATING SYSTEM
936
APPLICATION PROGRAMS
938
OTHER PROGRAMS/MODULES
940
PROGRAM DATA
942
BROWSER
944

FIG. 9

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 290115-407PC	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US 11/23408	International filing date *(day/month/year)* 01 February 2011 (01.02.2011)	(Earliest) Priority Date *(day/month/year)* 01 February 2010 (01.02.2010)
Applicant EAGLE VIEW TECHNOLOGIES		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 7 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed.
      ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,
   a. the figure of the drawings to be published with the abstract is Figure No. 1A
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 11/23408

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06K 9/00, G06F 17/50 (2011.01)
USPC - 382/154; 703/1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 382/154; 703/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 382/154; 345/581-582, 598, 599; 700/1-7, 90, 95, 97, 98; 703/1,26 (keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Electronic Database Searched: PubWEST (PGPB, USPT, EPAB, JPAB), Google Scholar
Search Terms Used: roof, ceiling, building, skyscraper, house, top, surface, cover, facet, surface, side, plane, face, pitch, slope, angle, tilt, assign, allocate, attribute, transfer, determine, compute, calculate, identification, estimate, extract, derive, wirefra

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/0105573 A1 (Neumann et al.) 03 June 2004 (03.06.2004), see entire document; especially para [0005]-[0007], [0021]-[0027], [0032]-[0042], [0044]-[0050], [0053], [0058]-[0062], [0066], Fig. 5	1-28
A	US 2009/0132436 A1 (Pershing et al.) 21 May 2009 (21.05.2009), see entire document	1-26
A	US 2009/0132210 A1 (Royan et al.) 21 May 2009 (21.05.2009), see entire document	1-28
A	US 2008/0021683 A1 (Rahmes et al.) 24 January 2008 (24.01.2008), see entire document	1-28
A	US 2006/0262112 A1 (Shimada) 23 November 2008 (23.11.2006), see entire document	1-28

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 July 2011 (28.07.2011)	11 AUG 2011
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

ARTIFACT SHEET

Enter artifact number below. Artifact number is application number + artifact type code (see list below) + sequential letter (A, B, C …). The first artifact folder for an artifact type receives the letter A, the second B, etc..
Examples: 59123456PA, 59123456PB, 59123456ZA, 59123456ZB

12467244ZA

Indicate quantity of a single type of artifact received but not scanned. Create individual artifact folder/box and artifact number for each Artifact Type.

☐ CD(s) containing:
- computer program listing ☐ — Doc Code: Computer — Artifact Type Code: P
- pages of specification and/or sequence listing and/or table ☐ — Doc Code: Artifact — Artifact Type Code: S
- content unspecified or combined ☐ — Doc Code: Artifact — Artifact Type Code: U

☐ Stapled Set(s) Color Documents or B/W Photographs
Doc Code: Artifact Artifact Type Code: C

☐ Microfilm(s)
Doc Code: Artifact Artifact Type Code: F

☐ Video tape(s)
Doc Code: Artifact Artifact Type Code: V

☐ Model(s)
Doc Code: Artifact Artifact Type Code: M

☐ Bound Document(s)
Doc Code: Artifact Artifact Type Code: B

☐ Confidential Information Disclosure Statement or Other Documents marked Proprietary, Trade Secrets, Subject to Protective Order, Material Submitted under MPEP 724.02, etc.
Doc Code: Artifact Artifact Type Code X

1 Other, description: **DVD**
Doc Code: Artifact Artifact Type Code: Z

March 8, 2004

EM# EV 887976986 US
USAN: 12/467,244
Inventor: Chris Pershing

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: JEREMIAH BAUNACH
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
SUITE 5400
701 FIFTH AVENUE
SEATTLE, WA 98104-7064

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	11 AUG 2011
Applicant's or agent's file reference: 290115-407PC	FOR FURTHER ACTION: See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 11/23408	01 February 2011 (01.02.2011)	01 February 2010 (01.02.2010)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - G06K 9/00, G06F 27/50 (2011.01)
USPC - 382/154; 703/1

Applicant EAGLE VIEW TECHNOLOGIES

1. This opinion contains indications relating to the following items:

- [X] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [X] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1 *bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to th IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Fom PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	28 July 2011 (28.07.2011)	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/23408

Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

      ☐ on paper

      ☐ in electronic form

   b. (time)

      ☐ in the international application as filed

      ☐ together with the international application in electronic form

      ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/23408

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	None	YES
	Claims	1-28	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-28	NO
Industrial applicability (IA)	Claims	1-28	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-28 lack novelty under PCT Article 33(2) as being anticipated by US 2004/0105573 A1 to Neumann et al. (hereinafter 'Neumann').

As per claim 1, Neumann discloses a method (see abstract) comprising: assigning an initial set of pitch values to a plurality of facets of a roof (see Fig. 5, para [0033]-[0036], [0038], [0042] and [0048]-[0050] - slope values are assigned to facets of a triangle mesh roof structure); automatically adjusting lateral positions of points associated with one or more first line segments of the roof identified as one or more ridge segments to accommodate pitch values of the initial set of pitch values associated with facets that share the one or more ridge segments or share endpoints of the one or more roof segments (see Fig. 5, para [0038], [0041]-[0042], [0046]-[0050] and [0059]-[0062] - the positions of points associated with line segments of roof primitives, including ridge segments, are fitted to the slope values detected by the range sensor and assigned to the triangle mesh roof structure); and automatically adjusting lateral positions of points associated with one or more second line segments of the roof identified as a junction or seam between adjacent facets of the roof to accommodate pitch values of the initial set of pitch values associated with the adjacent facets (see Fig. 5, para [0038], [0041]-[0042], [0045]-[0050] and [0059]-[0062] - the positions of points associated with line segments of roof primitives, including all edge segments, are fitted to the slope values detected by the range sensor and assigned to the triangle mesh roof structure).

As per claim 2, Neumann discloses the method according to claim 1 further comprising repeating the automatically adjusting lateral positions of points associated with the one or more first line segments until the adjusting of lateral positions of points converges to a stable state (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor data encapsulated by the triangle mesh).

As per claim 3, Neumann discloses the method according to claim 2 further comprising automatically repeating the automatically adjusting lateral positions of points associated with the one or more second line segments until the adjusting of lateral positions of points converges to a stable state (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor date encapsulated by the triangle mesh).

As per claim 4, Neumann discloses the method according to claim 3 further comprising repeating the assigning an initial set of pitch values before repeating the automatically adjusting lateral positions of points associated with the one or more first line segments and before repeating the automatically adjusting lateral positions of points associated with the one or more second line segments (see Fig. 5, para [0021] and [0033] - "[t]he model reconstruction component 160 and the model refinement component 170 can interact with each other to improve the three-dimensional (3D) model continuously").

As per claim 5, Neumann discloses the method according to claim 1, further comprising assigning an initial set of orientations to the plurality of roof facets (see para [0005]-[0007], [0026], [0032], [0042], [0044] and [0049] - the orientation information of the roof is assigned to the triangle mesh).

As per claim 6, Neumann discloses the method according to claim 1, further comprising automatically generating a first 3D wireframe of the roof based on the adjusted lateral positions of points associated with the one or more first line segments and the adjusted lateral positions of points associated with the one or more second line segments (see Fig. 5, para [0021]-[0024], [0033]-[0035] and [0059]-[0062] - disclosing the automatic generation and refining of a 3D model of the roof based on the fitted positions of the points associated with the primitive).

As per claim 7, Neumann discloses the method according to claim 6 wherein the automatically generating the first 3D wireframe is further based on an initial set of input roof elevation values (see para [0024]-[0025], [0032]-[0033], [0036]-[0038] and [0060]-[0062] - the range sensor information can provide a clear footprint of a building's position and height information which is used to construct the model).

As per claim 8, Neumann discloses the method according to claim 7 further comprising automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints (see Fig. 5, para [0021], [0036], [0041]-[0042], [0045]-[0048], [0050], [0053] and [0058]-[0060] - multiple models of the roof are iteratively generated to satisfy the constraints captured from range sensor).

SEE SUPPLEMENTAL SHEET

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/23408

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box V.2 - Citations and Explanations

As per claim 9, Neumann discloses the method according to claim 8 wherein the changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints includes one or more of the following: preserving a footprint of the first 3D wireframe (see para [0036] - generated models must preserve the footprint captured by the range sensor); correcting angles of intersection between line segments of the first 3D wireframe (see para [0050]); straightening line segments of the first 3D wireframe; specifying a particular pitch for one or more facets of the roof see Fig. 5, para [0033]-[0036], [0038], [0042] and [0048]-[0050] - slope values are assigned to facets of a triangle mesh roof structure); allowing a pitch of one or more facets of the roof to conform with other constraints; enforcing relationships between line segments and facets of the first 3D wireframe to satisfy symmetry requirements (see para [0049]-[0050]); constraining groups of points or line segments of the first 3D wireframe to reside at a same elevation; constraining two or more different groups of points or line segments of the first 3D wireframe to maintain a particular difference in elevation; enforcing symmetry between nearly symmetric objects in the first 3D wireframe.

As per claim 10, Neumann discloses the method of claim 8 wherein the automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints includes using metadata regarding relationships between roof line segments and points (see Fig. 5, para [0021], [0036], [0041]-[0042], [0045]-[0048], [0050], [0053] and [0058]-[0060] - updated models of the roof are generated by changing geometric characteristics of the roof primitive to fit the measured data and relationships).

As per claim 11, Neumann discloses the method according to claim 1, further comprising deriving metadata from an initial wireframe of the roof, the metadata including information regarding one or more of the following: nearest neighbor points of the points associated with the one or more first line segments, nearest neighbor line segments of the one or more first line segments, nearest neighbor points of the points associated with the one or more second line segments, nearest neighbor line segments of the one or more second line segments (see Fig. 5 and para [0032]-[0035] - disclosing adaptive-weighting neighborhood interpolation), roof line segment membership in polygons, whether line segments of the roof are edges or ridges (see Fig. 5 and para [0048]-[0050] - disclosing the identification of ridges), which points resemble roof hip junctions of the roof, which points resemble roof gable junctions of the roof (see para [0038] - disclosing the identification of gable roofs), which points resemble roof corners on a perimeter of the roof, or identification of roof geometric shape primitives (see Fig. 5 and para [0036]-[0040] - "[a] set of geometric primitives can be selected based on a shape of the structure"); wherein the metadata is used in one or both of: the automatically adjusting lateral positions of points associated with one or more first line segments, and the automatically adjusting lateral positions of points associated with one or more second line segments (see Fig. 5, para [0038]-[0041] and [0044]-[0050] - the metadata is used to identify a primitive and to fit that primitive to the constraints derived from the metadata such as whether line segments are edges or ridges).

As per claim 12, Neumann discloses the method according to claim 11 wherein the initial wireframe is a 2D wireframe (see para [0038], [0042] and [0044]-[0048] - the primitive model used for the roof can be set to a two dimensional wireframe by setting the building's orientation parallel to an axis).

As per claim 13, Neumann discloses the method according to claim 11 wherein the initial wireframe is a 3D wireframe (see Fig. 5 and para [0038]-[0042] - the initial primitive selected may be a 3D mesh model).

As per claim 14, Neumann discloses the method according to claim 1 wherein the assigning an initial set of pitch values to a plurality of facets of a roof comprises automatically analyzing neighboring polygons of the roof to infer relative pitch values (see Fig. 5, para [0033]-[0036], [0038], [0040]-[0042] and [0047]-[0050] - depth discontinuity is used for surface segmentation and the slope of a surface can be determined relative to neighboring surface faces).

As per claim 15, Neumann discloses the method according to claim 1 wherein the initial set of pitch values are automatically assigned based on received input pitch values from a user (see para [0060] - "system can also include editing tools that allow users to modify the models or obtain a specific representation quickly and accurately").

As per claim 16, Neumann discloses a method comprising: generating metadata from a wireframe model of a roof (see Fig. 5, para [0032]-[0035], [0038]-[0040], [0044]-[0045] and [0048]-[0050] - disclosing the generation of metadata such as edge lines, ridge lines and shapes from a mesh model of a roof); moving a location of roof junction points from the wireframe model to a normalized roof outline based on the generated metadata (see Fig. 5, para [0021], [0036], [0038]-[0043], [0045]-[0048], [0050], [0053] and [0058]-[0060] - the points of the mesh are mapped to a geometric primitive corresponding to the roof type); modifying a shape of the roof facets of the wireframe model (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor data encapsulated by the triangle mesh); and outputting a revised wireframe model based on the moved junction points and modified shapes to more closely approximate the actual shape of the roof (see Fig. 5, para [0021], [0025], [0053] and [0058]-[0060] - the 3D model is revised based on the fitting of the primitive to the detected data).

As per claim 17, Neumann discloses the method according to claim 16 wherein the modifying the shape of the roof facets of the wireframe model includes: comparing the roof facets of the wireframe model to a database of roof geometric shape primitives (see Fig. 5, para [0021], [0036], [0038]-[0043], [0045]-[0048], [0050], [0053] and [0058]-[0060] - the mesh model is compared to a geometric roof primitive); and modifying the shape of at least one of the roof facets of the wireframe model to match the geometric shape of a previously stored primitive (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor data encapsulated by the triangle mesh).

As per claim 18, Neumann discloses the method according to claim 17 where in one of the primitives is a hip or gable (see para [0036] - disclosing a gable primitive).

SEE SUPPLEMENTAL SHEET

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box V.2 - Citations and Explanations

As per claim 19, Neumann discloses the method according to claim 16 wherein the modifying the shape of the roof facets of the wireframe model is based on the generated metadata (see Fig. 5, para [0038]-[0041] and [0044]-[0050] - the metadata is used to identify a primitive and to fit that primitive to the constraints derived from the metadata such as whether line segments are edges or ridges).

As per claim 20, Neumann discloses the method according to claim 16 wherein the wireframe model is a 2D top view of the roof (see para [0038], [0042] and [0044]-[0048] - the primitive model used for the roof can be set to a two dimensional wireframe by setting the building's orientation parallel to an axis).

As per claim 21, Neumann discloses the method according to claim 20 further including: generating a 3D wireframe of the roof based on the revised wireframe model (see Fig. 5, para [0021], [0025], [0053] and [0058]-[0060] - the 3D model is revised based on the fitting of the primitive to the detected data).

As per claim 22, Neumann discloses a non-transitory computer readable medium having computer executable instructions thereon that (see Fig. 2, para [0027] and [0066]), when executed, cause a computer processor to perform the following: automatically adjusting lateral positions of points associated with one or more first line segments of a roof identified as one or more ridge segments to accommodate pitch values of an initial set of pitch values associated with facets that share the one or more ridge segments or share endpoints of the one or more roof segments (see Fig. 5, para [0038], [0041]-[0042], [0046]-[0050] and [0059]-[0062] - the positions of points associated with line segments of roof primitives, including ridge segments, are fitted to the slope values detected by the range sensor and assigned to the triangle mesh roof structure); and automatically adjusting lateral positions of points associated with one or more second line segments of the roof identified as a junction or seam between adjacent facets of the roof to accommodate pitch values of the initial set of pitch values associated with the adjacent facets (see Fig. 5, para [0038], [0041]-[0042], [0045]-[0050] and [0059]-[0062] - the positions of points associated with line segments of roof primitives, including all edge segments, are fitted to the slope values detected by the range sensor and assigned to the triangle mesh roof structure).

As per claim 23, Neumann discloses the method according to claim 22 wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform automatically generating a first 3D wireframe of the roof based on the adjusted lateral positions of points associated with the one or more first line segments and the adjusted lateral positions of points associated with the one or more second line segments (see Fig. 5, para [0021]-[0024], [0033]-[0035] and [0059]-[0062] - disclosing the automatic generation and refining of a 3D model of the roof based on the fitted positions of the points associated with the primitive).

As per claim 24, Neumann discloses the method according to claim 23 wherein the generating the first 3D wireframe is further based on and initial set of input roof elevation values (see para [0024]-[0025], [0032]-[0033], [0036]-[0038] and [0060]-[0062] - the range sensor information can provide a clear footprint of a building's position and height information which is used to construct the model).

As per claim 25, Neumann discloses the method according to claim 23 wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform automatically generating a second 3D wireframe of the roof to satisfy a set of constraints by changing geometric characteristics of the first 3D wireframe that are inconsistent with the constraints (see Fig. 5, para [0021], [0036], [0041]-[0042], [0045]-[0048], [0050], [0053] and [0058]-[0060] - multiple models of the roof are iteratively generated to satisfy the constraints captured from range sensor).

As per claim 26, Neumann discloses a non-transitory computer readable medium having computer executable instructions thereon that (see Fig. 2, para [0027] and [0066]), when executed, cause a computer processor to perform the following: generating metadata from a wireframe model of a roof, the wireframe model having roof junction points and roof facets (see Fig. 5, para [0032]-[0035], [0038]-[0040], [0044]-[0045] and [0048]-[0050] - disclosing the generation of metadata such as edge lines, ridge lines and shapes from a mesh model of a roof); moving a location of roof junction points from the wireframe model to a normalized roof outline based on the generated metadata (see Fig. 5, para [0021], [0036], [0038]-[0043], [0045]-[0048], [0050], [0053] and [0058]-[0060] - the points of the mesh are mapped to a geometric primitive corresponding to the roof type); modifying a shape of the roof facets of the wireframe model (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor data encapsulated by the triangle mesh); and outputting a revised wireframe model based on the moved junction points and modified shapes to more closely approximate the actual shape of the roof (see Fig. 5, para [0021], [0025], [0053] and [0056]-[0060] - the 3D model is revised based on the fitting of the primitive to the detected data).

As per claim 27, Neumann discloses the non-transitory computer readable medium of claim wherein the modifying the shape of the roof facets of the wireframe model includes: comparing the roof facets of the wireframe model to a database of roof geometric shape primitives (see Fig. 5, para [0021], [0036], [0038]-[0043], [0045]-[0048], [0050], [0053] and [0058]-[0060] - the mesh model is compared to a geometric roof primitive); and modifying the shape of at least one of the roof facets of the wireframe model to match the geometric shape of a previously stored primitive (see Fig. 5, para [0021], [0053] and [0058]-[0060] - the the points and line segments of the roof primitives are continuously and iteratively fitted to the range sensor data encapsulated by the triangle mesh).

As per claim 28, Neumann discloses the non-transitory computer readable medium of claim, wherein the computer executable instructions thereon, when executed, further cause the computer processor to perform generating a 3D wireframe of the roof based on the revised wireframe model (see Fig. 5, para [0021], [0025], [0053] and [0058]-[0060] - the 3D model is revised based on the fitting of the primitive to the detected data).

Claims 1-28 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/467,244	05/15/2009	Chris Pershing	290115.403	7599

500 7590 08/26/2011

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EXAMINER	
PIERRE LOUIS, ANDRE	

ART UNIT	PAPER NUMBER
2123	

MAIL DATE	DELIVERY MODE
08/26/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	12/467,244	PERSHING, CHRIS	
	Examiner	Art Unit	
	ANDRE PIERRE LOUIS	2123	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-28* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-28* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☒ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *15 May 2009* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *5/15/2009*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. Claim 1-28 have been presented for examination.

Drawings

2. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference character(s) not mentioned in the description: see for example reference number 448, 711, 1188 of figure 3E. Corrected drawing sheets in compliance with 37 CFR 1.121(d), or amendment to the specification to add the reference character(s) in the description in compliance with 37 CFR 1.121(b) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Double Patenting

3. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined

application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

3.1 Claims 1-28 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-25 of copending Application No. 12/467,250. Although the conflicting claims are not identical, they are not patentably distinct from each other because the claims of application No. 12/467,250 contain every elements of the instant application No. 12/467,244.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claim Rejections - 35 USC § 101

4. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

4.1 Claims 16-28 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. While the claims are directed to a computer-readable medium, para 107 of the original specification describes to include carrier wave/signal bearing medium which does not fit into one of the statutory categories and therefore are not statutory.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

5.0 Claims 1-28 are rejected under 35 U.S.C. 102 (e) as being anticipated by Pershing ET al. (USPG_PUB No. 2008/0262789 A1).

The applied reference has a common inventor with the instant application. Based upon the earlier effective U.S. filing date of the reference, it constitutes prior art under 35 U.S.C. 102(e). This rejection under 35 U.S.C. 102(e) might be overcome either by a showing under 37 CFR 1.132 that any invention disclosed but not claimed in the reference was derived from the inventor of this application and is thus not the invention "by another," or by an appropriate showing under 37 CFR 1.131.

5.1 In considering claims 1, 10, and 16, Pershing et al. discloses a computer-implemented method for generating a roof estimate report, the method comprising: displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch (see fig.1-2, 5, para 11-13, 22, 28); displaying a pitch determination marker operable to indicate pitch of a planar roof section (see fig.5, para 11-13, 28-31); receiving, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building (see fig.1-2, 5, para 28-31); and modifying a model of the roof based on the received indication of the pitch of the one planar roof section (para 34-37); and further teaches the step of providing roof measurement information based on the model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section (see para 34-37), shown in claim 10.

5.2 As per claims 2 and 17, Pershing et al. discloses that wherein the pitch determination marker is adjustable to specify pitch of a planar roof section (fig.2, para 27-28, 32).

5.3 With regards to claims 3, 11, 18, and 20 Pershing et al. discloses the step of transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section (fig.1-2, para 22, 25-28, 34-37).

5.4 With regards to claims 4 and 21, Pershing et al. teaches that wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building (see para 34-37).

5.5 As per claims 5-6 and 22, Pershing et al. teaches the step of displaying a wireframe rendering of the modified model superimposed on the aerial image of the building in response to the receiving of the indicated pitch (fig.1-2, 5, para 22-24).

5.6 With regards to claims 7-8 and 12, Pershing et al. teaches that wherein the pitch determination marker includes an adjustable protractor tool having a member that is adjustable to indicate an angle and wherein the pitch determination marker includes an envelope tool having two surfaces that are adjustable to indicate an angle (para 25-28).

5.7 As per claims 9, 15, and 28, Pershing et al. teaches that wherein modifying the model of the roof includes modifying a three-dimensional model of the roof (para 34-37).

5.8 Regarding claim 13, Pershing et al. teaches that wherein the roof estimation module includes an interactive roof modeling user interface (para 22-24).

5.9 With regards to claim 14, Pershing et al. teaches that wherein the roof estimation module is further configured to display the pitch determination marker as part of an interactive user interface (para 22-24, 28-32).

5.10 Regarding claim 19, Pershing et al. teaches that wherein the transmitted roof estimate report includes a line drawing of the roof of the house labeled with a measure of the pitch of the planar roof section (para 22-26, 28).

5.11 With regards to claim 23, Pershing et al. teaches wherein the method further comprises: registering, based on operator indicated features, multiple aerial images to a reference grid corresponding to the model (fig.1-2, para 22-24).

5.12 Regarding claims 24 and 27, Pershing et al. teaches that wherein registering multiple images includes: displaying a marker operable to specify a point on the aerial image,

receiving, via the marker, an indication of a point on the aerial image, and registering, based on the received indication of the point, the aerial image to the reference grid (fig.1-2, para 22-24, 32-34).

5.13 As per claim 25, Pershing et al. teaches that wherein registering the aerial image to the reference grid includes determining a transformation between the aerial image and the reference grid (para 28-30).

5.14 With regards to claim 26, Pershing et al. teaches wherein the method further comprises: correcting lean of the aerial image with respect to a vertical axis of a reference grid corresponding to the model (para 34-37).

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

6.1 Kennedy et al. (USPG_PUB No. 2009/0304227) teaches a method for provisioning energy systems.

6.2 Neumann (USPG_PUB No. 2004/0105573) teaches an augmented virtual environment.

7. Claims 1-28 are rejected and this action is non-final. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ANDRE PIERRE LOUIS whose telephone number is (571)272-8636. The examiner can normally be reached on Mon-Fri, 8:00AM-4:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul L. Rodriguez can be reached on 571-272-3753. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/A. P./
Examiner, Art Unit 2123

August 23, 2011

/Paul L Rodriguez/
Supervisory Patent Examiner, Art Unit 2123

Notice of References Cited	Application/Control No. 12/467,244	Applicant(s)/Patent Under Reexamination PERSHING, CHRIS	
	Examiner ANDRE PIERRE LOUIS	Art Unit 2123	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2008/0262789	10-2008	Pershing et al.	702/156
*	B	US-2009/0304227	12-2009	Kennedy et al.	382/100
*	C	US-2004/0105573	06-2004	Neumann et al.	382/103
	D	US-			
	E	US-			
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FOREIGN PATENT DOCUMENTS

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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08a (04-09)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2009-05-15
First Named Inventor	Chris Pershing
Art Unit	
Examiner Name	
Attorney Docket Number	290115.403

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6446053	B1	2002-09-03	Elliott	
	2	6636803	B1	2003-10-21	Hartz, Jr. et al.	
	3	6836270	B2	2004-12-28	Du	
	4	7003400	B2	2006-02-21	Bryant	
	5	7006977	B1	2006-02-28	Attra et al.	
	6	7133551	B2	2006-11-07	Chen et al.	
	7	7324666	B2	2008-01-29	Zoken et al.	
	8	6385541	B1	2002-05-07	Blumberg et al.	

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2009-05-15
	First Named Inventor	Chris Pershing
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

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	1	20020154174	A1	2002-10-24	Redlich et al.		
	2	20050288959	A1	2005-12-29	Eraker et al.		
	3	20060200311	A1	2006-09-07	Aruntunian et al.		
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Gulch E., et al., "On the Performance of Semi-Automatic Building Extraction," In the International Archives of Photogrammetry and Remote Sensing, Vol. 23, 8 pages, 1998.	☐
	2	"How precigeo Roof Works," http://web.archive.org/web/20070107012311/roof.precigeo.com/how-precigeo-roof-works.htm, retrieved April 30, 2009, 1 page.	☐

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2009-05-15
	First Named Inventor	Chris Pershing
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

	3	"Microsoft's MSN Virtual Earth: The Map is the Search Platform," Directions Magazine, http://www.directionsmag.com/article.php?article_id=873&trv=1, retrieved February 6, 2009, 10 pages.	☐
	4	Miller, M., et al., "Miller's Guide to Framing and Roofing," 2005, pages 131-136 and 162-163, McGraw Hill.	☐
	5	"Pictometry - In the News," http://204.8.121.114/pressrelease%20archived/pressrelease_aec.asp, retrieved February 6, 2009, 3 pages.	☐
	6	"Welcome to precigeo," http://web.archive.org/web/20080110074814/http://www.precigeo.com", February 17, 2009, 1 page.	☐
	7	"Welcome to precigeoRoof," http://web.archive.org/web/20070106063144/roof.precigeo.com, retrieved April 30, 2009, 1 page.	☐
	8	"YouTube - Pictometry Online Demo," http://www.youtube.com/watch?v=jURSK7o0OD0, retrieved February 6, 2009, 1 page	☐
	9	Ziegler, R, et al. "3D Reconstruction Using Labeled Image Regions," Mitsubishi Electric Research Laboratories, http://www.merl.com, 2003, 14 pages.	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/Andre Pierre Louis/ (08/18/2011)	Date Considered	(08/18/2011)

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /APL/

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12467244	PERSHING, CHRIS
	Examiner	Art Unit
	ANDRE PIERRE LOUIS	2123

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/23/2011								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
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	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								
	21	✓								
	22	✓								
	23	✓								
	24	✓								
	25	✓								
	26	✓								
	27	✓								
	28	✓								

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	77	(roof$3 with model$4) and pitch$3 and building$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:57
L2	12	1 and aerial and (roof with estimat$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:58
L3	11	2 and display$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:58
L4	8	3 and modif$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:59
L6	11	1 and (aerial with image$2) and measur$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:23
L7	8	6 and (modif$4 or adjust$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
L8	8	6 and (modif$4 or adjust$4 or edit$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
L9	11	6 and pitch$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
S1	2298	(703/1).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:19
S2	8	(roof$3 with model$4) and pitch$3 and building$2 and marker$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S3	8	S2 and display$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S4	4	S3 and (aerial with display$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S5	2	("20060265287").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:56
S6	2	("20080262789").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:56
S7	8	S3 and aerial	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 18:40

8/23/2011 10:25:16 PM
C:\Users\apierrelouis\Documents\EAST\Workspaces\7244.wsp

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UNITED STATES DEPARTMENT OF COMMERCE
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BIB DATA SHEET

CONFIRMATION NO. 7599

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/467,244	05/15/2009	703	2123	290115.403

APPLICANTS
Chris Pershing, Redmond, WA;

**** CONTINUING DATA ***************************
This appln claims benefit of 61/197,904 10/31/2008

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
05/26/2009

Foreign Priority claimed	35 USC 119(a-d) conditions met	Verified and Acknowledged	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	☐ Yes ☑ No	/ANDRE PIERRE LOUIS/ Examiner's Signature	☐ Initials	WA	29	28	3

ADDRESS

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104
UNITED STATES

TITLE

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

FILING FEE RECEIVED		
670	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12467244	PERSHING, CHRIS
	Examiner	**Art Unit**
	ANDRE PIERRE LOUIS	2123

SEARCHED

Class	Subclass	Date	Examiner
703	1	8/23/2011	AP

SEARCH NOTES

Search Notes	Date	Examiner
Inventor Name Search	8/23/2011	AP
NPL Text Search (Google, IEEE, ACM)_"Aerial Roof estimation" and Pitch determination	8/23/2011	AP
EAST (EAST (US- PGPUB;USPAT;USOCR;EPO;JPO;r ERWENT:IBM TDB-- SEE Search History	8/23/2011	AP

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

/A.P./
Examiner.Art Unit 2123

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

PUBLICATION NOTICE

OC00000041486162

Title:PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Publication No.US-2010-0110074-A1
Publication Date:05/06/2010

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
12/467,244	05/15/2009	2628	670	290115.403	28	3

CONFIRMATION NO. 7599

CORRECTED FILING RECEIPT

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104



Date Mailed: 07/15/2009

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Chris Pershing, Redmond, WA;

Assignment For Published Patent Application

Eagle View Technologies, Inc., Redmond, WA

Power of Attorney: The patent practitioners associated with Customer Number 00500

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/197,904 10/31/2008

Foreign Applications

If Required, Foreign Filing License Granted: 05/26/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/467,244**

Projected Publication Date: 05/06/2010

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Preliminary Class

345

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Application No.	:	12/467,244
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Art Unit	:	3633
Docket No.	:	290115.403
Date	:	July 8, 2009

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO NOTICE OF INFORMAL APPLICATION

Commissioner for Patents:

In response to the Notice of Informal Application dated June 3, 2009, please find enclosed the following documents:

X Copy of Notice of Informal Application
X Application Data Sheet

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/David V. Carlson/
David V. Carlson
Registration No. 31,153

1412541_1.DOC

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

NOTICE

OC000000036177893

Date Mailed: 06/03/2009

NOTICE OF INFORMAL APPLICATION

This application is considered to be informal since it does not comply with the regulations for the reason(s) indicated below. The period within to correct the informalities noted below and avoid abandonment is set in the accompanying Office action.

Items Required To Avoid Processing Delays:

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

A new oath or declaration, identifying this application number, or, if appropriate, an application data sheet (37 CFR 1.76), is required. The oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not identify the residence (e.g., city and either state or foreign country) of each inventor.
- does not identify the complete mailing or post office address of each inventor.

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	290115.403
	Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Chris		Pershing	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Redmond	State/Province	WA	Country of Residence [i]	US

Citizenship under 37 CFR 1.41(b) [i]: US

Mailing Address of Applicant:

Address 1	17401 Northeast 138th Street		
Address 2			
City	Redmond	State/Province	WA
Postal Code	98052	Country [i]	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	00500		
Email Address	DaveC.Docketing@SeedIP.com	Add Email	Remove Email

Application Information:

Title of the Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		
Attorney Docket Number	290115.403	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	29	Suggested Figure for Publication (if any)	

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	290115.403
	Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION	

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	**Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	00500		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61197904	2008-10-31

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	290115.403
	Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION	

If the Assignee is an Organization check here. ☒			
Organization Name	Eagle View Technologies, Inc.		
Mailing Address Information:			
Address 1	17401 Northeast 138th Street		
Address 2			
City	Redmond	**State/Province**	WA
Country [i]	US	Postal Code	98052
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the **Add** button.		Add	

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/David V. Carlson/			Date (YYYY-MM-DD)	2009-07-08
First Name	David	Last Name	Carlson	Registration Number	31153

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	5664553
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	00500
Filer:	David V. Carlson/Jamie Horner
Filer Authorized By:	David V. Carlson
Attorney Docket Number:	290115.403
Receipt Date:	08-JUL-2009
Filing Date:	15-MAY-2009
Time Stamp:	16:18:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	290115_403_Resp_Inf_App.pdf	50549 ba612092dafd351fff518fcfda60260e8719af64	no	1

Warnings:	
Information:	

2	Applicant Response to Pre-Exam Formalities Notice	290115_403_Notice_of_Informal_Application.PDF	30627 731d5a0813c31c5893842f037e575feeb8b73564	no	1
Warnings:					
Information:					
3	Application Data Sheet	290115_403_ADS.pdf	938404 060bf3ba16c478eec43b888ca53084949f1c3a08	no	4
Warnings:					
Information:					
			Total Files Size (in bytes):	1019580	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
12/467,244	05/15/2009	3633	670	290115.403	28	3

CONFIRMATION NO. 7599

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

FILING RECEIPT



Date Mailed: 06/03/2009

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Chris Pershing, Residence Not Provided;

Power of Attorney: The patent practitioners associated with Customer Number 00500

Domestic Priority data as claimed by applicant

This appln claims benefit of 61/197,904 10/31/2008

Foreign Applications

If Required, Foreign Filing License Granted: 05/26/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/467,244**

Projected Publication Date: 05/06/2010

Non-Publication Request: No

Early Publication Request: No
** **SMALL ENTITY** **

Title

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Preliminary Class

052

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

POA ACCEPTANCE LETTER

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

OC000000036145379

Date Mailed: 06/03/2009

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 05/15/2009.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/hkquach/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

500
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

NOTICE

OC000000036177893

Date Mailed: 06/03/2009

NOTICE OF INFORMAL APPLICATION

This application is considered to be informal since it does not comply with the regulations for the reason(s) indicated below. The period within to correct the informalities noted below and avoid abandonment is set in the accompanying Office action.

Items Required To Avoid Processing Delays:

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

A new oath or declaration, identifying this application number, or, if appropriate, an application data sheet (37 CFR 1.76), is required. The oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not identify the residence (e.g., city and either state or foreign country) of each inventor.
- does not identify the complete mailing or post office address of each inventor.

PTO/SB/08a (04-09)
Approved for use through 05/31/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2009-05-15
First Named Inventor	Chris Pershing
Art Unit	
Examiner Name	
Attorney Docket Number	290115.403

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6446053	B1	2002-09-03	Elliott	
	2	6636803	B1	2003-10-21	Hartz, Jr. et al.	
	3	6836270	B2	2004-12-28	Du	
	4	7003400	B2	2006-02-21	Bryant	
	5	7006977	B1	2006-02-28	Attra et al.	
	6	7133551	B2	2006-11-07	Chen et al.	
	7	7324666	B2	2008-01-29	Zoken et al.	
	8	6385541	B1	2002-05-07	Blumberg et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2009-05-15
	First Named Inventor	Chris Pershing
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

U.S.PATENT APPLICATION PUBLICATIONS							Remove
Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1	20020154174	A1	2002-10-24	Redlich et al.		
	2	20050288959	A1	2005-12-29	Eraker et al.		
	3	20060200311	A1	2006-09-07	Aruntunian et al.		
If you wish to add additional U.S. Published Application citation information please click the Add button.							Add

FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐
If you wish to add additional Foreign Patent Document citation information please click the Add button								Add

NON-PATENT LITERATURE DOCUMENTS			Remove
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Gulch E., et al., "On the Performance of Semi-Automatic Building Extraction," In the International Archives of Photogrammetry and Remote Sensing, Vol. 23, 8 pages, 1998.	☐
	2	"How precigeo Roof Works," http://web.archive.org/web/20070107012311/roof.precigeo.com/how-precigeo-roof-works.htm, retrieved April 30, 2009, 1 page.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2009-05-15
	First Named Inventor	Chris Pershing
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

	3	"Microsoft's MSN Virtual Earth: The Map is the Search Platform," Directions Magazine, http://www.directionsmag.com/article.php?article_id=873&trv=1, retrieved February 6, 2009, 10 pages.	☐
	4	Miller, M., et al., "Miller's Guide to Framing and Roofing," 2005, pages 131-136 and 162-163, McGraw Hill.	☐
	5	"Pictometry - In the News," http://204.8.121.114/pressrelease%20archived/pressrelease_aec.asp, retrieved February 6, 2009, 3 pages.	☐
	6	"Welcome to precigeo," http://web.archive.org/web/20080110074814/http://www.precigeo.com", February 17, 2009, 1 page.	☐
	7	"Welcome to precigeoRoof," http://web.archive.org/web/20070106063144/roof.precigeo.com, retrieved April 30, 2009, 1 page.	☐
	8	"YouTube - Pictometry Online Demo," http://www.youtube.com/watch?v=jURSK7o0OD0, retrieved February 6, 2009, 1 page	☐
	9	Ziegler, R, et al. "3D Reconstruction Using Labeled Image Regions," Mitsubishi Electric Research Laboratories, http://www.merl.com, 2003, 14 pages.	☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2009-05-15
	First Named Inventor	Chris Pershing
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/David V. Carlson/	Date (YYYY-MM-DD)	2009-05-15
Name/Print	David V. Carlson	Registration Number	31153

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Filer:	David V. Carlson/Jamie Horner
Attorney Docket Number:	290115.403

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	82	82
Utility Search Fee	2111	1	270	270
Utility Examination Fee	2311	1	110	110
Pages:				
Claims:				
Claims in excess of 20	2202	8	26	208
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**670**

Electronic Acknowledgement Receipt

EFS ID:	5346914
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	00500
Filer:	David V. Carlson/Jamie Horner
Filer Authorized By:	David V. Carlson
Attorney Docket Number:	290115.403
Receipt Date:	15-MAY-2009
Filing Date:	
Time Stamp:	22:13:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$670
RAM confirmation Number	5436
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Specification	290115_403_Specification.pdf	164421 f9471c80ddffbc0b9da9c73112582a9f2a5c1051	no	47
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2	Drawings-only black and white line drawings	290115_403_Drawings.pdf	2101438 6bd86ec0c2d702f061e79fb9739c62bc46dd0752	no	29
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7	NPL Documents	290115_403_Gulch.pdf	553287 ae3f5d0c5a10fe2e442643f027709c8c1cf898fa	no	8
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8	NPL Documents	290115_403_Roof_Works.pdf	25530 fb31880bc31d7963c9b2666f0be1eda2277771de	no	1
Warnings:					
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9	NPL Documents	290115_403_Directions_Magazine.pdf	390315 c2906e96ea8bb25d6f5b236b5cbbf98183e8d946	no	10
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10	NPL Documents	290115_403_Miller.pdf	368241 6859505f194deba7b94028bec0f4d7126498272f	no	9
Warnings:					
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11	NPL Documents	290115_403_Pictometry.pdf	71462 faa1dc0d9d4e5f85c0c14d2f8567a43c8fbad392	no	3
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12	NPL Documents	290115_403_Welcome.pdf	15068 20454917f41826547ca82e181721e645c504a5af	no	1
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PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/197,904, entitled "USER INTERFACE SYSTEMS AND METHODS FOR ROOF ESTIMATION," filed October 31, 2008, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention:

[0002] This invention relates to systems and methods for estimating construction projects, and more particularly, to such systems and methods for determining roof measurement information based on one or more aerial images of a roof of a building.

2. Description of the Related Art:

[0003] The information provided below is not admitted to be part of the present invention, but is provided solely to assist the understanding of the reader.

[0004] Homeowners typically ask several roofing contractors to provide written estimates to repair or replace a roof on a house. Heretofore, the homeowners would make an appointment with each roofing contractor to visit the house to determine the style of roof, take measurements, and to inspect the area around the house for access and cleanup. Using this information, the roofing contractor then prepares a written estimate and then timely delivers it to the homeowner. After receiving several estimates from different rooting contractors, the homeowner then selects one.

[0005] There are factors that impact a roofing contractor's ability to provide a timely written estimate. One factor is the size of the roof contractor's company and the

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location of the roofing jobs currently underway. Most roof contractors provide roofing services and estimates to building owners over a large geographical area. Larger roof contractor companies hire one or more trained individuals who travel throughout the entire area providing written estimates. With smaller roofing contractors, the owner or a key trained person is appointed to provide estimates. With both types of companies, roofing estimates are normally scheduled for buildings located in the same area on a particular day. If an estimate is needed suddenly at a distant location, the time for travel and the cost of commuting can be prohibitive. If the roofing contractor is a small company, the removal of the owner or key person on a current job site can be time prohibitive.

[0006] Another factor that may impact the roofing contractor's ability to provide a written estimate is weather and traffic.

[0007] Recently, solar panels have become popular. In order to install solar panels, the roof's slope, geometrical shape, and size as well as its orientation with respect to the sun all must be determined in order to provide an estimate of the number and type of solar panels required. Unfortunately, not all roofs on a building are proper size, geometrical shape, or orientation for use with solar panels.

SUMMARY

[0008] These and other objects are met by the systems and methods disclosed herein that determine and provide roof measurement information about the sizes, dimensions, slopes and orientations of the roof sections of a building roof. Roof measurement information may be used to generate a roof estimate report that provides and graphically shows this information. A roof estimation system that practices at least some of the techniques described herein may include an image acquisition engine, a roof modeling engine, and a report generation engine. The roof estimation system is configured to generate a model of a roof of a building, based on one or more aerial images. In addition, the roof estimation system is configured to

determine roof measurement information and generate a roof estimate report based on the generated model and/or the determined roof measurement information.

[0009] In some embodiments, the roof estimation system includes a user interface engine which provides access to at least some of the functions of the roof estimation system. In one embodiment, the user interface engine provides interactive user interface components operable by an operator to perform various functions related to generating a model of a roof of a building, including image registration, lean correction, pitch determination, feature identification, and model review and/or correction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system.

[0011] Figures 2A-2B illustrate aerial images of a building at a particular address.

[0012] Figures 3A-3F illustrate individual pages of an example roof estimate report generated by an example embodiment of a roof estimation system.

[0013] Figures 4A-4F are screen displays illustrating image registration and image lean correction in an example embodiment. (Also shows lean correction.)

[0014] Figures 5A-5D are screen displays illustrating pitch determination in an example embodiment.

[0015] Figures 6A-6D are screen displays illustrating model construction and concurrent display of operator specified roof features in an example embodiment.

[0016] Figures 7A-7C are screen displays illustrating roof model review in an example embodiment.

[0017] Figure 8 is an example block diagram of a computing system for practicing embodiments of a roof estimation system.

[0018] Figure 9 is an example flow diagram of an image registration routine provided by an example embodiment.

[0019] Figure 10 is an example flow diagram of a pitch determination routine provided by an example embodiment.

[0020] Figure 11 is an example flow diagram of concurrent feature display routine provided by an example embodiment.

DETAILED DESCRIPTION

[0021] Embodiments described herein provide enhanced computer- and network-based methods, techniques, and systems for estimating construction projects based on one or more images of a structure. Example embodiments provide a Roof Estimation System ("RES") that is operable to provide a roof estimate report for a specified building, based on one or more aerial images of the building. In one embodiment, a customer of the RES specifies the building by providing an address of the building. The RES then obtains one or more aerial images showing at least portions of the roof of the building. Next, the RES generates a model of the roof of the building, which is then utilized to determine roof measurement information. The roof measurement information may include measurements such as lengths of the edges of sections of the roof, pitches of sections of the roof, areas of sections of the roof, etc. The model of the roof and/or the roof measurement information is then used to generate a roof estimate report. The roof estimate report includes one or more line drawings of the roof of the building, which are annotated with information about the roof, such as lengths of the edges of sections of the roof, pitches of sections of the roof, areas of sections of the roof, etc.

[0022] Some embodiments of the roof estimation system include an interactive user interface configured to provide access to one or more of the functions of the roof estimation system. In one embodiment, the roof estimation system includes user interface controls that facilitate image registration, image lean correction, roof model generation, pitch determination, and roof model review. Image registration includes aligning, based at least in part on operator inputs, one or more images of a building

roof to a set of reference points within a single three-dimensional ("3D") grid that is shared between the one or more images. Roof model generation includes generating a 3D model of a roof, based at least in part on operator inputs specifying various features and/or dimensional attributes of the roof. Roof model generation may further include the determination of the pitches of various planar sections of a roof. Roof model review includes display of a model of a roof, possibly in conjunction with one or more images of the roof, so that an operator may review the model for accuracy and possibly make adjustments and/or corrections to the roof model. In other embodiments, all or some of the functions of the roof estimation system may be performed automatically. For example, image registration may include automatically identifying building features for the placement of reference markers. Further, roof model generation may include automatically recognizing features, dimensional attributes, and/or pitches of various planar roof sections of the roof.

[0023] The described user interface is also configured to concurrently display roof features onto multiple images of a roof. For example, in the context of roof model generation, an operator may indicate a roof feature, such as an edge or a corner of a section of the roof, in a first image of the roof. As the roof estimation system receives the indication of the roof feature, the user interface concurrently displays that feature in one or more other images of the roof, so that the operator may obtain feedback regarding the accuracy of the roof model, the image registration, etc.

[0024] In the following, Figures 1-3 provide an overview of the operation of an example roof estimation system. Figures 4-7 provide additional details related an example interactive user interface provided by one embodiment of the roof estimation system. Figures 8-11 provide details related to roof estimation system implementation techniques.

1. Roof Estimation System Overview

[0025] Figure 1 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system. In particular, Figure 1 shows an example

Roof Estimation System ("RES") 100 comprising an image acquisition engine 101, a roof modeling engine 102, a report generation engine 103, image data 105, model data 106, and report data 107. The RES 100 is communicatively coupled to an image source 110, a customer 115, and optionally an operator 120. The RES 100 and its components may be implemented as part of a computing system, as will be further described with reference to Figure 8.

[0026] More specifically, in the illustrated embodiment of Figure 1, the RES 100 is configured to generate a roof estimate report 132 for a specified building, based on aerial images 131 of the building received from the image source 110. The image source 110 may be any provider of images of the building for which a roof estimate is being generated. In one embodiment, the image source 110 includes a computing system that provides access to a repository of aerial images of one or more buildings. In addition, the aerial images 131 may include images obtained via manned or unmanned aircraft (*e.g.*, airplane, helicopter, blimp, drone, etc.), satellite, etc. Furthermore, the aerial images 131 may include images obtain via one or more ground-based platforms, such as a vehicle-mounted camera that obtains street-level images of buildings, a nearby building, a hilltop, etc. In some cases, a vehicle-mounted camera may be mounted in an elevated position, such as a boom. Example aerial images are described further with reference to Figures 2A-2B.

[0027] The image acquisition engine 101 obtains one or more aerial images of the specified building by, for example, providing an indicator of the location of the specified building (*e.g.*, street address, GPS coordinates, lot number, etc.) to the image source 110. In response, the image source 110 provides to the image acquisition engine 101 the one or more aerial images of the building. The image acquisition engine 101 then stores the received aerial images as image data 105, for further processing by other components of the RES 100. Obtaining aerial images of a specified building may include various forms of geo-coding, performed by the image acquisition engine 101 and/or the image source 110. In one embodiment, the image source geo-codes a provided street address into latitude and longitude coordinates,

which are then used to look up (*e.g.*, query a database) aerial images of the provided street address.

[0028] Next, the roof modeling engine 102 generates a model of the roof of the specified building. In the illustrated embodiment, the roof modeling engine 102 generates a three-dimensional ("3D") model, although in other embodiments, a two-dimensional (*e.g.*, top-down roof plan) may be generated instead or in addition. Generating a model of the roof may generally include image calibration, in which the distance between two pixels on a given image is converted into a physical length. Image calibration may be performed automatically, such as based on meta-information provided along with the aerial images 131.

[0029] A variety of automatic and semi-automatic techniques may be employed to generate a model of the roof of the building. In one embodiment, generating such a model is based at least in part on a correlation between at least two of the aerial images of the building. For example, the roof modeling engine 102 receives an indication of a corresponding feature that is shown in each of the two aerial images. In one embodiment, an operator 120, viewing two or more images of the building, inputs an indication in at least some of the images, the indications identifying which points of the images correspond to each other for model generation purposes.

[0030] The corresponding feature may be, for example, a vertex of the roof of the building, the corner of one of the roof planes of the roof, a point of a gable or hip of the roof, etc. The corresponding feature may also be a linear feature, such as a ridge or valley line between two roof planes of the roof. In one embodiment, the indication of a corresponding feature on the building includes "registration" of a first point in a first aerial image, and a second point in a second aerial image, the first and second points corresponding the substantially the same point on the roof of the building. Generally, point registration may include the identification of any feature shown in both aerial images. Thus, the feature need not be a point on the roof of the building. Instead, it may be, for example, any point that is visible on both aerial images, such as on a nearby building (*e.g.*, a garage, neighbor's building, etc.), on a nearby structure (*e.g.*,

swimming pool, tennis court, etc.), on a nearby natural feature (*e.g.*, a tree, boulder, etc.), etc.

[0031] In some embodiments, the roof modeling engine 102 determines the corresponding feature automatically, such as by employing on one or more image processing techniques used to identify vertexes, edges, or other features of the roof. In other embodiments, the roof modeling engine 102 determines the corresponding feature by receiving, from the human operator 120 as operator input 133, indications of the feature shown in multiple images of the building.

[0032] In one example embodiment, the RES 100 generates a model of the roof of the building in the following manner. First, a set of reference points are be identified in each of the images. These reference points are identified by the operator 120 utilizing a suitable input device, such as a mouse or joystick. The roof modeling engine 102 then uses these reference points and any acceptable algorithm to co-register the images and reconstruct the three-dimensional geometry of the object identified by the reference points. There are a variety of photogrammetric algorithms that can be utilized to perform this reconstruction. One such algorithm used by the RES 100 uses photographs taken from two or more view points to "triangulate" points of interest on the object in three-dimensional ("3D") space. This triangulation can be visualized as a process of projecting a line originating from the location of the photograph's observation point that passes through a particular reference point in the image. The intersection of these projected lines from the set of observation points to a particular reference point identifies the location of that point in 3D space. Repeating the process for all such reference points allows the software to determine a 3D volume suitable for building a 3D model of the structure. The choice of reconstruction algorithm depends on a number of factors such as the spatial relationships between the photographs, the number and locations of the reference points, and any assumptions that are made about the geometry and symmetry of the object being reconstructed. Several such algorithms are described in detail in textbooks, trade journals, and academic publications.

[0033] In addition, generating a model of the roof of a building may include correcting one or more of the aerial images for various imperfections. For example, the vertical axis of a particular aerial image sometimes will not substantially match the actual vertical axis of its scene. This will happen, for example, if the aerial images were taken at different distances from the building, or at a different pitch, roll, or yaw angles of the aircraft from which the images were produced. In such cases, an aerial image may be corrected by providing the operator 120 with a user interface control operable to adjust the scale and/or relative angle of the aerial image to correct for such errors. The correction may be either applied directly to the aerial image, or instead be stored (*e.g.*, as an offset) for use in model generation or other functions of the RES 100.

[0034] Generating a model of the roof of a building further includes the automatic or semi-automatic identification of features of the roof of the building. In one embodiment, one or more user interface controls may be provided, such that the operator 120 may indicate (*e.g.*, draw, paint, etc.) various features of the roof, such as valleys, ridges, hips, vertexes, planes, edges, etc. As these features are indicated by the operator 120, a corresponding three-dimensional ("3D") model may be updated accordingly to include those features. These features are identified by the operator based on a visual inspection of the images and by providing inputs that identify various features as valleys, ridges, hips, etc. In some cases, a first and a second image view of the roof (*e.g.*, a north and east view) are simultaneously presented to the operator 120, such that when the operator 120 indicates a feature in the first image view, a projection of that feature is automatically presented in the second image view. By presenting a view of the 3D model, simultaneously projected into multiple image views, the operator 120 is provided with useful visual cues as to the correctness of the 3D model and/or the correspondence between the aerial images.

[0035] In addition, generating a model of the roof of a building may include determining the pitch of one or more of the sections of the roof. In some embodiments, one or more user interface controls are provided, such that the operator 120 may accurately determine the pitch of each of the one or more roof

sections. An accurate determination of the roof pitch may be employed (by a human or the RES 100) to better determine an accurate cost estimate, as roof sections having a low pitch are typically less costly surfaces to repair and/or replace.

[0036] The generated model typically includes a plurality of planar roof sections that each correspond to one of the planar sections of the roof of the building. Each of the planar roof sections in the model has a number of associated dimensions and/or attributes, among them slope, area, and length of each edge of the roof section. Other information may include any information relevant to a roof builder or other entity having an interest in construction of, or installation upon, the roof. For example, the other information may include identification of valleys, ridges, rakes, eaves, or hip ridges of the roof and/or its sections; roof and/or roof section perimeter dimensions and/or outlines; measurements of step heights between different roof levels (*e.g.*, terraces); bearing and/or orientation of each roof section; light exposure and/or shadowing patterns due to chimneys, other structures, trees, latitude, etc.; roofing material; etc? Once a 3D model has been generated to the satisfaction of the roof modeling engine 102 and/or the operator 120, the generated 3D model is stored as model data 106 for further processing by the RES 100. In one embodiment, the generated 3D model is then stored in a quality assurance queue, from which it is reviewed and possibly corrected by a quality control operator.

[0037] The report generation engine 103 generates a final roof estimate report based on a model stored as model data 106, and then stores the generated report as report data 107. Such a report typically includes one or more plan (top-down) views of the model, annotated with numerical values for the slope, area, and/or lengths of the edges of at least some of the plurality of planar roof sections of the model of the roof. The report may also include information about total area of the roof, identification and measurement of ridges and/or valleys of the roof, and/or different elevation views rendered from the 3D model (top, side, front, etc). An example report is illustrated and discussed with respect to Figures 3A-3E, below.

[0038] In some embodiments, generating a report includes labeling one or more views of the model with annotations that are readable to a human user. Some models include a large number of small roof details, such as dormers or other sections, such that applying uniformly sized, oriented, and positioned labels to roof section views results in a visually cluttered diagram. Accordingly, various techniques may be employed to generate a readable report, including automatically determining an optimal or near-optimal label font size, label position, and/or label orientation, such that the resulting report may be easily read and understood by the customer 115.

[0039] In addition, in some embodiments, generating a report includes automatically determining a cost estimate, based on specified costs, such as those of materials, labor, transportation, etc. For example, the customer 115 provides indications of material and labor costs to the RES 100. In response, the report generation engine 103 generates a roof estimate report that includes a cost estimate, based on the costs provided by the customer 115 and the attributes of the particular roof, such as area, pitch, etc.

[0040] In one embodiment, the generated report is then provided to a customer. The generated report can be represented, for example, as an electronic file (*e.g.*, a PDF file) or a paper document. In the illustrated example, roof estimate report 132 is transmitted to the customer 115. The customer 115 may be or include any human, organization, or computing system that is the recipient of the roof estimate report 132. For example, the customer 115 may be a property owner, a property manager, a roof construction/repair company, a general contractor, an insurance company, a solar power panel installer, a climate control (*e.g.*, heating, ventilation, and/or air conditioning) system installer, a roof gutter installer, an awning installer, etc. Reports may be transmitted electronically, such as via a network (*e.g.*, as an email, Web page, etc.) or by some shipping mechanism, such as the postal service, a courier service, etc.

[0041] In some embodiments, one or more of the models stored as model data 106 are provided directly to the customer or other computing system, without first being

transformed into a report. For example, a model and/or roof measurement information based thereon may be exported and/or transmitted as a data file, in any suitable format, that may be consumed or otherwise utilized by some other computing system, such as a computer-aided design ("CAD") tool, a drawing program, a labor and material estimation software, a project management/estimation software, etc.

[0042] The RES 100 may be operated by various types of entities. In one embodiment, the RES 100 is operated by a roof estimation service that provides roof estimate reports to customers, such as roofing contractors, in exchange for payment. In another embodiment, the RES 100 is operated by a roof construction/repair company, to generate roof estimate reports that are used internally and/or provided to customers, such as property owners.

[0043] In addition, the RES 100 may be operated in various ways. In one embodiment, the RES 100 executes as a desktop computer application that is operated by the operator 120. In another embodiment, the RES 100 executes as a network-accessible service, such as by a Web server, that may be operated remotely by the operator 120 and/or the customer 115. Additional details regarding the implementation of an example roof estimation system are provided with respect to Figure 8, below.

[0044] Figures 2A-2B illustrate aerial images of a building at a particular address. In the illustrated example, the aerial images are represented as stylized line drawings for clarity of explanation. As noted above, such aerial images may be acquired in various ways. In one embodiment, an aircraft, such as an airplane or helicopter is utilized to take photographs while flying over one or more properties. Such aircraft may be manned or unmanned. In another embodiment, a ground-based vehicle, such as a car or truck, is utilized to take photographs (*e.g.*, "street view" photographs) while driving past one or more properties. In such an embodiment, a camera may be mounted on a boom or other elevating member, such that images of building roofs may be obtained. In another embodiment, photographs may be taken from a fixed position, such as a tall building, hilltop, tower, etc.

[0045] In particular, Figure 2A shows a top plan (top-down) aerial image 210 of a building 200. The roof of the building 200 includes multiple planar roof sections 200a-200d. Figure 2A also shows a second aerial image 211 providing a perspective (oblique) view of the building 200. The roof sections 200a and 200c are also visible in image 211.

[0046] Figure 2B shows a top-down, wide angle image 212 of the building 200. The image 212 includes details of the surrounding areas 220 of the building 220. Information about the surrounding areas 220 of the building 220 are in some embodiments used to determine additional cost factors related to a roof estimate. For example, the cleanup of, or access to, a worksite at building 220 may be complicated by various factors, including a substantial amount of landscaping; steeply sloped building sites; proximity to environmentally sensitive areas; etc. In such cases, the roof estimation system may automatically increase a cost factor in a corresponding roof estimate report.

[0047] In some embodiments, an aerial image has corresponding meta-information. Such meta-information may include details about the type of camera used (*e.g.*, focal length, exposure, etc.), the position of the camera (*e.g.*, GPS coordinates of the aircraft at the time the image was captured), the orientation of the camera (*e.g.*, the angle of the camera), the time and/or date the image was captured, etc.

[0048] Figures 3A-3F illustrate individual pages of an example roof estimate report generated by an example embodiment of a roof estimation system. As discussed with respect to Figure 1, a roof estimate report is generated by the roof estimation system based on one or more aerial images of a building. The roof estimate report may be based on a computer model (*e.g.*, a 3D model) of the roof, and includes one or more views of the model. In this example, the various views of the model are presented as annotated line drawings, which provide information about the roof, such as the roof section areas, roof section edge lengths, roof section pitches, etc. The roof estimate report may be in an electronic format (*e.g.*, a PDF file) and/or paper format (*e.g.*, a

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printed report). In some embodiments, the roof estimate report may be in a format that may be consumed by a computer-aided design program.

[0049] Figure 3A shows a cover page 301 of the report and includes the address 301a of a building 301c and an overhead aerial image 301b of the building 301c.

[0050] Figure 3B shows a second page 302 of the report and includes two wide perspective (oblique) views 302a and 302b of the building 301c at the address with the surrounding areas more clearly shown.

[0051] Figure 3C shows a third page 303 of the report and includes a line drawing 303a of the building roof showing ridge lines 303b and 303c, and a compass indicator 303d. In addition, a building roof having valleys would result in a line drawing including one or more valley lines. The ridge and/or valley lines may be called out in particular colors. For example, ridge lines 303b and 303c may be illustrated in red, while valley lines may be illustrated in blue. The line drawing 303a is also annotated with the dimensions of the planar sections of the building roof. In this case, the dimensions are the lengths of the edges of the planar roof sections.

[0052] Fig 3D shows a fourth page 304 of the report and includes a line drawing 304a of the building roof showing the pitch of each roof section along with a compass indicator. The pitch in this example is given in inches, and it represents the number of vertical inches that the labeled planar roof section drops over 12 inches of horizontal run. The slope can be easily calculated from such a representation using basic trigonometry. The use of a numerical value of inches of rise per foot of run is a well known measure of slope in the roofing industry. A roof builder typically uses this information to assist in the repair and/or construction of a roof. Of course, other measures and/or units of slope may be utilized as well, including percent grade, angle in degrees, etc.

[0053] Figure 3E shows a fifth page 305 of the report and includes a line drawing 305a of the building roof showing the square footage of each roof section along with the total square foot area value. Of course, other units of area may be used as well, such

as square meters or the number of "squares" of roofing material required for covering each roof section.

[0054] Figure 3F shows a fifth page 306 of the report and includes a line drawing 306a of the building roof where notes or comments may be written. The line drawing 306a includes a label for each roof section (shown here as "A", "B", "C"), such that comments may be conveniently related to specific roof sections.

[0055] In other embodiments, more or less information may be provided, or the illustrated information may be arranged in different ways. For example, the report may be provided in electronic form, such as a PDF file or a computer aided design software format. In some embodiments, the report may be "active" or editable, such that the user of the report may make changes to the report, based on on-site observations.

2. Roof Estimation System User Interface

[0056] Figures 4A-4F, 5A-5D, 6A-6D, and 7A-7C describe an example interactive user interface provided by one embodiment of the roof estimation system. As noted, the RES 100 described with reference to Figure 1 includes a user interface engine 104 that is configured to provide access to one or more functions of the RES 100, including image registration (described with respect to Figures 4A-4F), roof pitch determination (described with respect to Figures 5A-5D), roof model construction (described with reference to Figures 6A-6D), and roof model review (described with respect to Figures 7A-7C).

A. Image Registration

[0057] Figures 4A-4F are screen displays illustrating image registration and image lean correction in an example embodiment. In particular, Figure 4A shows a user interface screen 400 that is utilized by an operator to generate a three dimensional model of a roof of a building. The user interface screen 400 shows a roof modeling project in an initial state, after the operator has specified an address of a building and

after images of the building have been obtained and loaded into the roof estimation system.

[0058] The user interface screen 400 includes a control panel 401 and five images 402-406 of a building roof 407. The control panel 401 includes user selectable controls (*e.g.*, buttons, check boxes, menus, etc.) for various roof modeling tasks, such as setting reference points for the images, setting the vertical (Z) axis for the images, switching between different images, saving the model, and the like. Each of the images 402-406 provides a different view of the building roof 407. In particular, images 402-406 respectively provide substantially top-down, south, north, west, and east views of the building roof 407. Each image 402-406 includes four marker controls (also called "reference points" or "registration markers") that are used by the operator to set reference points in the image for purposes of image registration. The registration markers will be described further with respect to an enlargement of image portion 408 described with respect to Figures 4B-4C, below.

[0059] Figures 4B-4C show an enlarged view of image portion 408 during the process of image registration for image 402, which provides a top-down view of the building roof 407. As shown in Figure 4B, image portion 408 includes the building roof 407 and registration markers 410-413. The markers 410-413 are interactive user interface controls that can be directly manipulated (*e.g.*, moved, rotated, etc.) by the operator in order to specify points to use for purposes of image registration. In particular, image registration includes determining a transformation between each of one or more images and a uniform 3D reference grid. The uniform 3D reference grid is used as a coordinate system for a 3D model of the roof. By registering multiple images to the reference grid, an operator may indicate a roof feature on an image (such as a roof edge), which may then be translated from the coordinate system of the image to the coordinate system of the reference grid, for purposes of including of the indicated feature in the 3D model.

[0060] Marker 410 is an origin marker control, and includes arms 410a-410c. Arms 410a and 410b are horizontal arms that are utilized to specify the X and Y axes (*e.g.*,

the horizontal plane) of the reference grid. Arm 410c is a vertical arm that may be utilized to specify the Z axis (*e.g.*, the vertical axis) of the reference grid. The use of the vertical arm to specify the Z axis will be further described with respect to Figure 4E, below.

[0061] Typically, markers 410-413 are color coded, such that they may be distinguished from one another. For example, marker 411-413 may be respectively colored red, blue, and green. Origin marker 410 has a different appearance than markers 411-413, so may be of any color. In other embodiments, markers 411-413 may be distinguished in other ways, such as by utilizing different sized dashed lines, different line thicknesses, etc. In still other embodiments, markers are not distinguished any way from each other, such as by being of uniform shape, color, etc.

[0062] Figure 4C shows image portion 408 with markers 410-413 after they have been placed by an operator. Typically, registration markers are placed at four spatially distributed corners of the roof. As shown in Figure 4C, the operator has placed markers 410-413 at four different corners of the building roof 407. In particular, the operator first placed the origin marker 410 at the lower left corner of the building roof 407, and has adjusted (*e.g.*, rotated) the arms 410a and 410b to align with the major horizontal axes of the roof. By adjusting the arms 410a and 410b of the origin marker 410, the rotational orientation of markers 411-413 is automatically adjusted by the roof estimation system. Next, the operator places markers 411-413 on some other corners of the roof. In general, the operator can place registration marker over any roof feature, but roof corners are typically utilized because they are more easily identified by the operator. After the operator is satisfied with the placement of markers 410-413, the operator typically registers a next image of the building roof 407, as will be described next.

[0063] Figures 4D-4F illustrate image registration for image 404, which provides a north view of the building roof 407. In particular, Figure 4D shows the user interface screen 400 described with reference to Figure 4A. Here, image 402 has been minimized, while image 404 has been enlarged so that the operator may register that

image by placing markers on image 404, as will be described below with respect to an enlarged view of image portion 418.

[0064] Figure 4E shows an enlarged view of image portion 418 during the process of image registration for image 404. Image portion 418 includes the building roof 407 and registration markers 420-423. Markers 420-423 respectively correspond to markers 410-413 described above. In particular, marker 420 is an origin marker control that includes arms 420a-420c. Arms 420a and 420b are horizontal arms that are utilized to specify the X and Y axes of the reference grid. Arm 420c is a vertical arm that may be utilized to specify the Z axis of the reference grid.

[0065] In the example of Figure 4E, the operator has moved each of markers 420-423 to a corner of the roof 407. Note that the markers 420-423 are moved to roof corners that correspond to those selected by the operator with markers 410-413, as described with reference to Figure 4C. In particular, origin marker 420 has been moved to the corner of the roof 407 selected with origin marker 410 in image 408; marker 421 has been moved to the corner selected with marker 411 in image 408; marker 422 has been moved to the corner selected with marker 412 in image 408; and marker 423 has been moved to the corner selected with marker 413 in image 408. In addition, markers 420-423 have been rotated, by operator rotation of the origin marker 420, to align with the major axes of the roof 407.

[0066] As noted, the operator can utilize the origin marker 420 to specify the vertical axis of the reference grid. In particular, the operator can adjust (*e.g.*, by dragging with a mouse or other pointing device) arm 420c of marker 420 to specify the vertical (Z) axis of the image. In some cases, aerial images may include some amount of lean, due to the orientation of the aircraft during image capture. For example, pitch, yaw, or roll of an aircraft during the course of image capture may result in images that are misaligned with respect to the vertical axis of the building and its roof. Typically, an operator may adjust arm 420c to line up with a feature of a building or roof that is known to be substantially vertical, such as a wall of a house or a chimney. Then, based on the angle of arm 420c with respect to the vertical axis of the image, the roof

estimation system can determine a correction between the reference grid and the image.

[0067] Figure 4F shows an enlarged view of image portion 418 after registration of image 404. Once the operator has placed and adjusted markers 420-423, the operator may direct (*e.g.*, by clicking a button) the roof estimation system to register the image to the reference grid, based on the positions and orientations of markers 420-423. Once the roof estimation system registers the image, it provides the operator with feedback so that the operator may determine the correctness or accuracy of the registration.

[0068] In the example of Figure 4F, the operator has directed the roof estimation system to register image 404, and the roof estimation system has updated image portion 418 with registration indicators 430-433. Registration indicators 430-433 provide the operator with feedback so that the operator may judge the accuracy of the registration of image 404.

[0069] Registration indicator 430 is an origin registration indicator that includes two arms 430a-430b and three reference grid indicators 430c-430e, shown as dashed lines. The reference grid indicators 430c-430e show the vertical axis (430c) and the two horizontal axes (430d and 430e) of the reference grid determined based on the placement and orientation of the markers 420-423. Arms 430a and 430b correspond to the placement of arms 420a-420c of origin marker 420. If the arms 430a and 430b do not substantially align with the corresponding reference grid indicators 430e and 430d, then the determined reference grid is out of alignment with the specified axes of the house. Typically, an operator will return to the view of Figure 4E to make adjustments to origin marker, such as adjusting one or more of the vertical or horizontal axes, in order to refine the registration of the image. Although the arms 430a-430b and the reference grid indicators 430c-430e are here illustrated as solid and dashed lines, in other embodiments they may be color coded. For example, arms 430a-430b may be red, while reference grid indicators 430c-430e may be blue.

[0070] Registration indicators 431-433 provide the operator with information regarding the accuracy of the placement of markers 421-423. In particular, each registration indicator 431-433 includes a solid crosshairs and a reference indicator, shown for example as a dashed line 432a. The crosshair of a registration indicator corresponds to the placement of a marker. For example, the crosshairs of registration indicator 431 corresponds to the placement of marker 421 in Figure 4E. If the reference indicator intersects the center (or substantially near the center) of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is accurate. On the other hand, if the reference indicator does not intersect the center of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is inaccurate. Typically, such an inaccuracy arises when the placement of markers in the top view of the roof does not agree with (correspond to) the placement of corresponding markers in another view of the roof. In such cases, the operator can return to the view of Figure 4C or 4E to adjust the position of one or more markers.

[0071] After registering image 404, the operator will proceed to register additional images of the building roof 407 utilizing a process similar to that described above. In this example, the operator will register images 403, 405, and 406. Although the operator is here described as registering a total of five images, in other cases more or fewer images may be registered.

B. Roof Model Construction

[0072] Figures 5A-5D and 6A-6C generally illustrate aspects of the process of roof model generation based on multiple registered images. In particular, these figures illustrate the construction of a roof model by an operator. Model generation/construction may include identification of roof features shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. Each identified roof feature is incorporated by the roof estimation system into a 3D model of

the roof, based on a translation between an image in which the feature is identified and the reference grid, as determined by the process described with reference to Figures 4A-4F, above.

[0073] Figures 5A-5D are screen displays illustrating pitch determination in an example embodiment. In particular, Figure 5A shows the user interface screen 400 after images 402-406 have been registered. In this example, the operator is using a pitch determination control (also called a "pitch determination marker" or "pitch determination tool") to specify the pitch of a planar roof section of the building roof 407 visible in image 406. The pitch determination control will be further described in Figure 5B, below, with respect to an enlargement of image portion 508.

[0074] Figure 5B shows an enlarged view of image portion 508 during the process of pitch determination for image 406, which provides an east perspective view of the building roof 407. As shown in Figure 5B, the image portion 508 includes the building roof 407 and a pitch determination marker 510 (also called a "protractor tool"). The pitch determination marker 510 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407.

[0075] The pitch determination marker 510 includes arms 510a-510d. Arms 510a-510c are axes, which are automatically aligned, based on the registration of image 406, with the major (X, Y, and Z) axes of the building roof. Arm 510d is a "protractor" arm that is adjustable by the operator to specify roof pitch.

[0076] The marker 510 is typically first moved by the operator to a convenient location on the building roof 407, usually corner of a planar section of the roof 407. Next, the operator adjusts arm 510d so that is substantially aligns with the sloped edge of the planar roof section. Then, the roof estimation system determines the pitch of the roof section, based on the configuration of the marker 510 with respect to the image and the reference grid.

[0077] After specifying the pitch of a planar roof section, the operator will typically specify other information about the planar roof section, such as its outline, as will be

described with reference to Figures 6A-6D. Note that as the operator provides additional information about the geometry of the roof 407, the roof estimation system may automatically determine the pitch and/or other features of at least some of the other planar roof sections, based on the provided geometric information and/or assumptions about roof symmetry or other standard architectural practices.

[0078] Figure 5C shows a second type of pitch determination marker being used in the context of image 403 which provides a south perspective view of the building roof 407. The illustrated pitch determination marker may be used in addition to, or instead of, the pitch determination marker 510 described with respect to Figures 5A-5B, above. In particular, Figure 5C shows a pitch determination marker 520 (also called an "envelope tool") that includes surfaces 520a and 520b. The pitch determination marker 520 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407. In particular, the pitch determination marker 520 may be moved and/or adjusted so that it appears to lie substantially atop two adjacent planar sections of roof 407.

[0079] Figure 5D shows the pitch determination marker 520 after the operator has used it to specify the pitch of two sections of roof 407. Here, the operator has moved the marker 520 to a position in which the spine of the marker 520 is substantially aligned with the ridge line of roof 407. Then, the operator has adjusted the angle of the surfaces 520a and 520b so that they appear to lie substantially atop corresponding sections of roof 407. Then, the roof estimation system determines the pitch of the roof sections, based on the configuration of the marker 520 with respect to the image and the reference grid. Also illustrated are pitch indicators 521 and 522. Pitch indicator 521 corresponds to the measured pitch of surface 520a, and pitch indicator 522 corresponds to the measured pitch of surface 520b. As the operator adjusts the angle of surfaces 520a and/or 520b, the corresponding pitch indicators 521-522 are automatically updated to reflect the determined pitch. In this example, the pitch of both surfaces is given as 4 inches of rise per foot of run.

[0080] The envelope pitch determination marker 520 may be adjusted in other ways, to specify pitches for types of roofs other than the gabled roof shown in image 403. For example, when measuring pitch of roof sections that form a roof hip, point 520c may be manipulated by the operator, such as by dragging it to the left or right, to adjust the shape of the surfaces 520a and 520b, so that the surfaces align with the edges formed by the intersection of the sections that form the roof hip.

[0081] Figures 6A-6D are screen displays illustrating model construction and concurrent display of operator specified roof features in an example embodiment. In particular, Figures 6A-6D illustrate the construction of a three dimensional wire frame model of a building roof, based on the specification of roof features by an operator. In addition, Figures 6A-6D illustrate the concurrent display of operator specified roof features in multiple views of a building roof.

[0082] Figure 6A shows the user interface screen 400 after images 402-406 have been registered, and after roof pitches have been determined. In this example, the operator is specifying sections of roof 407, visible in image 406, that are to be added to a 3D wire frame model of the roof 407 maintained by the roof estimation system. The specification of roof sections will be further described with reference to enlarged portion 608 of image 406 in Figure 6B, below. In addition, as the operator specifies roof sections in image 406, the roof estimation system concurrently displays the specified roof sections in each of the other images 402-405. The concurrent display of operator specified roof features will be further described with reference to enlarged portion 609 of image 402 in Figure 6C, below.

[0083] Figure 6B is an enlarged view of image portion 608 during the process of wire frame model construction in the context of image 406, which provides an east perspective view of the building roof 407. As shown in Figure 6B, the image portion 608 includes the building roof 407, drawing tool 610, and wire frame 611. The drawing tool 610 (also called a “drawing marker” or a “drawing control”) is an interactive user interface control that can be directly manipulated by the operator in order to specify roof features, such as edges, ridges, valleys, corners, etc. In the

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illustrated embodiment, the operator uses the drawing tool 610 to trace or outline planar sections of the roof 407, leading to the generation of wire frame 611. The drawing tool 610 may be used to establish a series of connected line segments that result in a closed polygon representing a planar roof section. As the operator specifies a planar roof section in this manner, the roof estimation system determines, based on the image and the reference grid, the geometry of the planar roof section, and includes (adds) the specified planar roof section in a 3D model that corresponds to roof 407.

[0084] Figure 6C is an enlarged view of image portion 609 illustrating the concurrent display of operator specified roof features, in the context of image 402, which provides a top plan view of the building roof 407. As the operator specifies roof sections as described with respect to Figure 6B, the roof estimation system concurrently displays the specified roof features in one or more of the other images displayed by the user interface screen 400. More specifically, image portion 609 includes building roof 407 and wire frame 612. Wire frame 612 corresponds to wire frame 611 constructed by the operator with reference to Figure 6B, except that wire frame 612 is automatically displayed as a projection from the 3D model into the top-down view of image 402. Changes that the operator makes to wire frame 611 are concurrently displayed by the roof estimation system as wire frame 612 in image portion 609. For example, if a new planar roof section is added by the operator to wire frame 611, the new planar roof section is automatically displayed in wire frame 612. By concurrently displaying operator identified features in multiple views of building roof 407, the operator obtains feedback regarding the correctness and/or accuracy of the 3D model or other aspects of the model generation process, such as image registration and pitch determination.

[0085] Generally, the roof estimation system can be configured to concurrently display any operator-identified features, such as corners, ridges, valleys, planar sections, and the like, in multiple views of a building.

[0086] Furthermore, the concurrently displayed wire frame 612 is an interactive user interface element, in that the operator can make changes to the wire frame 612, which

are then concurrently displayed in wire frame 611. Wire frames similar to those described above are also projected by the roof estimation system into images 403, 404, and 405 displayed by the user interface screen 400. In this manner, the operator can switch between various images of the building roof 407, making refinements to the 3D model by adjusting the wire frame in whichever image is more convenient and/or provides a more suitable perspective/view of the model.

[0087] Figure 6D shows the user interface screen 400 during construction of a 3D model of the building roof 407. In particular, the user interface 400 includes a shaded wire frame 613 representation of the 3D model constructed as described above. In this view, the operator can review the wire frame 613 in isolation from any images to determine whether the wire frame 613 accurately represents the building roof 407. The wire frame 613 is an interactive user interface component, in that it can be directly manipulated (*e.g.*, moved, rotated, resized, etc.). In some embodiments, manipulating the wire frame 613, such as by changing its shape, results in corresponding changes in the underlying 3D model.

C. Roof Model Review

[0088] Figures 7A-7C are screen displays illustrating roof model review in an example embodiment. In particular, Figures 7A-7C illustrate various techniques to facilitate the review of a roof model by an operator. Reviewing the roof model may include reviewing roof section pitches (*e.g.*, to determine whether they conform to the building roof and/or standard construction practices), reviewing the shape and/or location of the roof model (*e.g.*, to determine whether it substantially conforms to the building roof), etc.

[0089] Figure 7A shows the user interface screen 400 after the operator has constructed a model of the roof 407 using one or more of the images 402-406. In this example, a wire frame has been projected onto (superimposed upon) image 402 and annotated with roof section pitches, as will be described further with respect to enlarged portion 708 of image 402 in Figure 7B, below.

[0090] Figure 7B is an enlarged view of image portion 708 during the process of roof model review in the context of image 402, which provides a substantially top plan view of the building roof 407. As shown in Figure 7B, the image portion 708 includes a wire frame 710 and labels 711a-711c that indicate pitches of corresponding sections of roof 407. The wire frame 710 and the illustrated pitches are determined by the roof estimation system based on the pitch determination described with respect to Figures 5A-5D, above, and the operator's specification of the wire frame model described with respect to Figures 6A-6D, above.

[0091] The wire frame 710 includes multiple vertexes connected by line segments. Each vertex includes a handle, such as handle 710a. The handles may be directly manipulated (individually or in groups) by the operator to make adjustments/modifications to the wire frame 710. For example, when an operator drags handle 710a to a new location, the ends of the two line segments connected to handle 710a will also move to the new location.

[0092] Figure 7C is an alternative view of the 3D model of roof 407 during the process of roof model review. In Figure 7C, the user interface screen 400 includes a wire frame 720 representation of the 3D model of the roof 407. The wire frame 720 consists of multiple line segments corresponding to edges of planar roof sections. Each line segment is annotated with a label, such as label 723, indicating the determined length of the corresponding roof section edge. Furthermore, some of the line segments indicate that they correspond to a particular roof feature. For example, line segments 721 and 722 may be colored (*e.g.*, red) so as to indicate that they correspond to roof ridges. Other line segments may be differently colored (*e.g.*, blue) so as to indicate a correspondence to roof valleys or other features. In addition, the wire frame 720 may be directly manipulated by the operator in order to make adjustments to the underlying model of the roof 407. For example, the operator could increase or decrease the length of line segment 721, resulting in a change in the corresponding feature of the 3D model of roof 407.

[0093] Note that although the operator is shown, in Figures 5-7 above, operating upon a total of five images, in other cases, fewer images may be used. For example, in some cases fewer images may be available, or some images may provide obstructed views of the building roof, such as due to tree cover, neighboring buildings, etc.

3. Implementation Techniques

[0094] Figure 8 is an example block diagram of a computing system for practicing embodiments of a roof estimation system. Figure 8 shows a computing system 800 that may be utilized to implement a Roof Estimation System ("RES") 810. One or more general purpose or special purpose computing systems may be used to implement the RES 810. More specifically, the computing system 800 may comprise one or more distinct computing systems present at distributed locations. In addition, each block shown may represent one or more such blocks as appropriate to a specific embodiment or may be combined with other blocks. Moreover, the various blocks of the RES 810 may physically reside on one or more machines, which use standard inter-process communication mechanisms (*e.g.*, TCP/IP) to communicate with each other. Further, the RES 810 may be implemented in software, hardware, firmware, or in some combination to achieve the capabilities described herein.

[0095] In the embodiment shown, computing system 800 comprises a computer memory ("memory") 801, a display 802, one or more Central Processing Units ("CPU") 803, Input/Output devices 804 (*e.g.*, keyboard, mouse, joystick, track pad, CRT or LCD display, and the like), other computer-readable media 805, and network connections 806. The RES 810 is shown residing in memory 801. In other embodiments, some portion of the contents, some of, or all of the components of the RES 810 may be stored on and/or transmitted over the other computer-readable media 805. The components of the RES 810 preferably execute on one or more CPUs 803 and generate roof estimate reports, as described herein. Other code or programs 830 (*e.g.*, a Web server, a database management system, and the like) and potentially other data repositories, such as data repository 820, also reside in the

memory 801, and preferably execute on one or more CPUs 803. Not all of the components in Figure 8 are required for each implementation. For example, some embodiments embedded in other software do not provide means for user input, for display, for a customer computing system, or other components.

[0096] In a typical embodiment, the RES 810 includes an image acquisition engine 811, a roof modeling engine 812, a report generation engine 813, an interface engine 814, and a roof estimation system data repository 816. Other and/or different modules may be implemented. In addition, the RES 810 interacts via a network 850 with an image source computing system 855, an operator computing system 865, and/or a customer computing system 860.

[0097] The image acquisition engine 811 performs at least some of the functions of the image acquisition engine 101 described with reference to Figure 1. In particular, the image acquisition engine 811 interacts with the image source computing system 855 to obtain one or more images of a building, and stores those images in the RES data repository 816 for processing by other components of the RES 810. In some embodiments, the image acquisition engine 811 may act as an image cache manager, such that it preferentially provides images to other components of the RES 810 from the RES data repository 816, while obtaining images from the image source computing system 855 when they are not already present in the RES data repository 816. In other embodiments, images may be obtained in an "on demand" manner, such that they are provided, either by the image acquisition engine 811 or the image source computing system 855, directly to modules of the RES 810 and/or the operator computing system 865, without intervening storage in the RES data repository 816.

[0098] The roof modeling engine 812 performs at least some of the functions of the roof modeling engine 102 described with reference to Figure 1. In particular, the roof modeling engine 812 generates a model based on one or more images of a building that are obtained from the RES data repository 816 or directly from the image source computing system 855. As noted, model generation may be performed semi-automatically, based on at least some inputs received from the computing system

865. In addition, at least some aspects of the model generation may be performed automatically, based on image processing and/or image understanding techniques. After the roof modeling engine 812 generates a model, it stores the generated model in the RES data repository 816 for further processing by other components of the RES 810.

[0099] The report generation engine 813 performs at least some of the functions of the report generation engine 103 described with reference to Figure 1. In particular, the report generation engine 813 generates roof reports based on models stored in the RES data repository 816. Generating a roof report may include preparing one or more views of a given 3D model of a roof, annotating those views with indications of various characteristics of the model, such as dimensions of sections or other features (*e.g.*, ridges, valleys, etc.) of the roof, slopes of sections of the roof, areas of sections of the roof, etc. In some embodiments, the report generation engine 813 facilitates transmission of roof measurement information that may or may not be incorporated into a roof estimate report. For example, the roof generation engine 813 may transmit roof measurement information based on, or derived from, models stored in the RES data repository 816. Such roof measurement information may be provided to, for example, third-party systems that generate roof estimate reports based on the provided information.

[00100] The interface engine 814 provides a view and a controller that facilitate user interaction with the RES 810 and its various components. For example, the interface engine 814 implements a user interface engine 104 described with reference to Figure 1. Thus, the interface engine 814 provides an interactive graphical user interface that can be used by a human user operating the operator computing system 865 to interact with, for example, the roof modeling engine 812, to perform functions related to the generation of models, such as point registration, feature indication, pitch estimation, etc. In other embodiments, the interface engine 814 provides access directly to a customer operating the customer computing system 860, such that the customer may place an order for a roof estimate report for an indicated building

location. In at least some embodiments, access to the functionality of the interface engine 814 is provided via a Web server, possibly executing as one of the other programs 830.

[00101] In some embodiments, the interface engine 814 provides programmatic access to one or more functions of the RES 810. For example, the interface engine 814 provides a programmatic interface (*e.g.*, as a Web service, static or dynamic library, etc.) to one or more roof estimation functions of the RES 810 that may be invoked by one of the other programs 830 or some other module. In this manner, the interface engine 814 facilitates the development of third-party software, such as user interfaces, plug-ins, adapters (*e.g.*, for integrating functions of the RES 810 into desktop applications, Web-based applications, embedded applications, etc.), and the like. In addition, the interface engine 814 may be in at least some embodiments invoked or otherwise accessed via remote entities, such as the operator computing system 865, the image source computing system 855, and/or the customer computing system 860, to access various roof estimation functionality of the RES 810.

[00102] The RES data repository 816 stores information related the roof estimation functions performed by the RES 810. Such information may include image data 105, model data 106, and/or report data 107 described with reference to Figure 1. In addition, the RES data repository 816 may include information about customers, operators, or other individuals or entities associated with the RES 810.

[00103] In an example embodiment, components/modules of the RES 810 are implemented using standard programming techniques. For example, the RES 810 may be implemented as a "native" executable running on the CPU 803, along with one or more static or dynamic libraries. In other embodiments, the RES 810 is implemented as instructions processed by virtual machine that executes as one of the other programs 830. In general, a range of programming languages known in the art may be employed for implementing such example embodiments, including representative implementations of various programming language paradigms, including but not limited to, object-oriented (*e.g.*, Java, C++, C#, Matlab, Visual

Basic.NET, Smalltalk, and the like), functional (*e.g.*, ML, Lisp, Scheme, and the like), procedural (*e.g.*, C, Pascal, Ada, Modula, and the like), scripting (*e.g.*, Perl, Ruby, Python, JavaScript, VBScript, and the like), declarative (*e.g.*, SQL, Prolog, and the like).

[00104] The embodiments described above may also use well-known synchronous or asynchronous client-server computing techniques. However, the various components may be implemented using more monolithic programming techniques as well, for example, as an executable running on a single CPU computer system, or alternatively decomposed using a variety of structuring techniques known in the art, including but not limited to, multiprogramming, multithreading, client-server, or peer-to-peer, running on one or more computer systems each having one or more CPUs. Some embodiments execute concurrently and asynchronously, and communicate using message passing techniques. Equivalent synchronous embodiments are also supported by an RES implementation. Also, other functions could be implemented and/or performed by each component/module, and in different orders, and by different components/modules, yet still achieve the functions of the RES.

[00105] In addition, programming interfaces to the data stored as part of the RES 810, such as in the RES data repository 816, can be available by standard mechanisms such as through C, C++, C#, and Java APIs; libraries for accessing files, databases, or other data repositories; through scripting languages such as XML; or through Web servers, FTP servers, or other types of servers providing access to stored data. For example, the RES data repository 816 may be implemented as one or more database systems, file systems, memory buffers, or any other technique for storing such information, or any combination of the above, including implementations using distributed computing techniques.

[00106] Also, the example RES 810 can be implemented in a distributed environment comprising multiple, even heterogeneous, computer systems and networks. For example, in one embodiment, the image acquisition engine 811, the roof modeling engine 812, the report generation engine 813, the interface engine 814, and the data

repository 816 are all located in physically different computer systems. In another embodiment, various modules of the RES 810 are hosted each on a separate server machine and are remotely located from the tables which are stored in the data repository 816. Also, one or more of the modules may themselves be distributed, pooled or otherwise grouped, such as for load balancing, reliability or security reasons. Different configurations and locations of programs and data are contemplated for use with techniques of described herein. A variety of distributed computing techniques are appropriate for implementing the components of the illustrated embodiments in a distributed manner including but not limited to TCP/IP sockets, RPC, RMI, HTTP, Web Services (XML-RPC, JAX-RPC, SOAP, and the like).

[00107] Furthermore, in some embodiments, some or all of the components of the RES are implemented or provided in other manners, such as at least partially in firmware and/or hardware, including, but not limited to one or more application-specific integrated circuits (ASICs), standard integrated circuits, controllers (*e.g.*, by executing appropriate instructions, and including microcontrollers and/or embedded controllers), field-programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), and the like Some or all of the system components and/or data structures may also be stored (*e.g.*, as software instructions or structured data) on a computer-readable medium, such as a hard disk, a memory, a network, or a portable media article to be read by an appropriate drive or via an appropriate connection. The system components and data structures may also be stored as data signals (*e.g.*, by being encoded as part of a carrier wave or included as part of an analog or digital propagated signal) on a variety of computer-readable transmission mediums, which are then transmitted, including across wireless-based and wired/cable-based mediums, and may take a variety of forms (*e.g.*, as part of a single or multiplexed analog signal, or as multiple discrete digital packets or frames). Such computer program products may also take other forms in other embodiments. Accordingly, embodiments of this disclosure may be practiced with other computer system configurations.

[00108] Figure 9 is an example flow diagram of an image registration routine provided by an example embodiment. The illustrated routine 900 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 900 facilitates image registration based upon operator indicated registration points and/or image lean corrections.

[00109] More specifically, the routine begins in step 901, where it displays, on a user interface screen, an aerial image of a building having a roof. As part of the user interface screen, the routine also displays user interface controls such as markers that may be used by an operator for purposes of image registration and/or lean correction, as described with reference to Figure 4A, above.

[00110] In step 902, the routine receives, via one or more registration markers, indications of one or more points on the aerial image. The registration markers are manipulated by the operator to specify points on the aerial image, as described with reference to Figures 4A-4E. Typically, the points are visually identifiable features, such as corners of the roof of the building. For example, if the roof has four corners (*e.g.*, a northwest, southwest, northeast, and southwest corner) the operator may place one registration marker on each of the four corners as shown in the aerial image. Then, the positions (*e.g.*, coordinates on the aerial image) of the markers are transmitted to the routine for use in registering the aerial image, as described below.

[00111] In step 903, the routine receives, via a lean correction marker, an indication of the vertical axis of the building roof. In at least some cases, the aerial image of the building is out of alignment with respect to the vertical axis of the building. This may be caused, for example, by pitch, roll, and/or yaw experienced by the aircraft during the process of photographing the building. To correct for such misalignment, the lean correction marker is manipulated by the operator to indicate a vertical axis of the building. Typically, the operator aligns the lean correction marker with known, substantially vertical feature of the building, such as a chimney, wall corner, etc., as described with reference to Figure 4E, above. After the operator has aligned the lean correction marker, the position (*e.g.*, angle of the marker, coordinates of the endpoints

of the marker, etc.) of the lean correction marker is transmitted to the routine for use in registering the aerial image, as described below.

[00112] Particular benefits may be obtained from lean correction performed in the context of an overhead, or "top down," view. An "overhead lean" occurs when the camera is not directly overhead with respect to the building when the photo is taken. In some cases, leans in excess of 5 degrees have been observed in "top down" photos. Furthermore, unlike oblique, perspective views, a top-down lean is typically less likely to include a convenient visual marker that provides sufficient angle to assess the lean direction and magnitude, such as the edge of the building or a tall chimney. An overhead lean affects the perceived location of the roof lines in a top down view. This effect is amplified as the pitch of the roof increases and/or as the vertical separation between disconnected roof sections increases. Without lean correction, superimposing a wire frame over the visible ridgelines (and other features of a building that reside at different elevations) may produce asymmetries in otherwise symmetric structures. Further, an absence of lean correction may introduce errors in pitch estimation, as the wire frame may not appear consistent between top and oblique view points. More specifically, without top view lean correction, the positions for the roof lines in an otherwise correct (*i.e.*, accurate with respect to the actual geometry of the roof) wire frame will typically not line up on the visible roof lines in the overhead reference photo. This often leads the user (or software) to either introduce errors by incorrectly drawing the wire frame to the image lines or perform a subjective determination of where and how to shift the wire frame lines off the image lines to produce a correct model. Top view lean correction allows the roof estimation system to trace to, or substantially to, the actual roof lines seen in the top image while still producing an accurate wire frame model.

[00113] Image misalignment may be specified in other ways. For example, in other embodiments, the operator may instead rotate the image to a position in which the building appears to be in a substantially vertical position. Then, the angle of rotation of the image may be transmitted to the routine for use in registering the aerial image.

[00114] In step 904, the routine registers, based on the received indications of the points and/or the received indication of the vertical axis, the aerial image to a reference grid. Registering the image to a reference grid may include determining a transformation between the reference grid and the image, based on the indicated points and/or the indicated vertical axis. Determining such a transformation may be based on other information as well, such as meta-information associated with the aerial image. In some embodiments, the aerial image has corresponding meta-information that includes image capture conditions, such as camera type, focal length, time of day, camera position (*e.g.*, latitude, longitude, and/or elevation), etc.

[00115] In step 905, the routine determines whether there are additional aerial images to be registered, and if so, returns to step 901, else proceeds to step 906. During execution of the loop of steps 901-905, the operator typically indicates, for each registration marker, the same feature (*e.g.*, corner) of the roof as shown in each of multiple images, such that the routine can register the multiple images to a single, uniform reference grid. Upon completion of the registration process, the routine has determined a uniform coordinate system for the multiple aerial images, for use during other phases of model construction, such as pitch determination or feature identification.

[00116] In step 906, the routine generates a three-dimensional model based at least in part on the aerial image(s) and the reference grid. As discussed above with reference to Figures 5A-5D and 6A-6D, model generation includes identification of roof features shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. In other embodiments, the routine performs other functions with the registered images, such as storing them for later use (*e.g.*, by an automated model generation module), transmitting them to another computing (*e.g.*, for use in a third-party design application), etc. After step 906, the routine ends.

[00117] Note that in at least some embodiments, aspects of the routine 900 may be performed in an automated manner. For example, operations discussed above as

being performed by an operator, such as the determination of the location of image registration points of step 902 and/or the indication of lean of step 903, may be performed by automated image processing techniques.

[00118] Figure 10 is an example flow diagram of a pitch determination routine provided by an example embodiment. The illustrated routine 1000 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1000 facilitates the determination of the pitch of a section of a roof, by displaying a pitch determination marker and modifying a 3D model of a roof based on an indication of roof pitch received via the pitch determination marker.

[00119] More specifically, the routine begins at step 1001 where it displays an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch. The aerial image is displayed in the context of a user interface screen, such as is described with reference to Figures 4A-6C, above. The aerial images may be received from, for example, the image source computing system 855 and/or from the RES data repository 816 described with reference to Figure 8. As discussed above, aerial images may be originally created by cameras mounted on airplanes, balloons, satellites, etc. In some embodiments, images obtained from ground-based platforms (*e.g.*, vehicle-mounted cameras) may be used instead or in addition.

[00120] In step 1002, the routine displays a pitch determination marker operable to indicate pitch of a planar roof section. The pitch determination marker may be, for example, a pitch determination marker 510 ("protractor tool") or 520 ("envelope tool"), such as are respectively described with respect to Figures 5B and 5C, above. The routine displays the pitch determination marker by, for example, presenting it on a user interface screen displayed on a computer monitor or other display device. The pitch determination marker is a direct manipulation user interface control, in that an operator may manipulate it (*e.g.*, adjust an angle, change its shape, alter its position, etc.) in order to indicate pitch of a planar roof section. Additional details regarding pitch determination controls are provided with respect to Figures 5A-5D, above.

[00121] In step 1003, the routine receives, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building. Receiving an indication of the pitch includes receiving an indication (*e.g.*, via an event, callback, etc.) that the marker has been manipulated by the operator, and then determining an angle based on the shape and/or position of the marker. In some embodiments, such an indication may be received on an event driven basis, such as every time the marker is manipulated in some manner. In other embodiments, the routine may poll the marker from time to time to determine its current state. In addition, the operator may explicitly indicate that the current state of the marker is to be transmitted to the routine, such as by pressing a button or other indication.

[00122] In step 1004, the routine modifies a three-dimensional model of the roof based on the received indication of the pitch of the one planar roof section. Modifying the 3D model of the roof includes associating the indicated pitch with a portion of the model corresponding to the one planar roof section. For example, the 3D model may include one or more data structures representing planar roof sections, and the indicated pitch may be included as part of the data structure representing the one planar roof section. In some embodiments, the 3D model may not at this point include representations of the planar roof sections, such as because the operator has not yet specified them. In such a case, the routine may store the indicated pitch in association with the location and orientation at which the pitch was specified by the operator, as determined from the aerial image. Then, at a later time, when the operator specifies a roof section that has the same orientation as the stored pitch and that includes or is near the stored location, the roof estimation system can store the indicated pitch in association with the specified roof section.

[00123] After step 1004, the routine ends. In other embodiments, the routine may instead return to step 1001, to determine the pitch for another planar roof section (of the same or different roof).

[00124] Figure 11 is an example flow diagram of concurrent feature display routine provided by an example embodiment. The illustrated routine 1100 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1100 concurrently displays operator indicated features in multiple aerial images of a building roof.

[00125] More specifically, the routine begins in step 1101, where it displays a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building. The aerial images are displayed in the context of a user interface screen, such as is described with reference to Figures 6A-6C, above.

[00126] In step 1102, the routine receives an indication of a feature of the building shown in the first aerial image. The indication is typically received via a user interface control, such as a drawing tool or marker, upon its manipulation by an operator. For example, the operator may manipulate a drawing tool in order to specify one or more features of the building roof, such as a corner on the roof, an edge of the roof, an outline of a section of the roof, etc. In one embodiment, the operator utilizes a drawing tool to indicate roof section corner points and roof section edges connecting those corner points. Additional details regarding feature indication are provided with respect to Figures 6A-6C, above.

[00127] In step 1103, the routine modifies a three-dimensional model of the roof based on the received indication of the feature of the building. Modifying the 3D model may include adding or updating the indicated feature to a wire frame model of the roof. For example, if the indicated feature is a roof section corner point, the corner point will be added to the 3D model, along with the location (*e.g.*, the X, Y, and Z position of the point) of the point. The location of the point is automatically determined based on a translation of the position of the point in the image to a point in the uniform reference grid associated with the image. If the indicated feature is a roof section edge, the edge will be added to the 3D model, such as by associating the edge with two points corresponding to the end points of the edge. Higher-level features can also be

indicated. For example, a planar roof section may be indicated by "closing" a sequence of two or more connected line segments, to create a closed polygon that represents the outline or perimeter of the planar roof section.

[00128] In step 1104, the routine concurrently displays a projection of the feature from the modified three-dimensional model onto the first and second aerial images. In one embodiment, displaying the feature from the modified three-dimensional model includes projecting the three-dimensional model onto both the first and second aerial images. For example, if the first image (for which the indicated feature was received) provides a west view of the building, and the second image provides an east view of the building, the routine will concurrently display a projection of the indicated feature from the 3D model onto both the first and second images. The projection of the indicated feature into the second image is based at least in part on a translation from the position of the feature in the reference grid to a position in the second image. In addition, the concurrent display onto two or more images occurs at substantially the same time (within a short time interval, at times that are substantially coincident) as the indication of the feature of the building in step 1102, giving the operator the illusion that as they are indicating a feature in the first image, the feature is being simultaneously projected into the second image.

[00129] After step 1104, the routine ends. In other embodiments, the routine may instead return to step 1101, to perform an interactive loop of steps 1101-1104with the operator, so that the routine can concurrently display multiple features as they are indicated by the operator. Note that in such an embodiment, each iteration of the loop of steps 1101-1104 may be performed at near real-time speeds, so as to provide a fluid, interactive model generation experience for the operator enabling the operator to drag, draw, or otherwise indicate/manipulate features in a first image and view the results of their work concurrently projected into a second image.

[00130] All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications

referred to in this specification and/or listed in the Application Data Sheet, including but not limited to U.S. Provisional Patent Application No. 61/197,904, entitled "USER INTERFACE SYSTEMS AND METHODS FOR ROOF ESTIMATION," filed October 31, 2008, are incorporated herein by reference, in their entireties.

[00131] From the foregoing it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the present disclosure. For example, the methods, systems, and techniques for generating and providing roof estimate reports discussed herein are applicable to other architectures other than the illustrated architecture or a particular roof estimation system implementation. Also, the methods and systems discussed herein are applicable to differing network protocols, communication media (optical, wireless, cable, etc.) and devices (such as wireless handsets, electronic organizers, personal digital assistants, portable email machines, game machines, pagers, navigation devices such as GPS receivers, etc.). Further, the methods and systems discussed herein may be utilized by and/or applied to other contexts or purposes, such as by or for solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and/or insurance companies.

CLAIMS

1. A computer-implemented method for generating a roof estimate report, the method comprising:

displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of a planar roof section;

receiving, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and

modifying a model of the roof based on the received indication of the pitch of the one planar roof section.

2. The method of claim 1 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.

3. The method of claim 1 further comprising:

transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

4. The method of claim 1 wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building.

5. The method of claim 1 further comprising:

displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

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6. The method of claim 5 wherein displaying the wireframe rendering occurs in response to the receiving of the indicated pitch.

7. The method of claim 1 wherein the pitch determination marker includes an adjustable protractor tool having a member that is adjustable to indicate an angle.

8. The method of claim 1 wherein the pitch determination marker includes an envelope tool having two surfaces that are adjustable to indicate an angle.

9. The method of claim 1 wherein modifying the model of the roof includes modifying a three-dimensional model of the roof.

10. A computing system for generating a roof estimate report, the computing system comprising:

a memory;

a roof estimation module that is stored on the memory and that is configured, when executed, to:

display an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;

display a pitch determination marker operable to indicate pitch of a planar roof section;

receive, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building;

modify a model of the roof based on the received indication of the pitch of the one planar roof section; and

provide roof measurement information based on the model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.

11. The computing system of claim 10 wherein the roof estimation module is further configured to transmit a roof estimate report based on the provided roof measurement information.

12. The computing system of claim 10 wherein the pitch determination marker includes at least one of an adjustable protractor tool and an envelope tool.

13. The computing system of claim 10 wherein the roof estimation module includes an interactive roof modeling user interface.

14. The computing system of claim 10 wherein the roof estimation module is further configured to display the pitch determination marker as part of an interactive user interface.

15. The computing system of claim 10 wherein the model of the roof is a three-dimensional model of the roof.

16. A computer-readable storage medium whose contents enable a computing system to generate a roof estimate report for a building having a roof, by performing a method comprising:

displaying an aerial image of a building having a roof comprising a planar roof section that has a corresponding pitch;

displaying a pitch determination marker operable to indicate pitch of the planar roof section;

receiving, via the displayed pitch determination marker, an indication of the pitch of the planar roof section; and

modifying a model of the roof based on the received indication of the pitch of the planar roof section.

17. The computer-readable storage medium of claim 16 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.

18. The computer-readable storage medium of claim 16 wherein the method further comprises:

generating a roof estimate report based on the modified model of the roof; and

transmitting the generated roof estimate report.

19. The computer-readable storage medium of claim 18 wherein the transmitted roof estimate report includes a line drawing of the roof of the house labeled with a measure of the pitch of the planar roof section.

20. The computer-readable storage medium of claim 16 wherein the method further comprises:

determining roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the planar roof section; and

transmitting the determined roof measurement information.

21. The computer-readable storage medium of claim 16 wherein modifying the model of the roof includes modifying a model of the roof by associating the indicated pitch with a portion of the model of the roof that corresponds to planar roof section of the roof of the building.

22. The computer-readable storage medium of claim 16 wherein the method further comprises:

displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

23. The computer-readable storage medium of claim 16 wherein the method further comprises:

registering, based on operator indicated features, multiple aerial images to a reference grid corresponding to the model.

24. The computer-readable storage medium of claim 23 wherein registering multiple images includes:

displaying a marker operable to specify a point on the aerial image;

receiving, via the marker, an indication of a point on the aerial image; and

registering, based on the received indication of the point, the aerial image to the reference grid.

25. The computer-readable storage medium of claim 24 wherein registering the aerial image to the reference grid includes determining a transformation between the aerial image and the reference grid.

26. The computer-readable storage medium of claim 16 wherein the method further comprises:

correcting lean of the aerial image with respect to a vertical axis of a reference grid corresponding to the model.

27. The computer-readable storage medium of claim 26 wherein correcting misalignment of the aerial image includes:

displaying a lean correction marker operable to indicate a vertical axis of the aerial image;

receiving, via the lean correction marker, an indication of the vertical axis of the aerial image; and

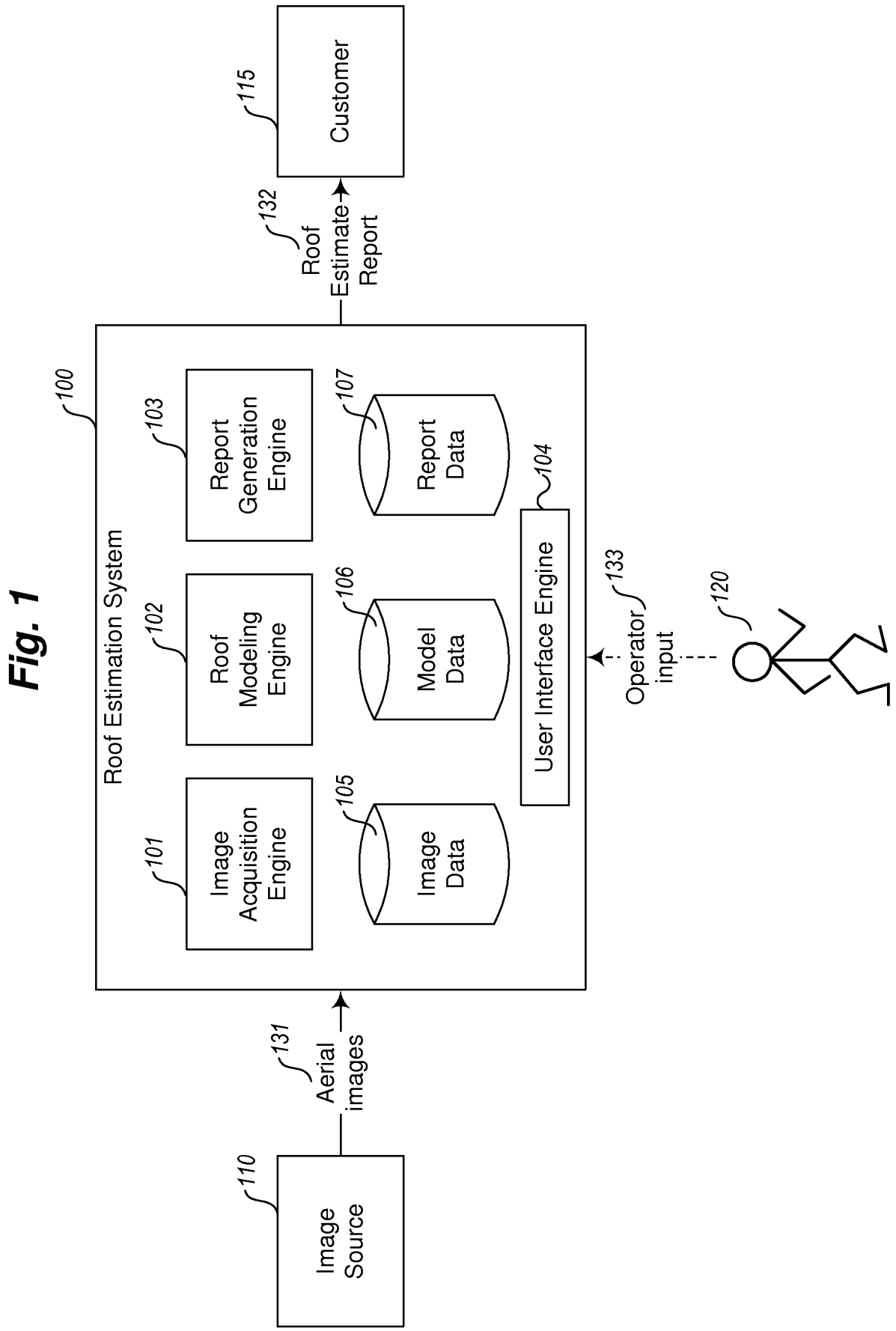
registering, based on the received indication of the vertical axis, the aerial image to the reference grid.

28. The computer-readable storage medium of claim 16 wherein modifying the model of the roof includes modifying a three-dimensional model of the roof.

ABSTRACT OF THE DISCLOSURE

User interface systems and methods for roof estimation are described. Example embodiments include a roof estimation system that provides a user interface configured to facilitate roof model generation based on one or more aerial images of a building roof. In one embodiment, roof model generation includes image registration, image lean correction, roof section pitch determination, wire frame model construction, and/or roof model review. The described user interface provides user interface controls that may be manipulated by an operator to perform at least some of the functions of roof model generation. In one embodiment, the user interface provides user interface controls that facilitate the determination of pitch of one or more sections of a building roof. This abstract is provided to comply with rules requiring an abstract, and it is submitted with the intention that it will not be used to interpret or limit the scope or meaning of the claims.

Fig. 1


Image Source
110
Aerial images
131
Roof Estimate Report
132
Customer
115
100
Roof Estimation System
Image Acquisition Engine
101
Roof Modeling Engine
102
Report Generation Engine
103
Image Data
105
Model Data
106
Report Data
107
User Interface Engine
104
Operator input
133
120

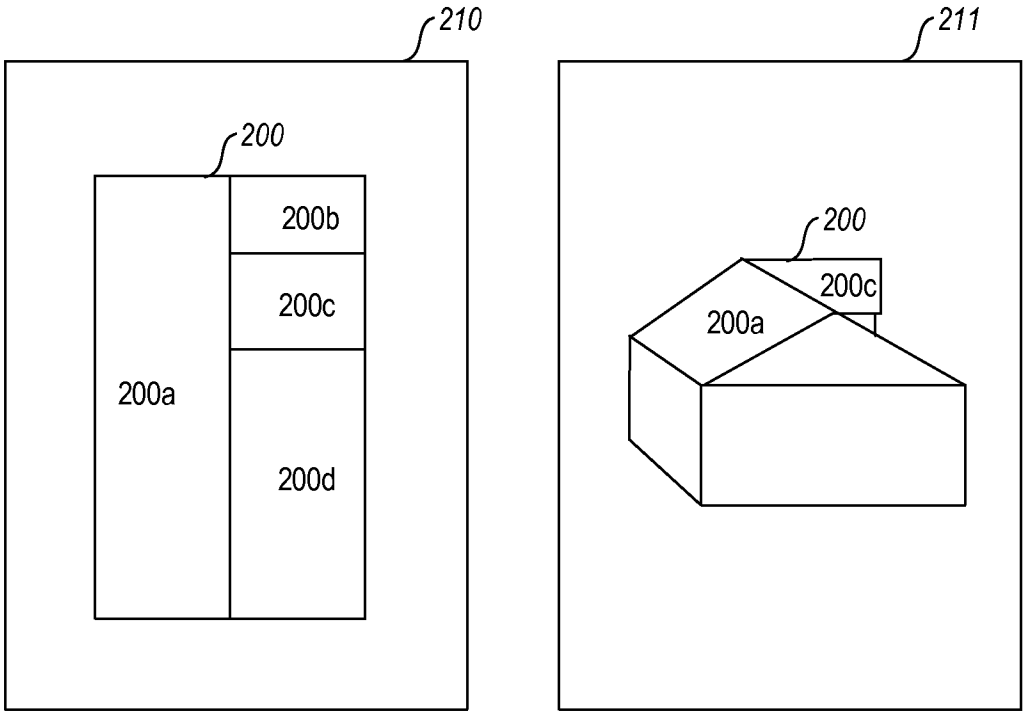

210
200
200b
200c
200a
200d
211
200
200c
200a

Fig. 2A

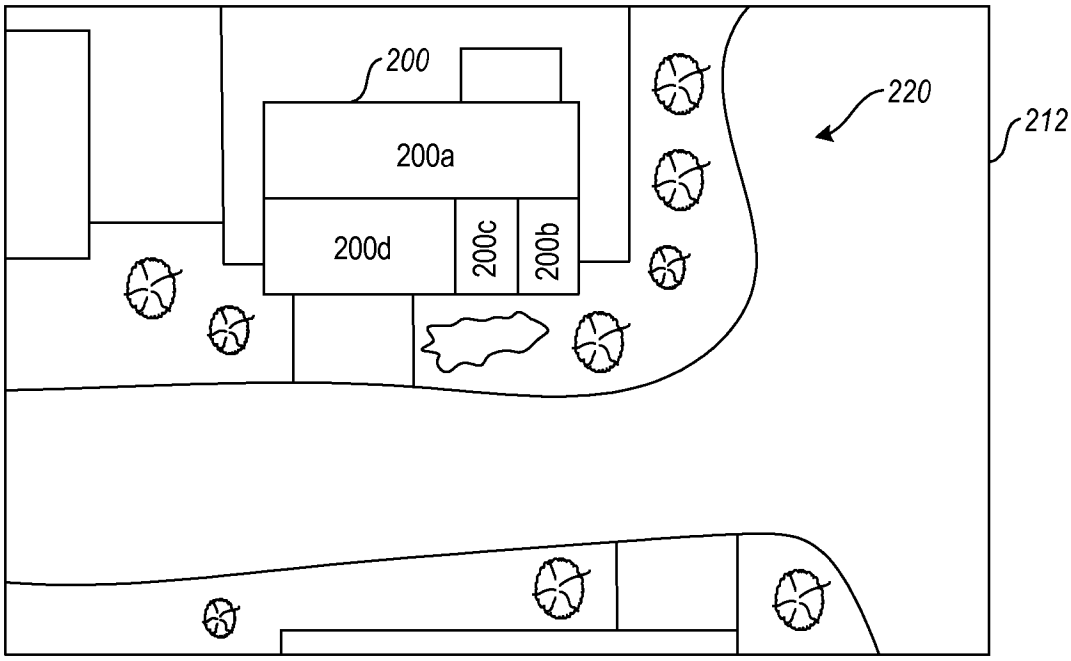

200
200a
200d
200c
200b
220
212

Fig. 2B

1234 Main Street, Redmond, WA

Order: 2468

<Customer Name Here>

4/16/2008

301a

1234 Main Street, Redmond, WA

301b



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Fig. 3A

1234 Main Street, Redmond, WA

Images:



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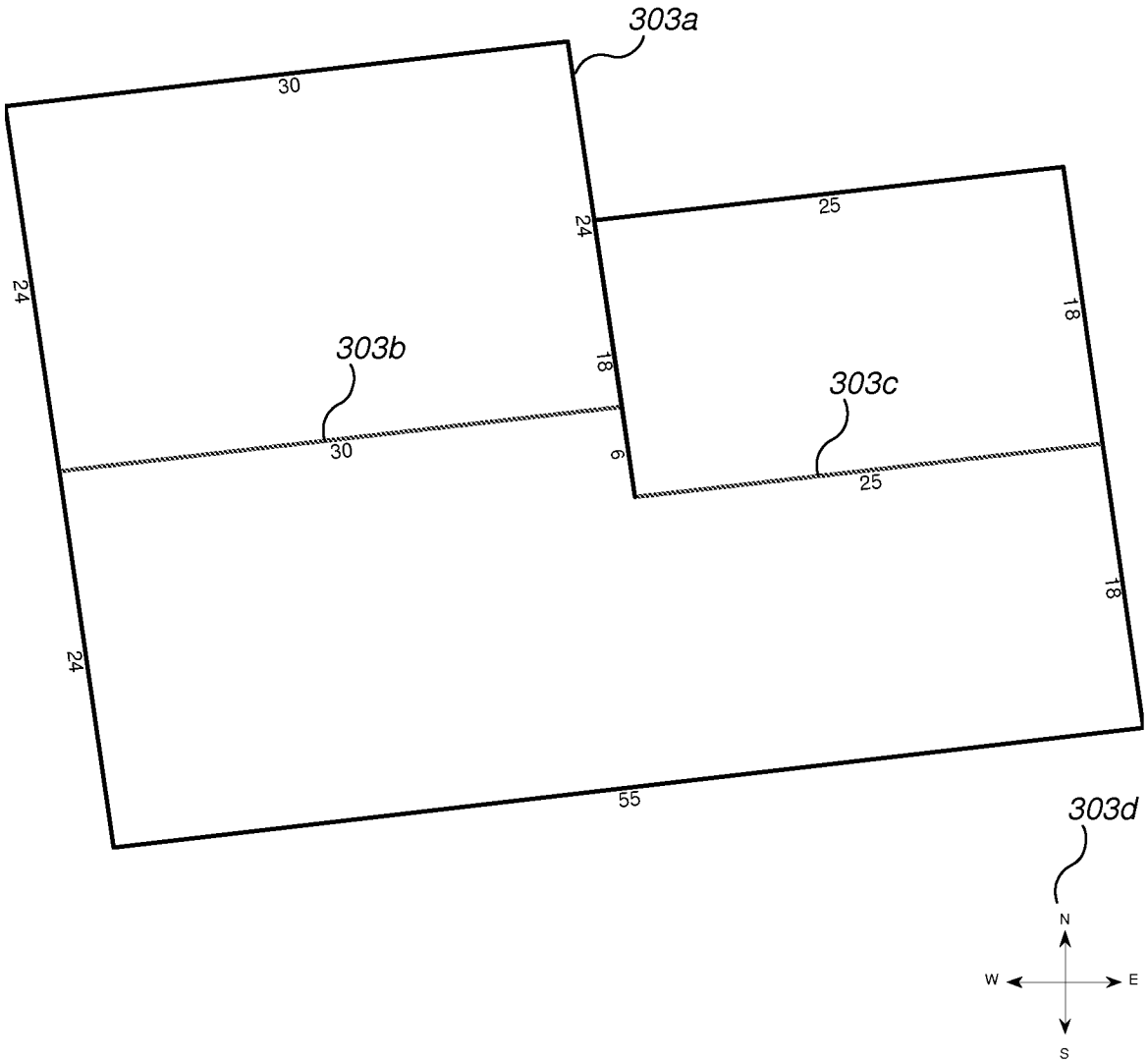
302

Fig. 3B

1234 Main Street, Redmond, WA

Length Diagram:

All measurements are rounded to the nearest foot
Ridge Length = 55 ft [Red Lines]
Valley Length = 0 ft [Blue lines]



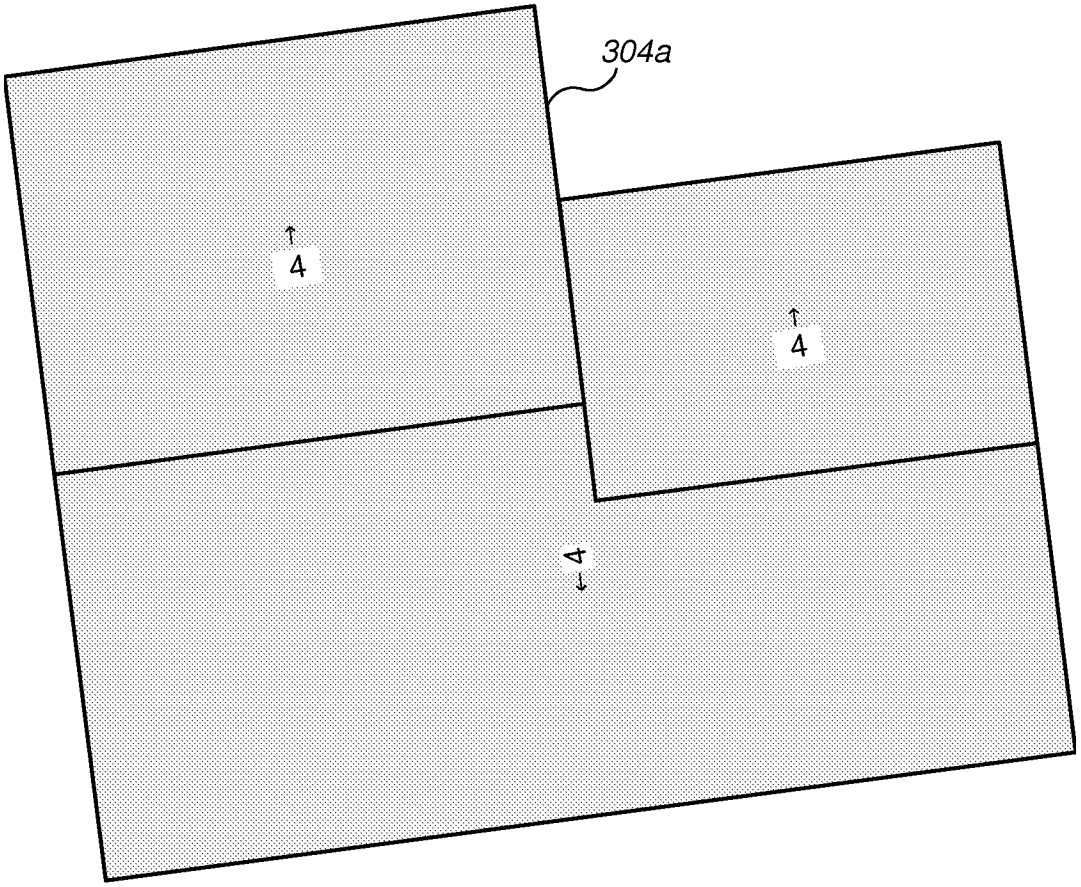
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Fig. 3C

1234 Main Street, Redmond, WA

Pitch Diagram:
Pitch units are inches per foot.



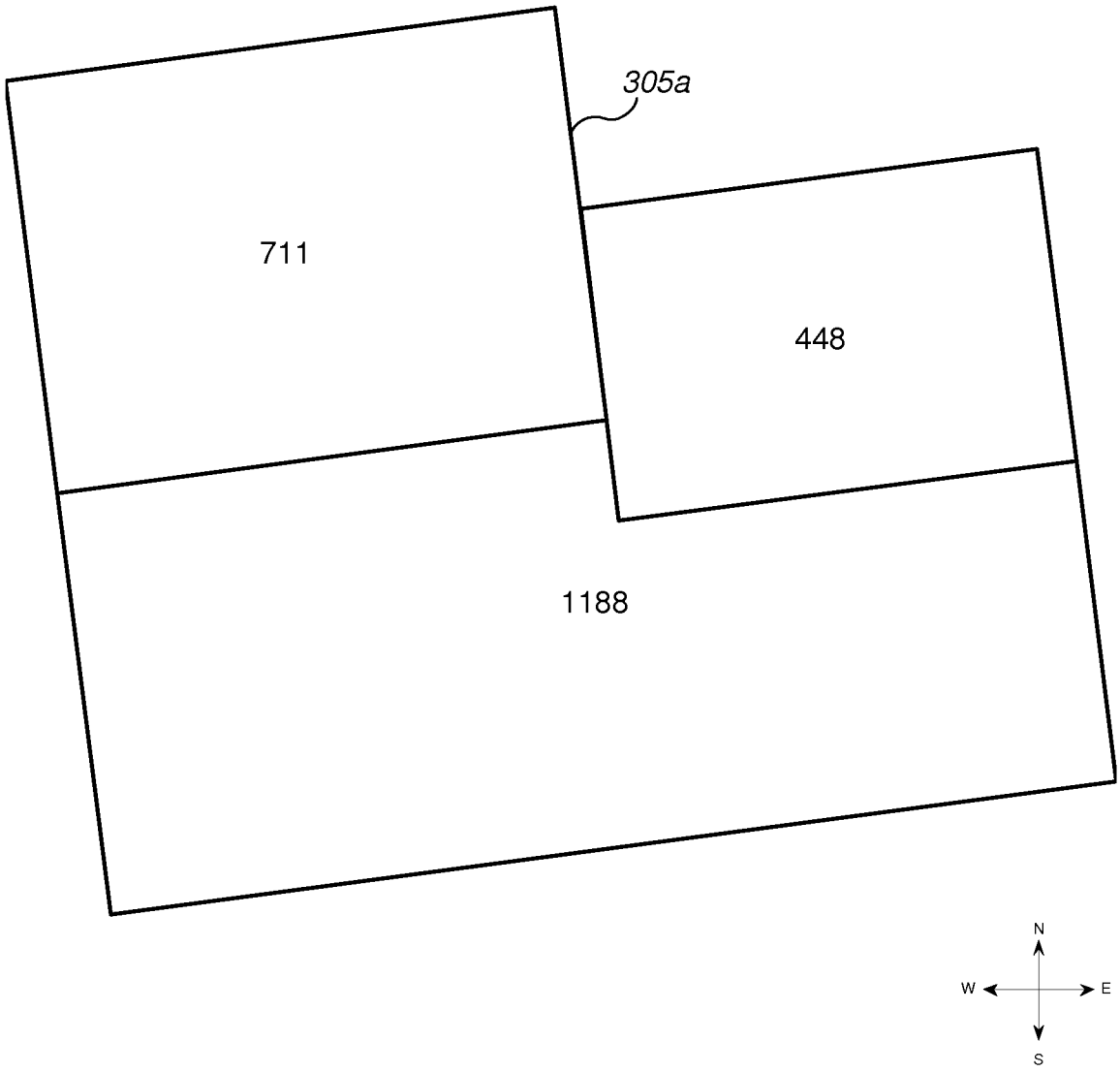
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Fig. 3D

1234 Main Street, Redmond, WA

Area Diagram:
Total Area = 2347 sqft



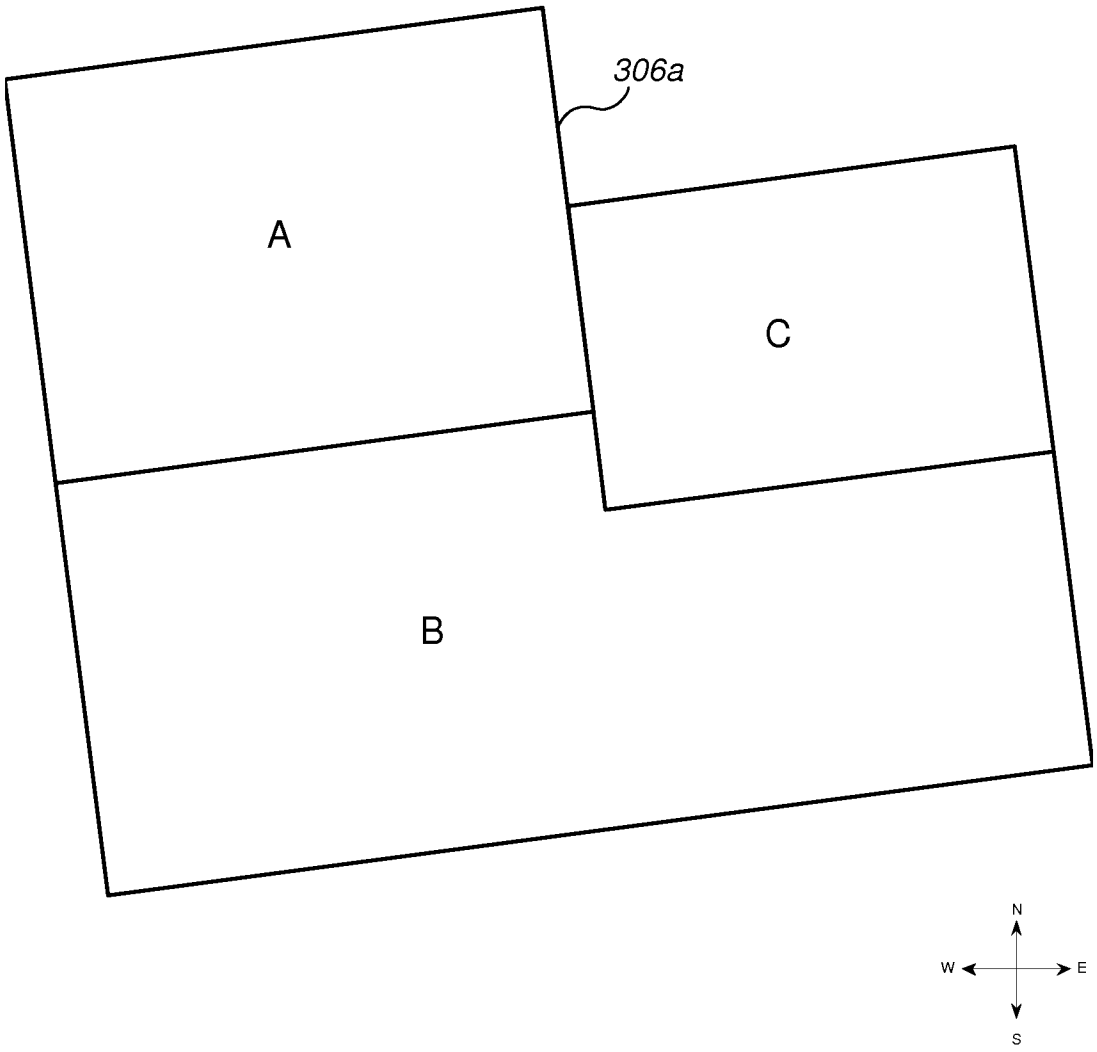
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305

Fig. 3E

1234 Main Street, Redmond, WA

Notes:



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Fig. 3F

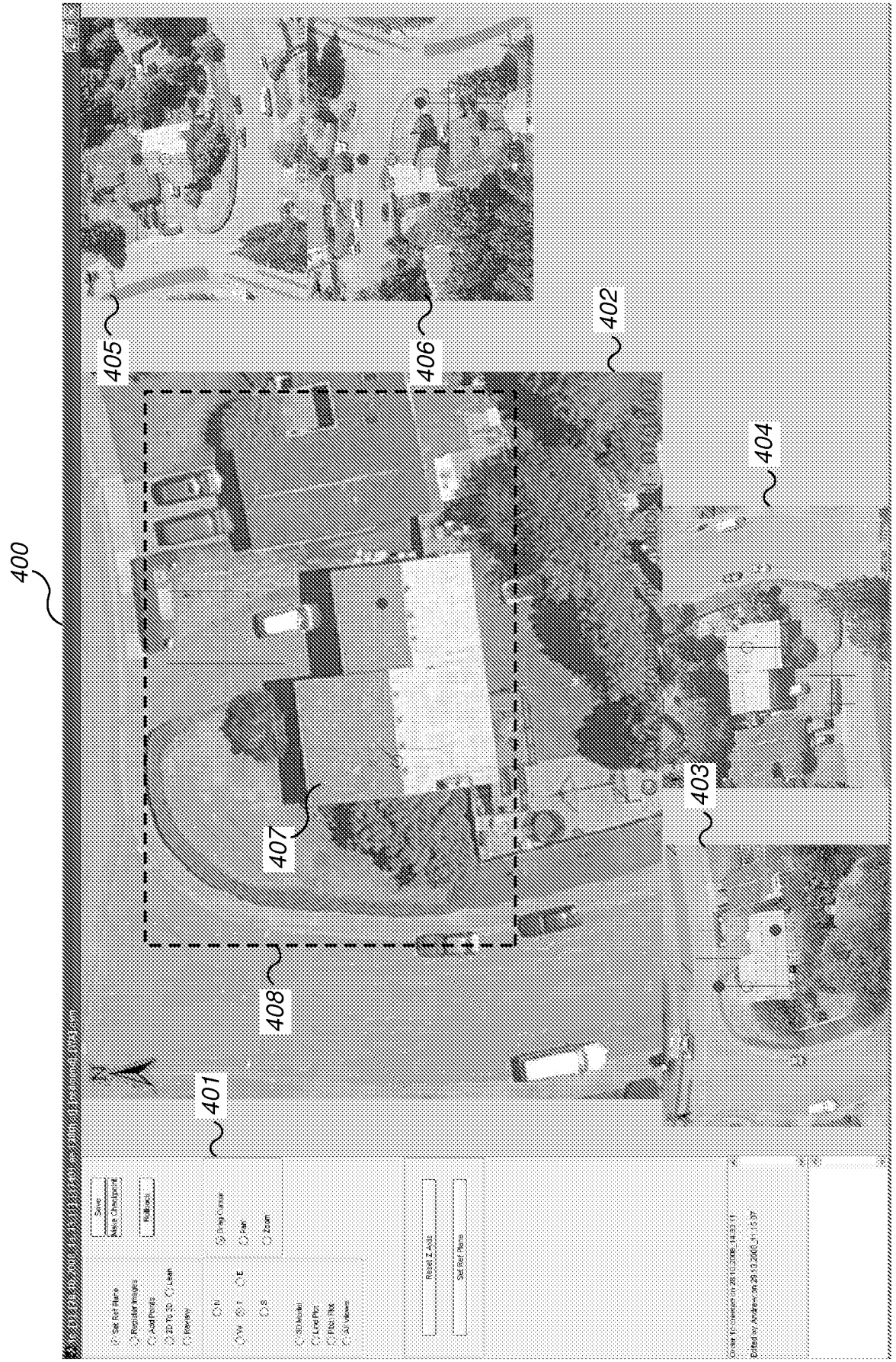


Fig. 4A

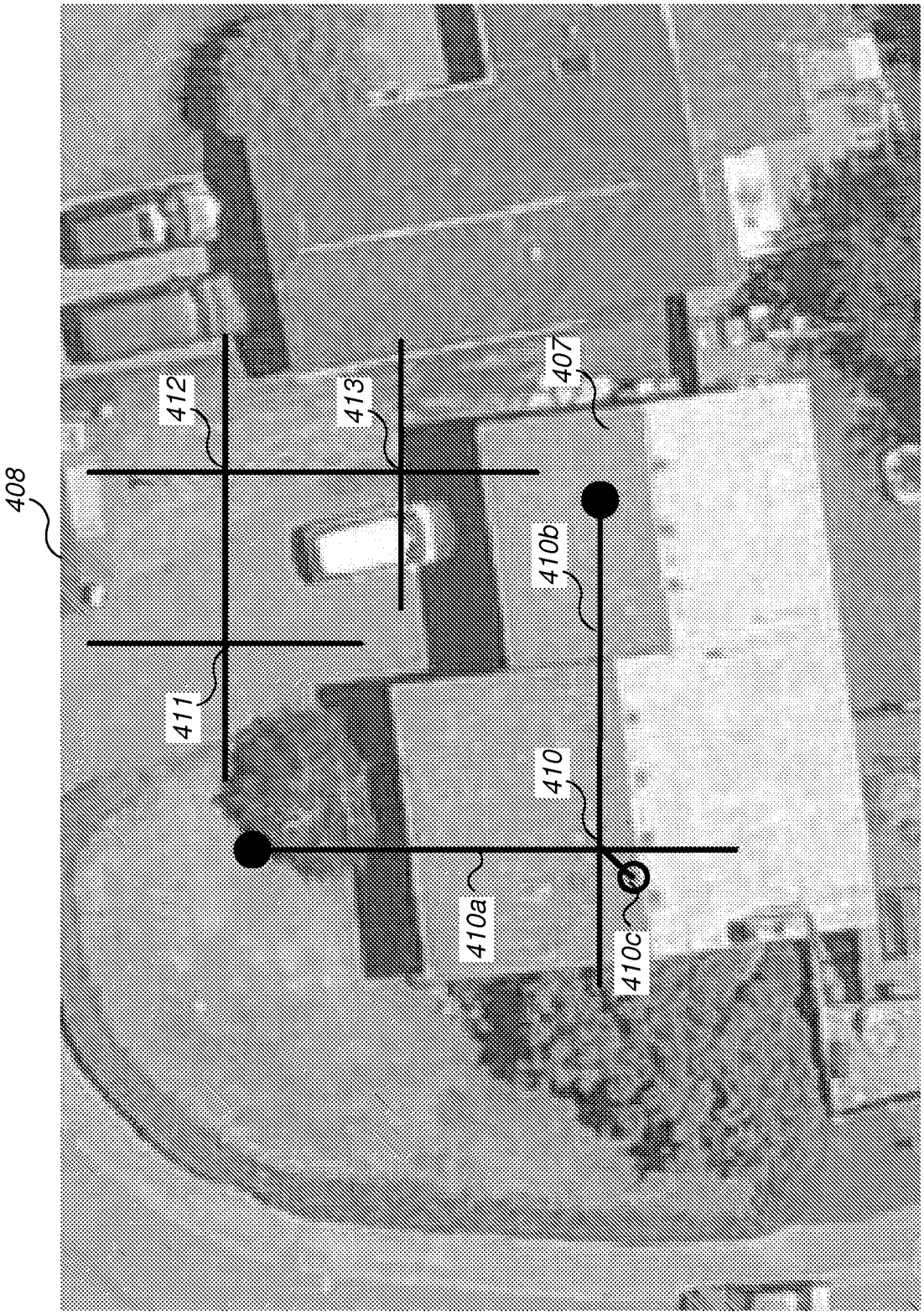


Fig. 4B

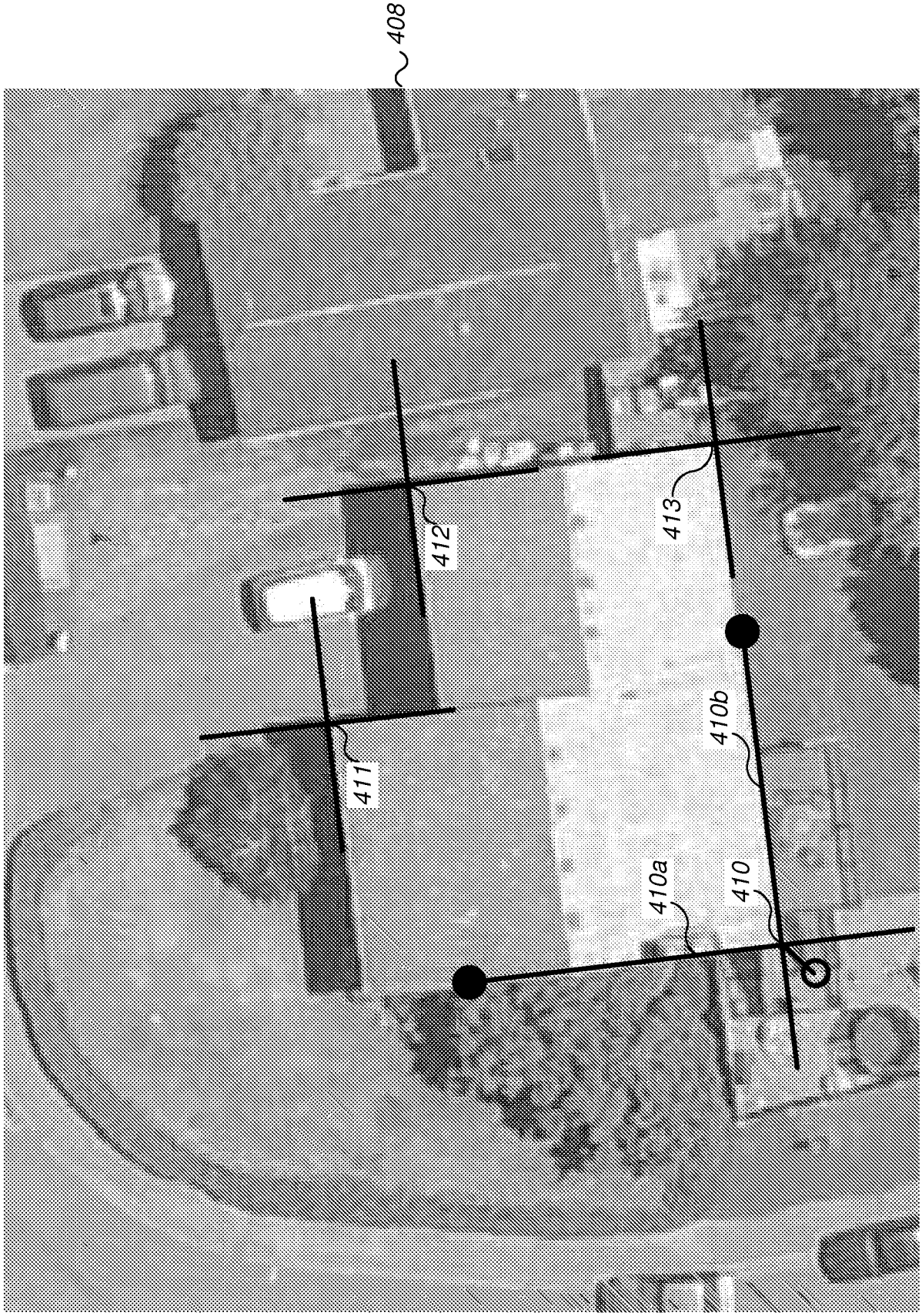


Fig. 4C

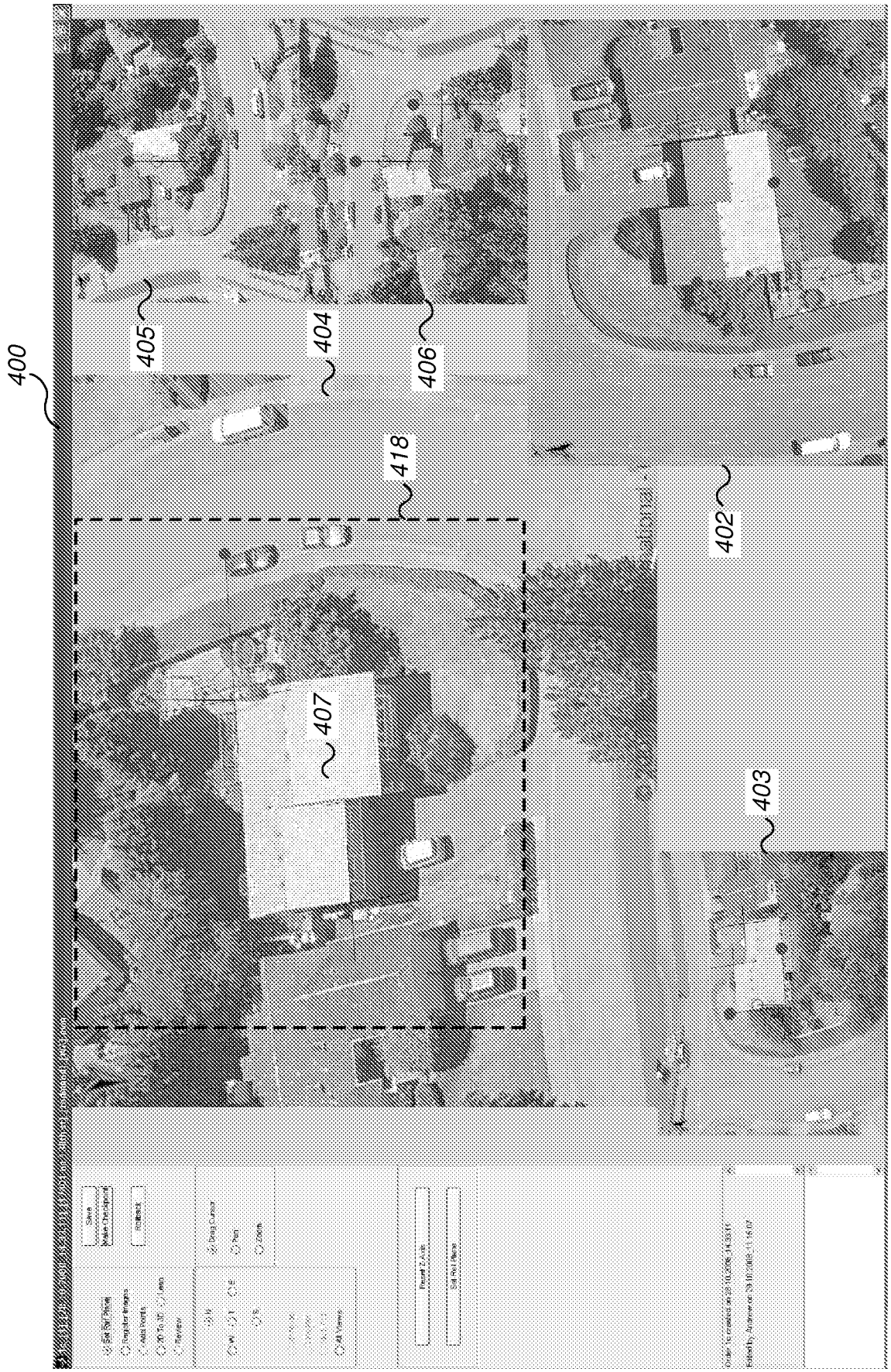


Fig. 4D

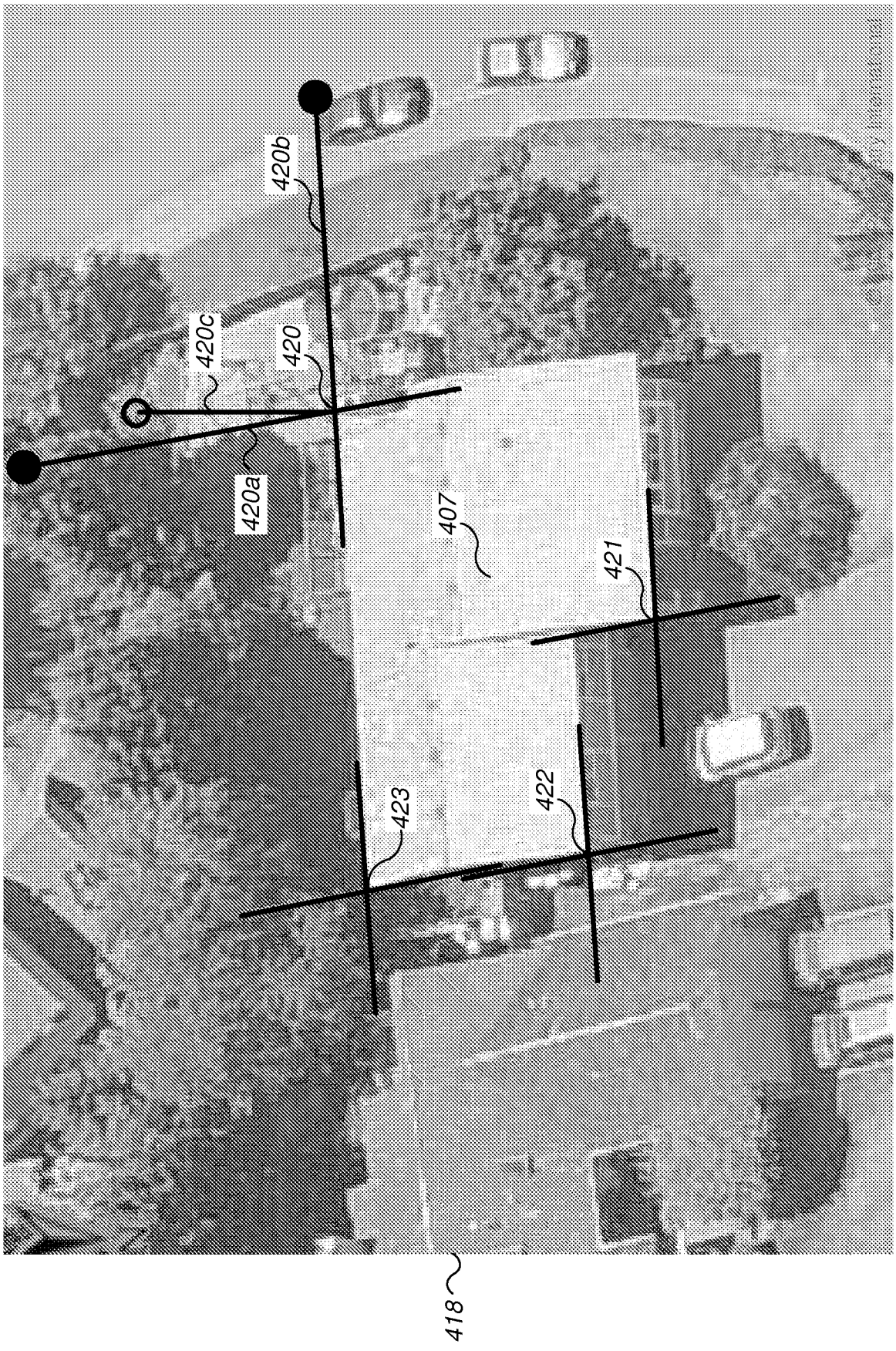


Fig. 4E



Fig. 4F

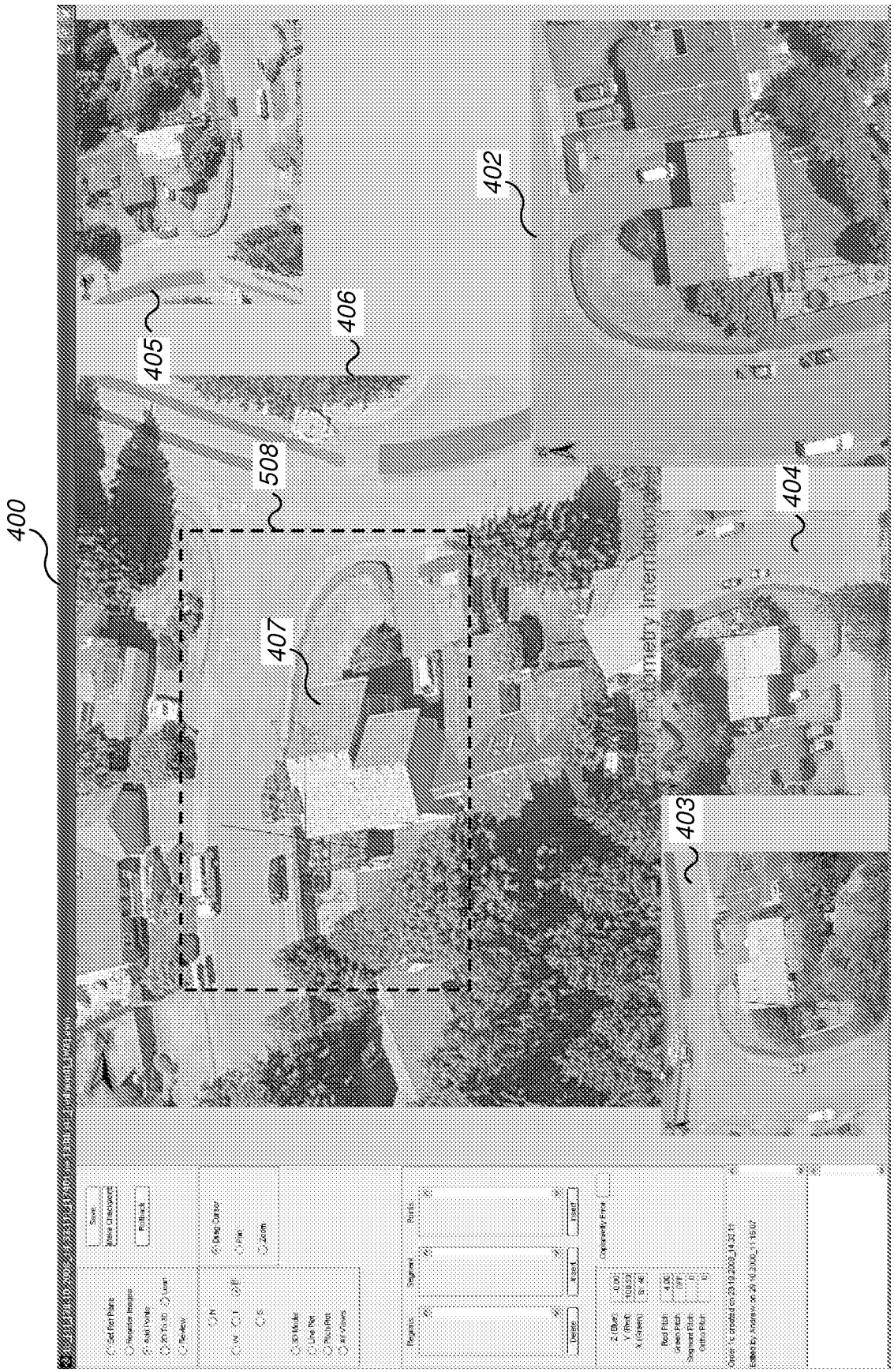


Fig. 5A

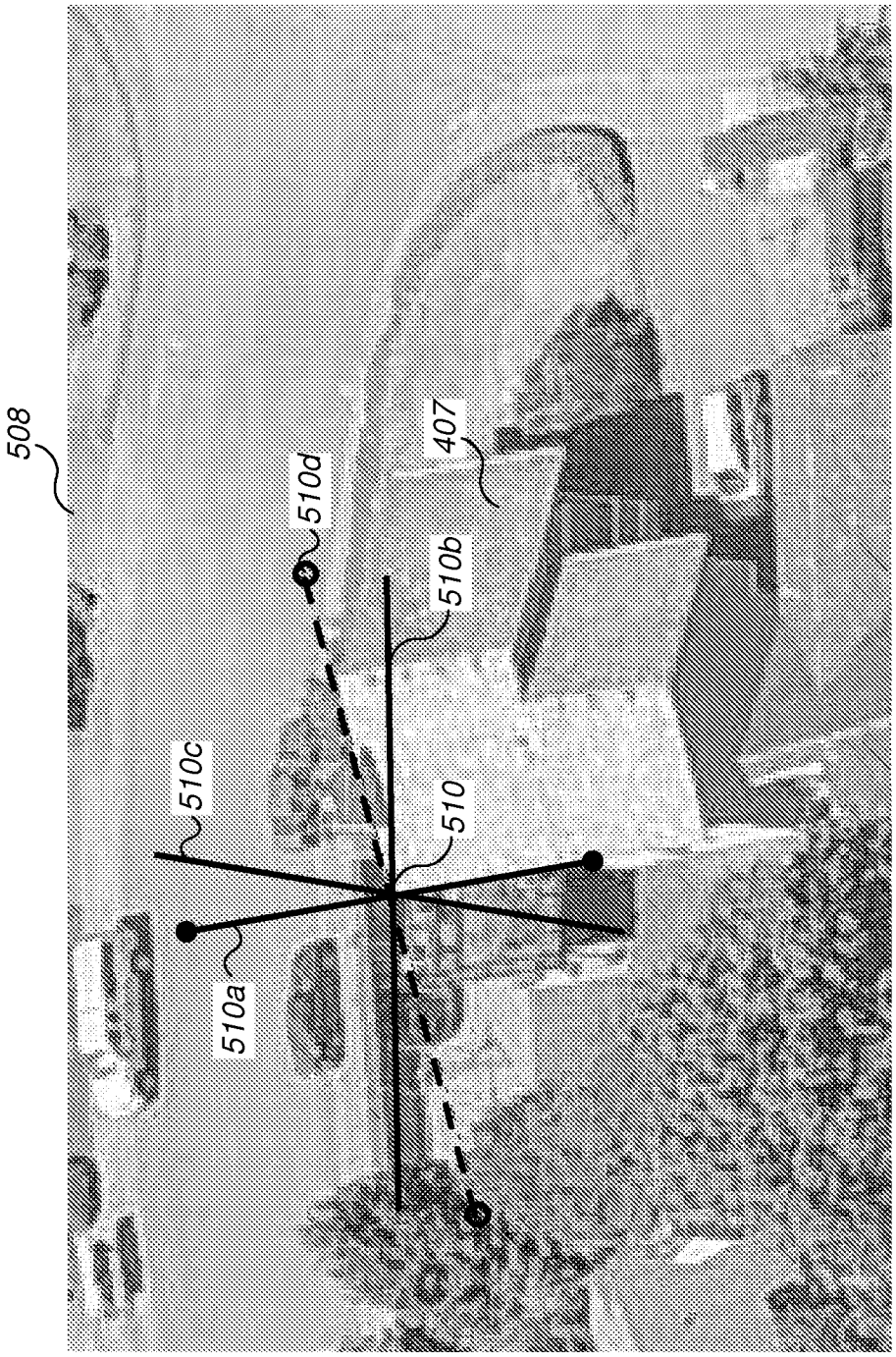


Fig. 5B

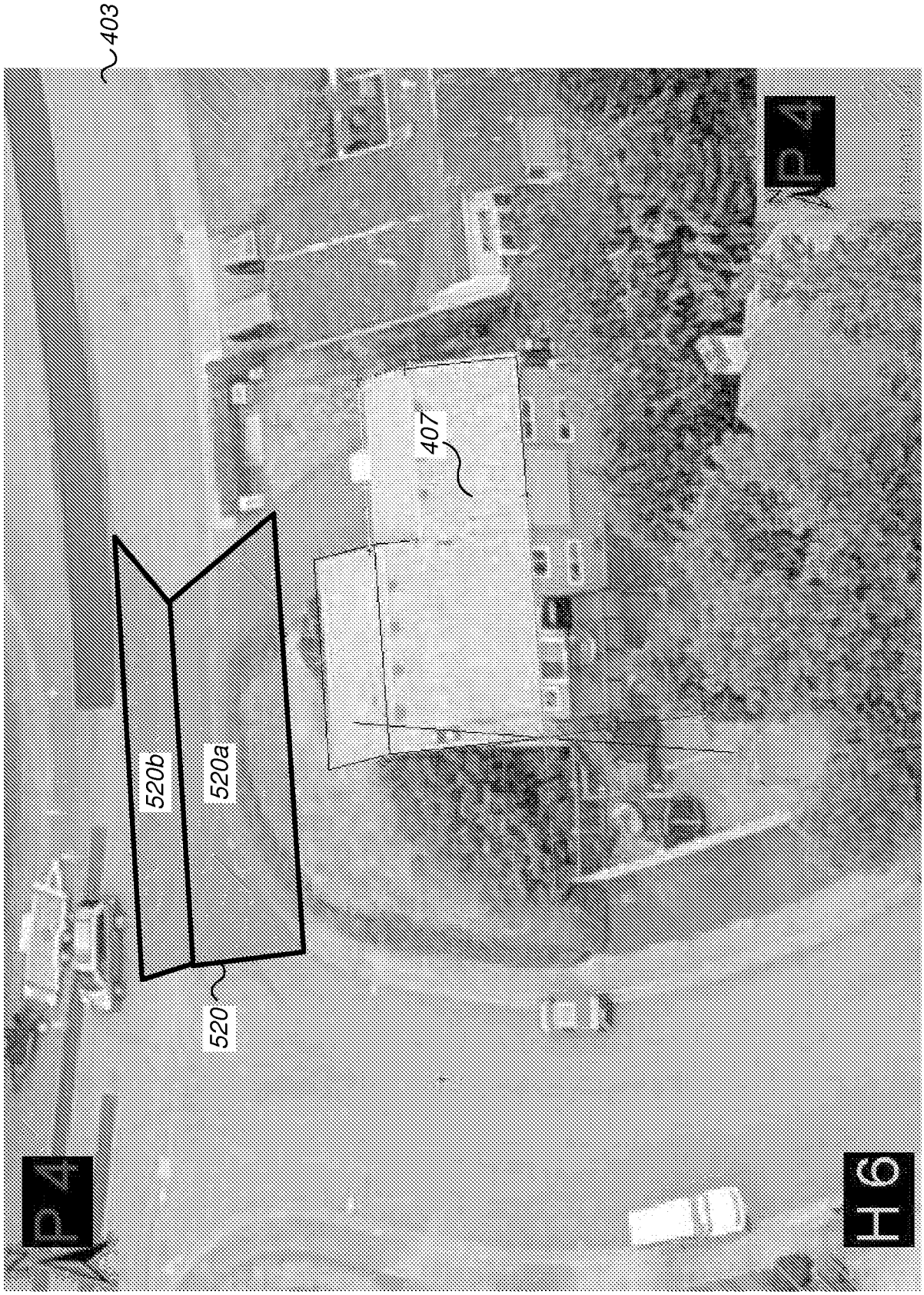


Fig. 5C

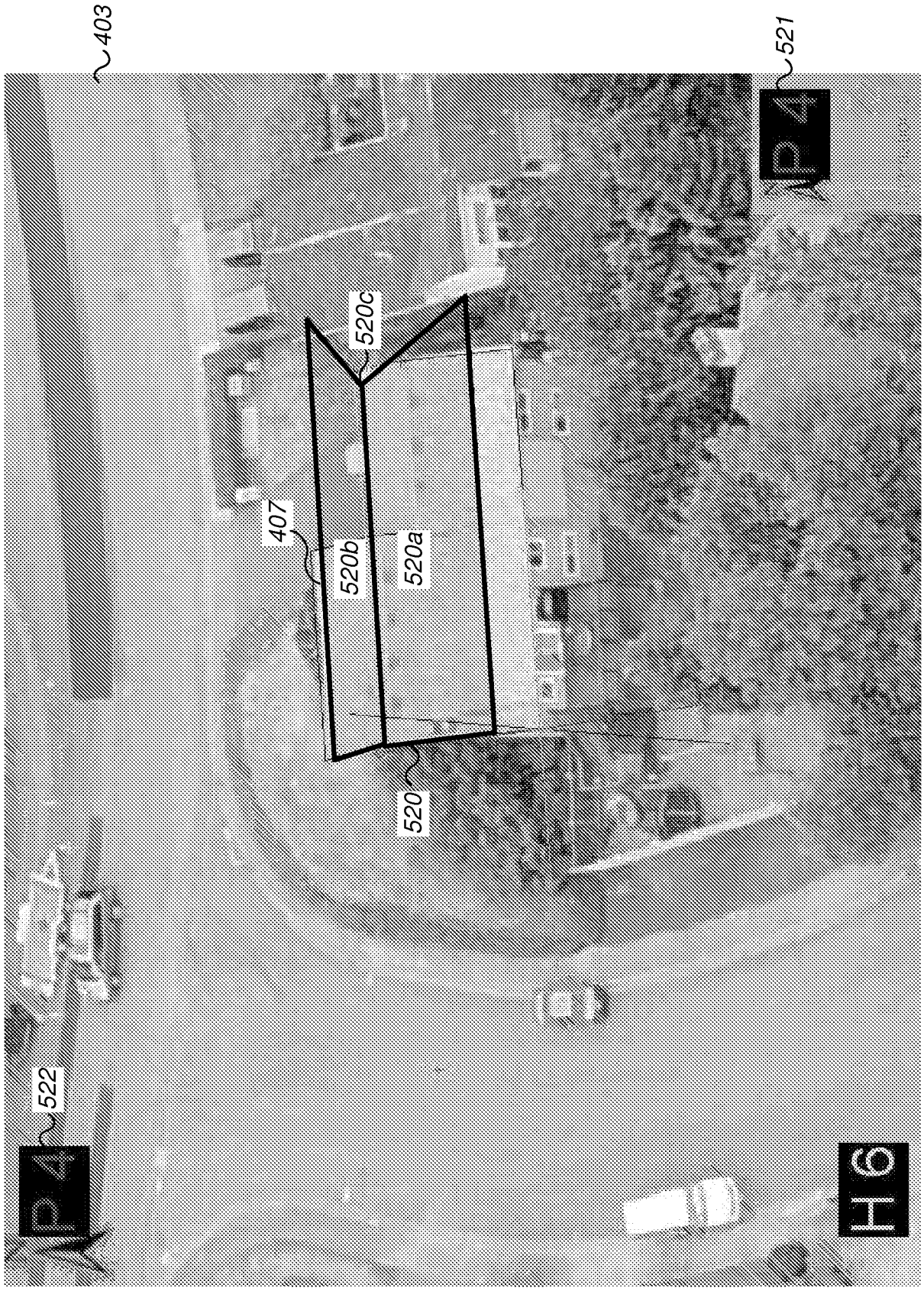


Fig. 5D

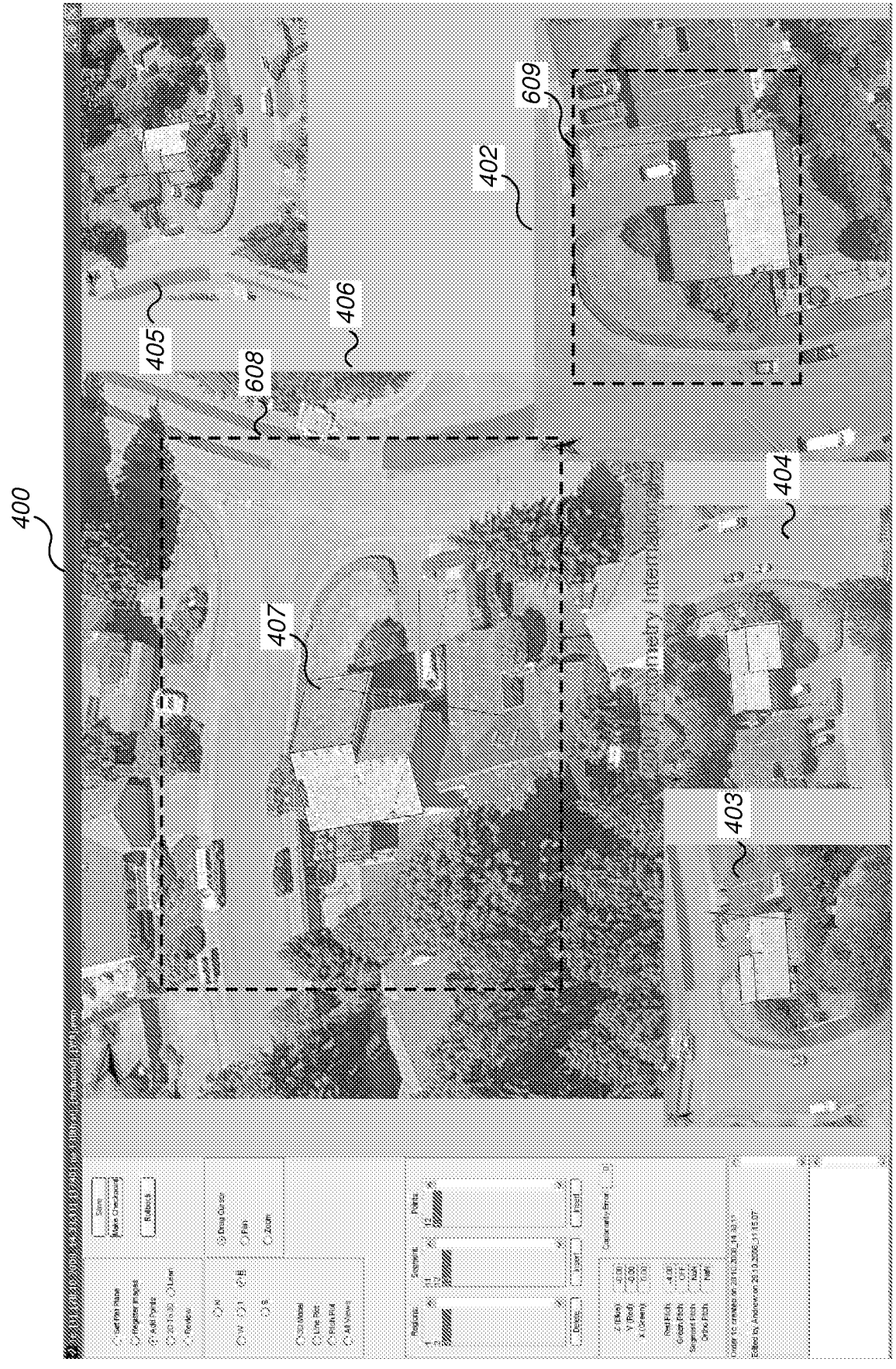


Fig. 6A

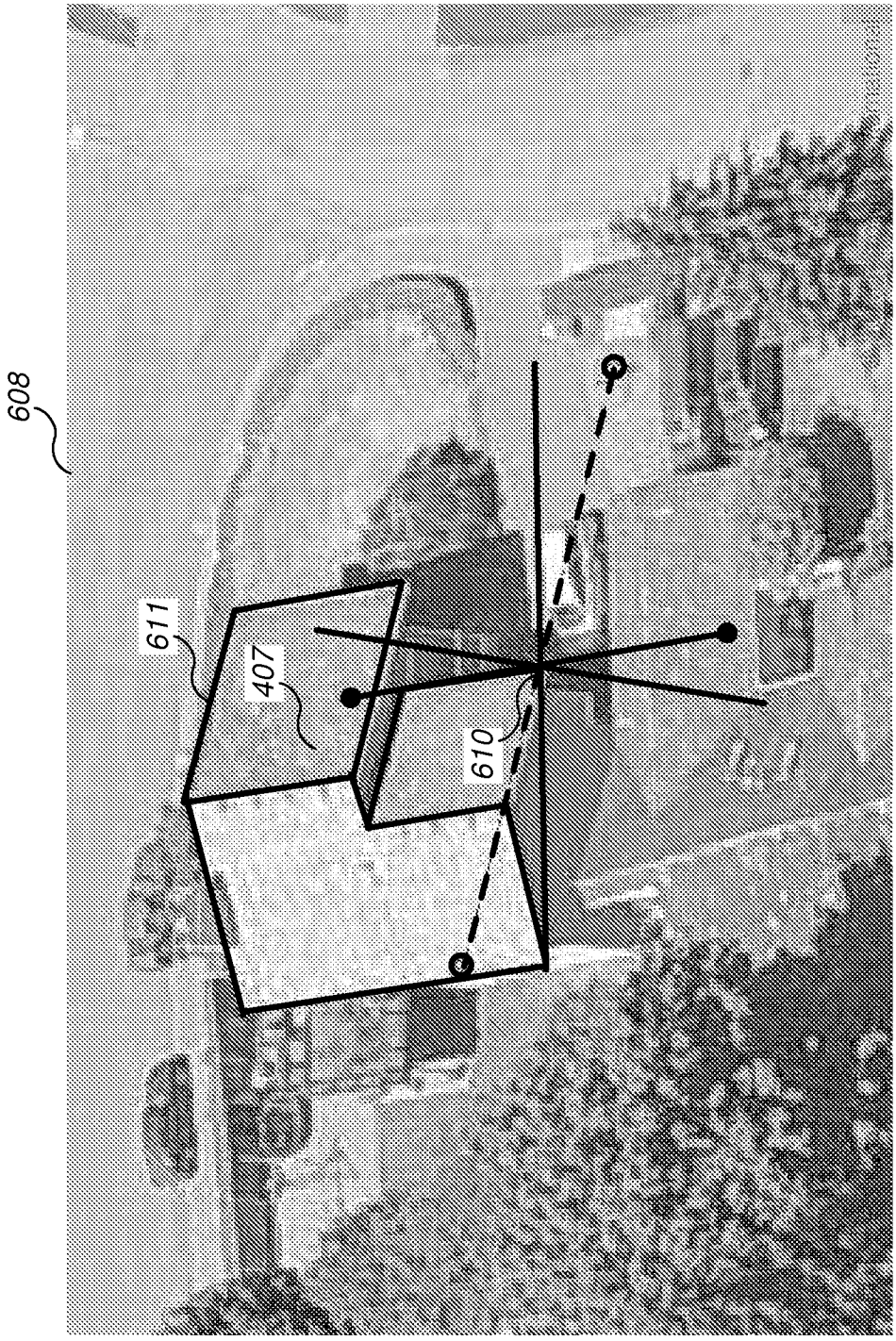


Fig. 6B

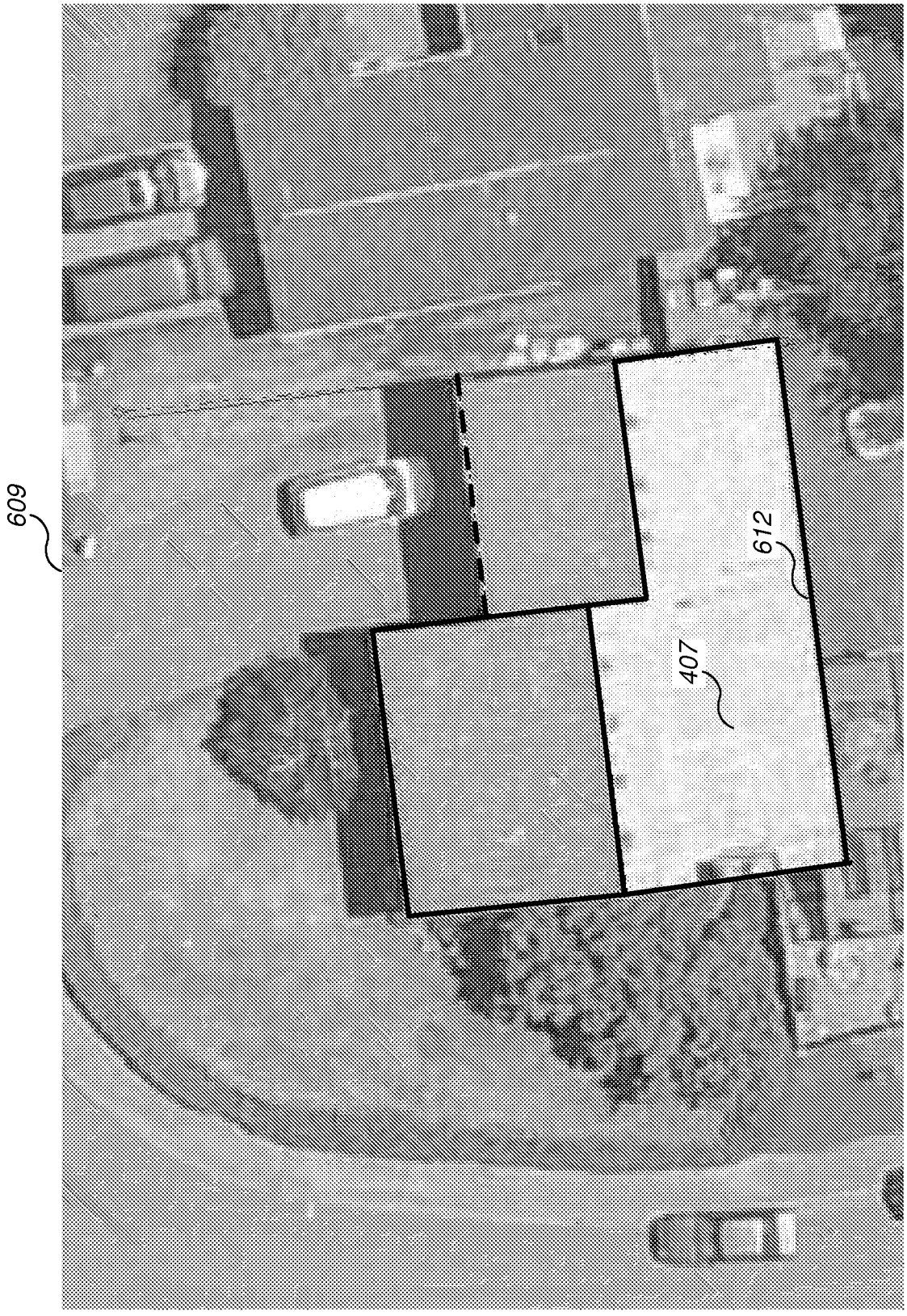


Fig. 6C

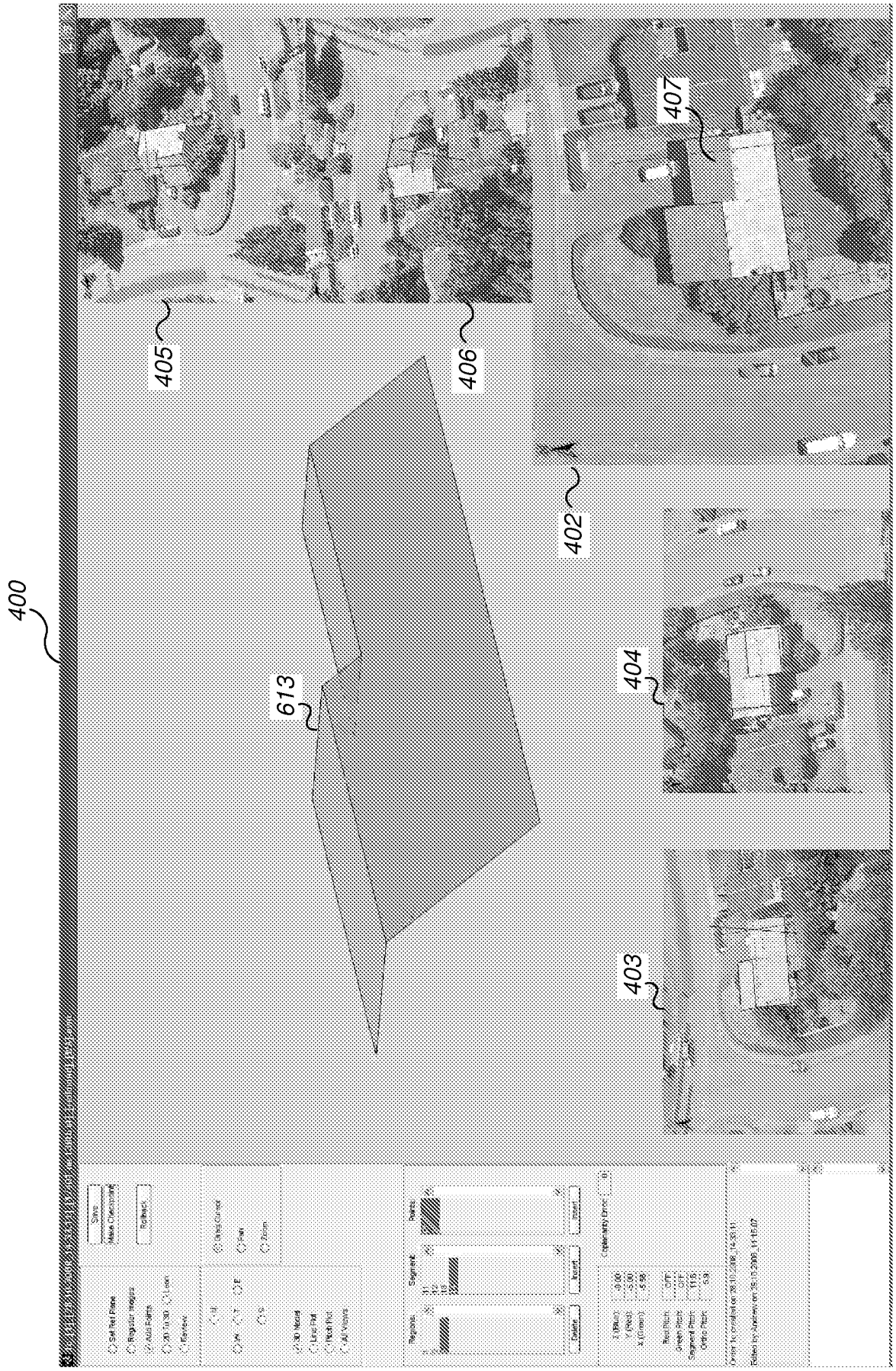


Fig. 6D

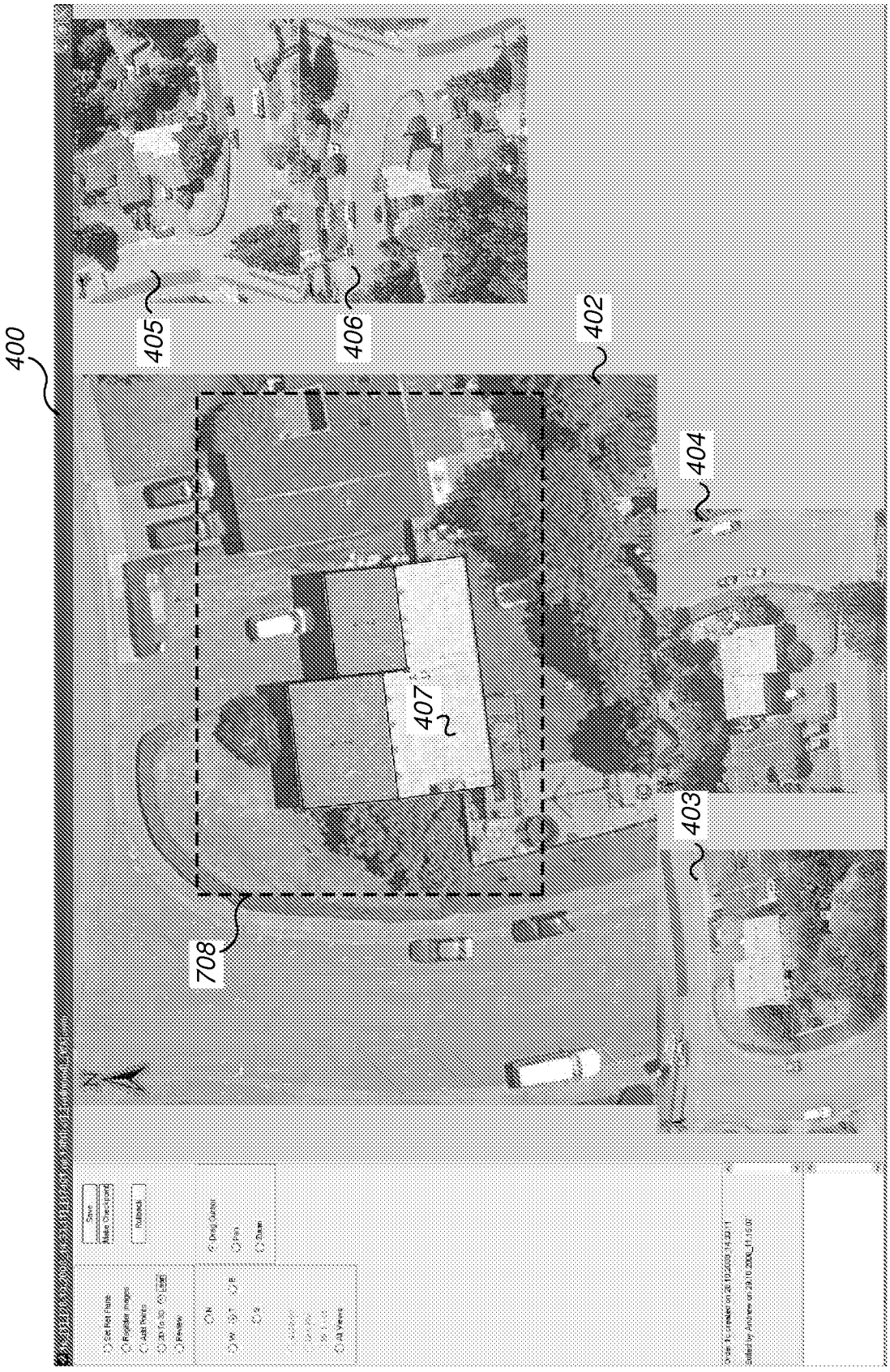


Fig. 7A

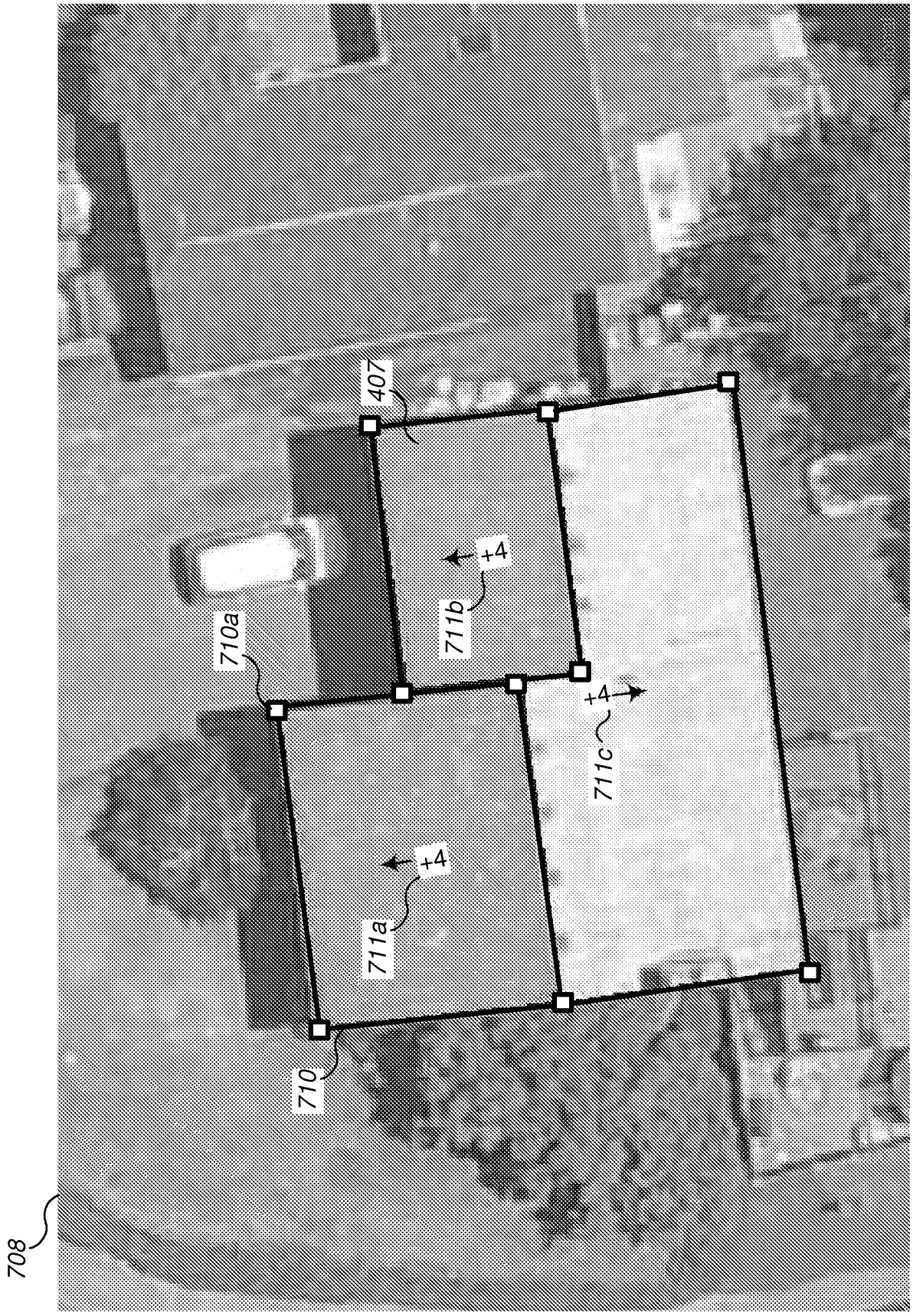


Fig. 7B

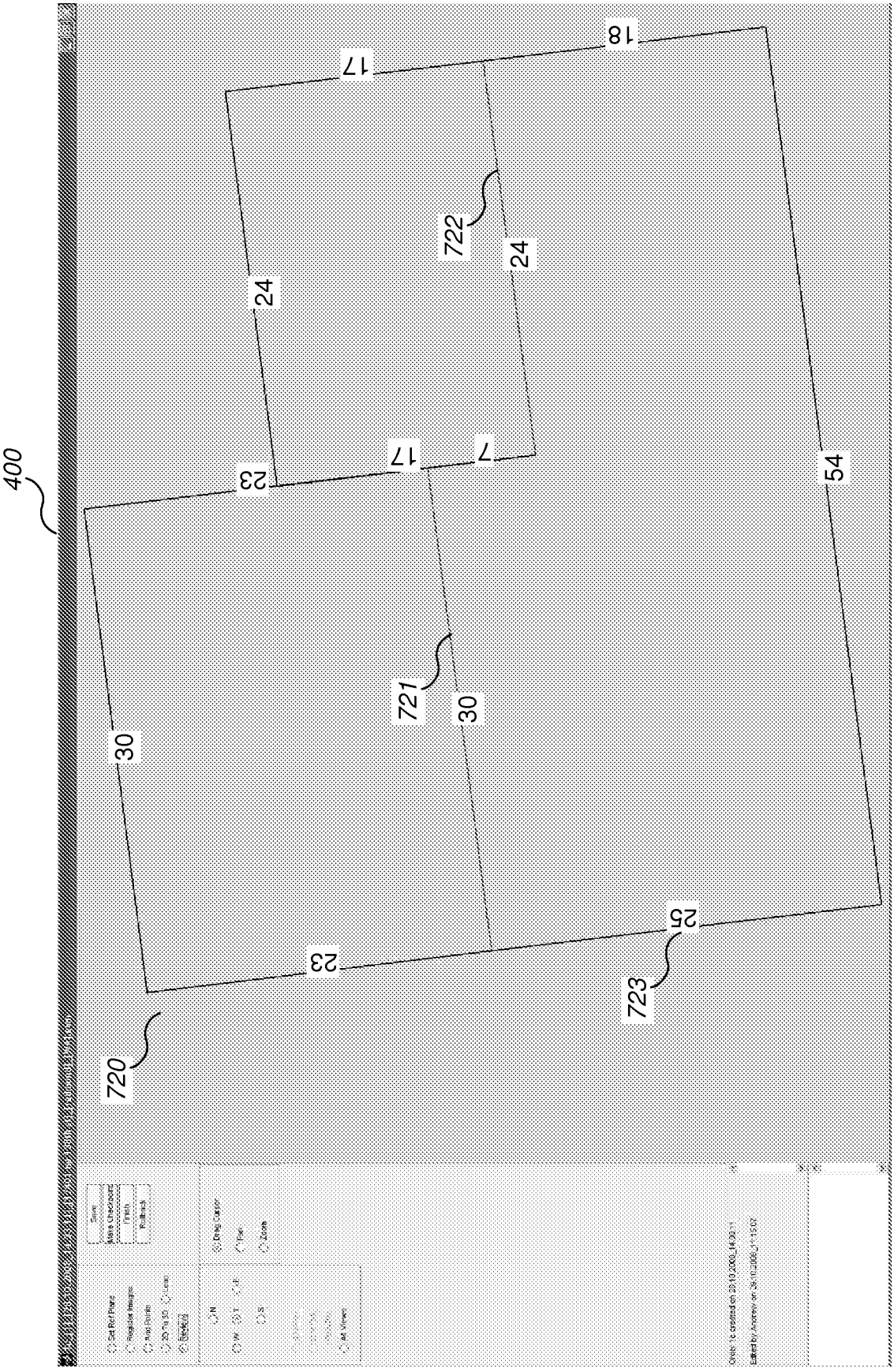


Fig. 7C

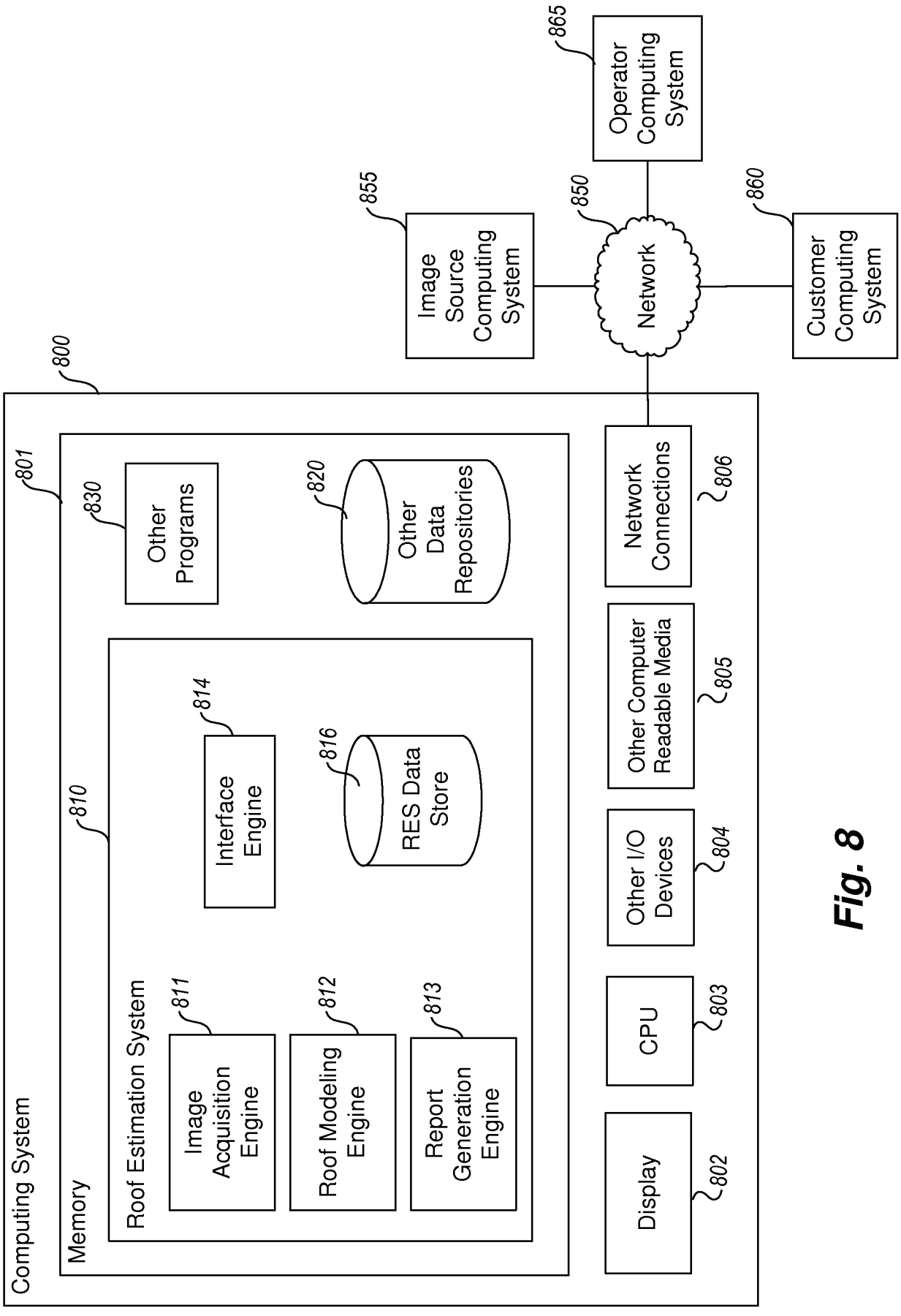

Computing System
800
Memory
801
Other Programs
830
Other Data Repositories
820
Roof Estimation System
810
Interface Engine
814
RES Data Store
816
Image Acquisition Engine
811
Roof Modeling Engine
812
Report Generation Engine
813
Display
802
CPU
803
Other I/O Devices
804
Other Computer Readable Media
805
Network Connections
806
Image Source Computing System
855
Network
850
Operator Computing System
865
Customer Computing System
860

Fig. 8

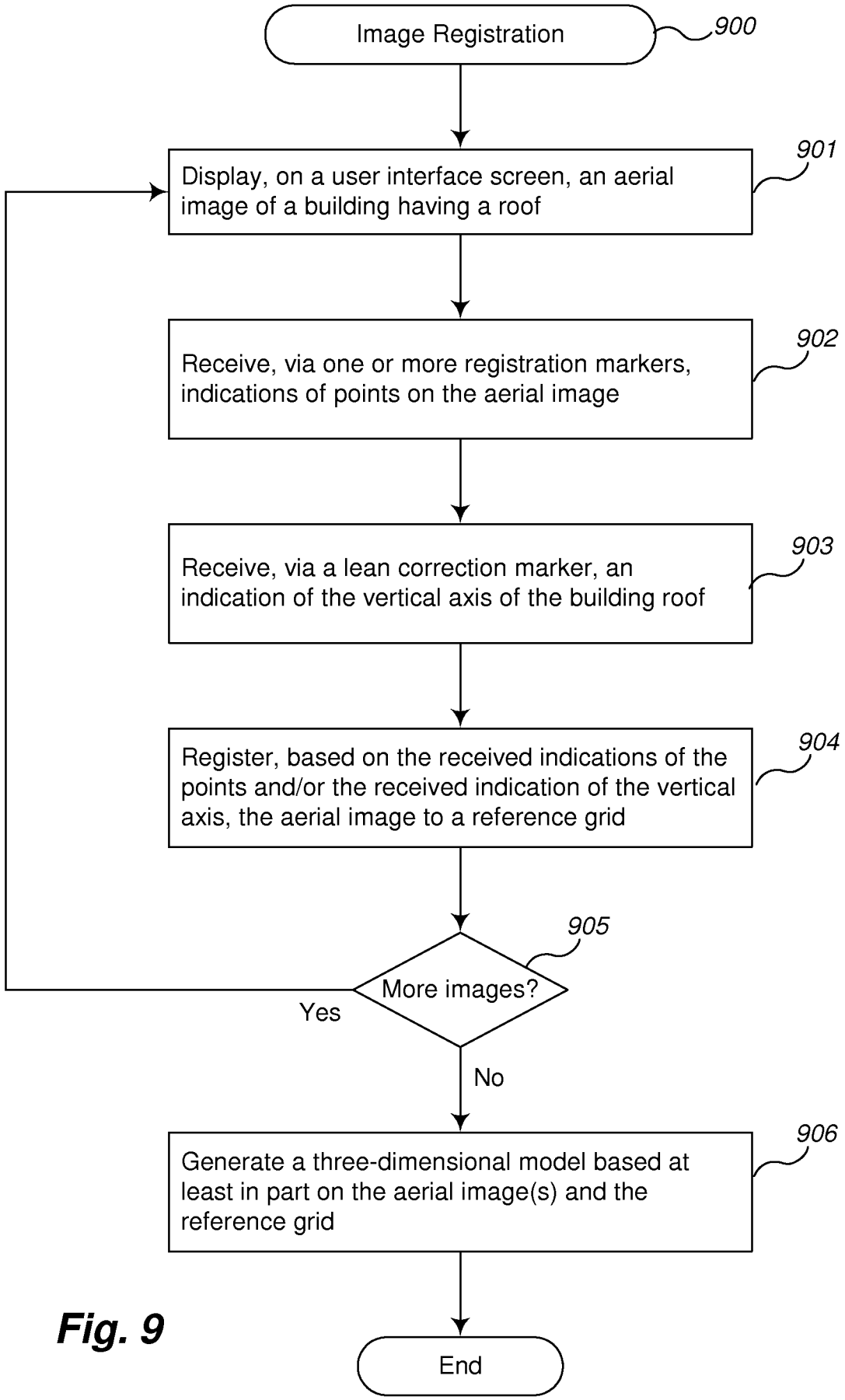

Image Registration
900
Display, on a user interface screen, an aerial image of a building having a roof
901
Receive, via one or more registration markers, indications of points on the aerial image
902
Receive, via a lean correction marker, an indication of the vertical axis of the building roof
903
Register, based on the received indications of the points and/or the received indication of the vertical axis, the aerial image to a reference grid
904
More images?
905
Yes
No
Generate a three-dimensional model based at least in part on the aerial image(s) and the reference grid
906
End

Fig. 9

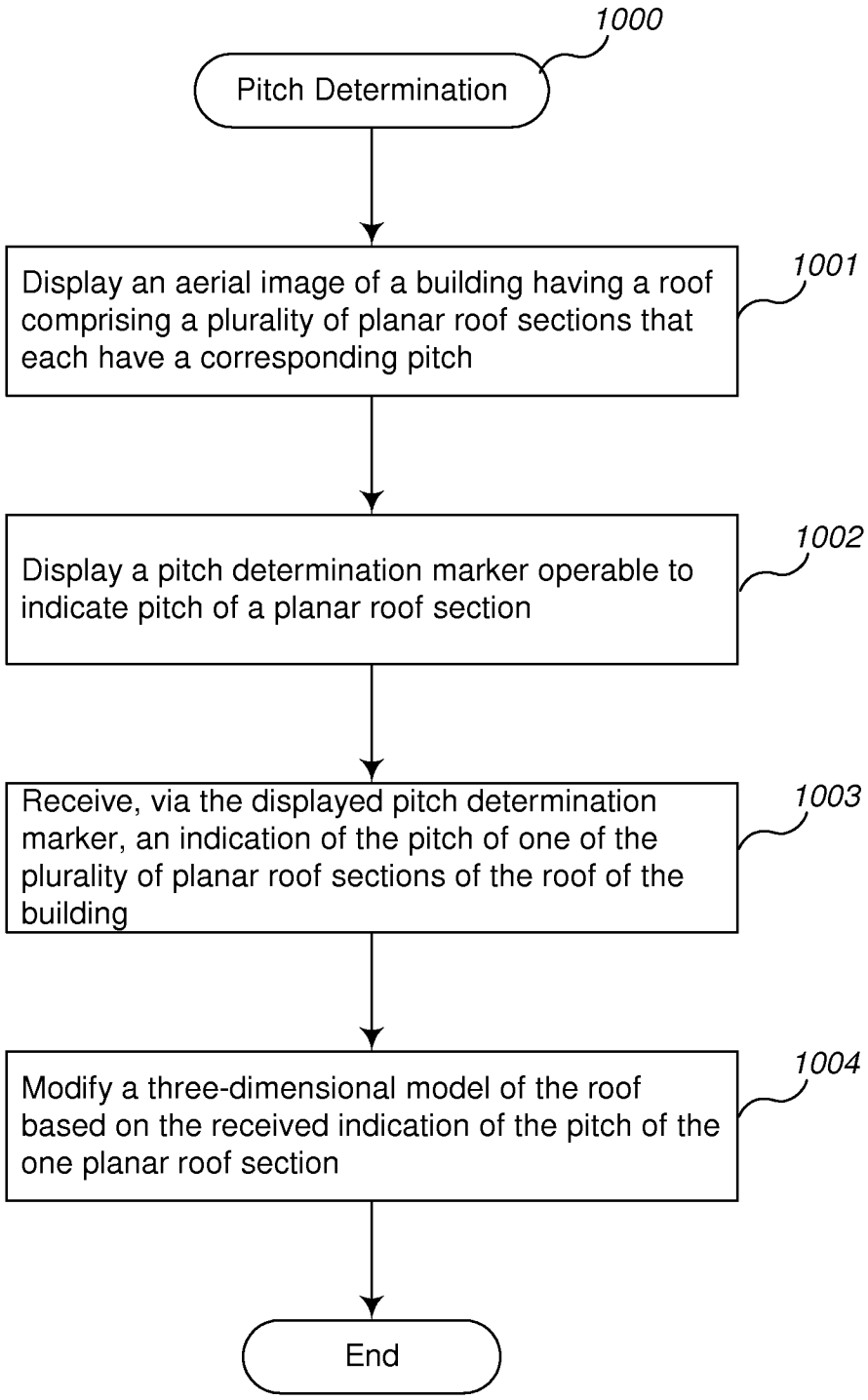

1000
Pitch Determination
Display an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch
1001
Display a pitch determination marker operable to indicate pitch of a planar roof section
1002
Receive, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building
1003
Modify a three-dimensional model of the roof based on the received indication of the pitch of the one planar roof section
1004
End

Fig. 10

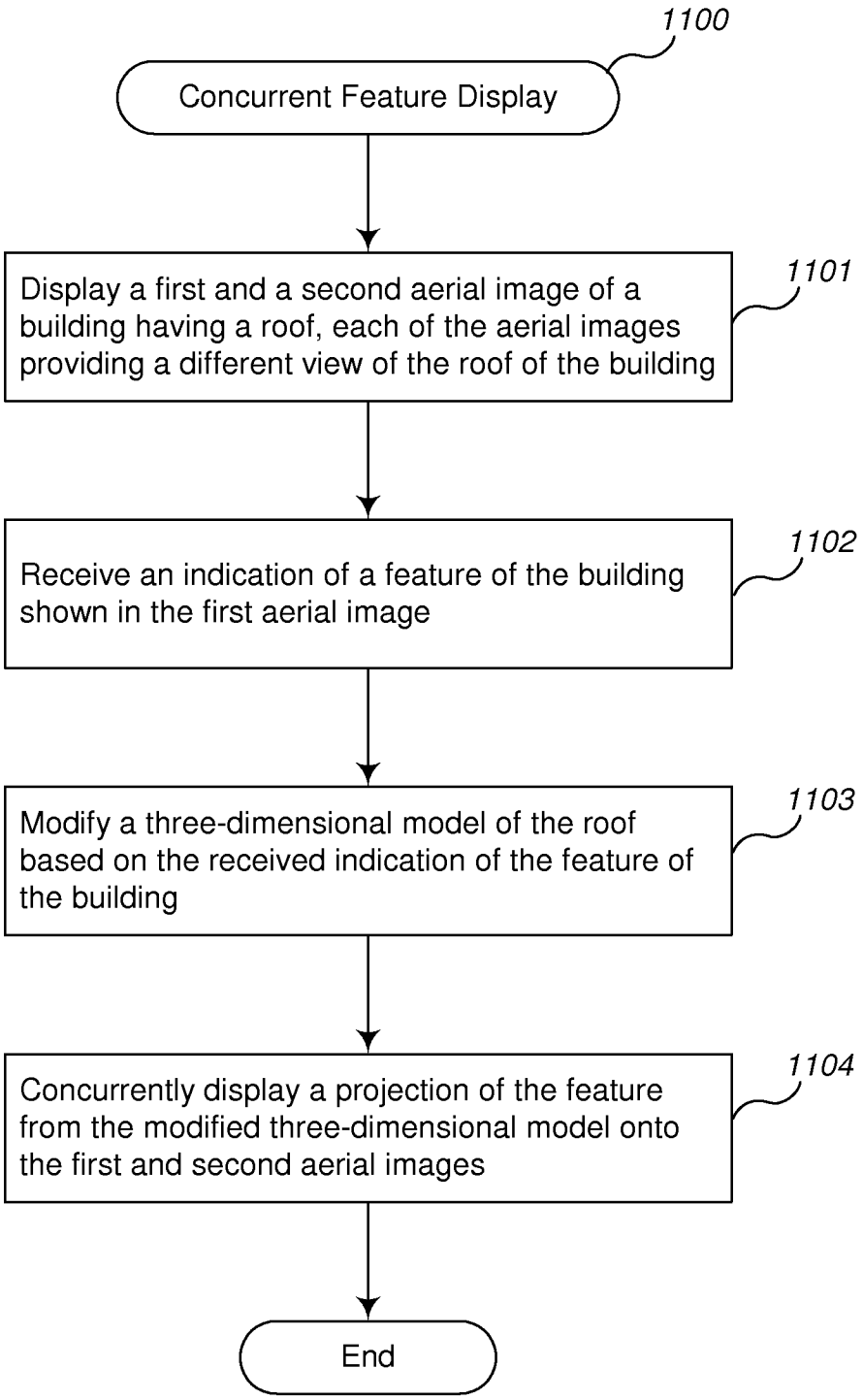

1100
Concurrent Feature Display
Display a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building
1101
Receive an indication of a feature of the building shown in the first aerial image
1102
Modify a three-dimensional model of the roof based on the received indication of the feature of the building
1103
Concurrently display a projection of the feature from the modified three-dimensional model onto the first and second aerial images
1104
End

Fig. 11

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

As the below named inventor(s), I/we declare that:

This declaration is directed to:

- [X] The attached application, or
- [ ] Application No. _____, filed on _____,
  - [ ] as amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

All statements made herein of my/our own knowledge are true, all statements made herein on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one:	Chris Pershing	Citizen of:	US
Signature:		Date:	3/15/2009
Inventor two:		Citizen of:	
Signature:		Date:	
Inventor three:		Citizen of:	
Signature:		Date:	
Inventor four:		Citizen of:	
Signature:		Date:	
Inventor five:		Citizen of:	
Signature:		Date:	

- [ ] Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
Docket No. 290115.403
1390348_1.DOC

ELECTION AND POWER OF ATTORNEY and CORRESPONDENCE ADDRESS INDICATION FORM		
	Application Number	
	Filing Date	
	First Named Inventor	Chris Pershing
	Title	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

I hereby revoke all previous powers of attorney given in the above-identified application.

I hereby appoint:

☒ Practitioners at Seed IP Law Group PLLC, Customer Number: **00500**

OR

☐ Practitioner(s) named below:

Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above (and any continuation/divisional applications therefrom), and to transact all business in the United States Patent and Trademark Office connected therewith.

Please recognize or change the correspondence address for the above-identified application to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
Address					
City		State		ZIP	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

☒ As assignee of record of the entire interest I/we hereby elect, under 37 CFR 3.71, to prosecute the application to the exclusion of the inventor(s).

SIGNATURE of Applicant or Assignee of Record

Signature		Date	3/15/2009
Name	Chris Pershing		
Title and Company (Assignee)	CTO Eagle View Technologies, Inc.		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of one form is submitted.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

1390350_1.DOC

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: **Chris Pershing**

Application No./Patent No.: _____ Filed/Issue Date: _____

Entitled: **PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION**

Eagle View Technologies, Inc. (Name of Assignee) a **corporation** (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. [X] the assignee of the entire right, title, and interest; or
2. [ ] an assignee of less than the entire right, title and interest. (The extent (by percentage) of its ownership interest is _____%)

in the patent application/patent identified above by virtue of either:

A. [X] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From:_____ To:_____

   The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

2. From:_____ To:_____

   The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

3. From:_____ To:_____

   The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet.

[X] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Signature — Date: 3/15/2009

Chris Pershing (Typed or printed name) — **CTO** (Title)

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Docket No. 290115.403

1390352_1.DOC

ASSIGNMENT

WHEREAS, I, Chris Pershing (hereinafter referred to as ASSIGNOR), having a mailing address of 17401 Northeast 138th Street, Redmond, Washington 98052, am the sole inventor of an invention entitled "PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION," as described and claimed in the specification forming part of an application for United States letters patent executed herewith. This application claims the benefit of U.S. Provisional Application No. 61/197,904, filed on October 31, 2008;

WHEREAS, Eagle View Technologies, Inc. (hereinafter referred to as ASSIGNEE), a corporation of the State of Washington having a business address at 17401 Northeast 138th Street, Redmond, Washington 98052, is desirous of acquiring the entire right, title and interest in and to the invention and in and to any letters patent that may be granted therefor in the United States and in any and all foreign countries;

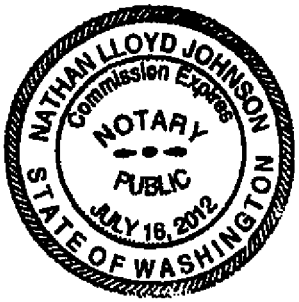
NOW, THEREFORE, in exchange for good and valuable consideration, the receipt of which is hereby acknowledged, ASSIGNOR hereby sells, assigns and transfers unto said ASSIGNEE, the entire right, title and interest in and to said invention, said application and any and all letters patent which may be granted for said invention in the United States of America and its territorial possessions and in any and all foreign countries, and in any and all divisions, reissues and continuations thereof, including the right to file foreign applications directly in the name of ASSIGNEE and to claim priority rights deriving from said United States application to which said foreign applications are entitled by virtue of international convention, treaty or otherwise, said invention, application and all letters patent on said invention to be held and enjoyed by ASSIGNEE and its successors and assigns for their use and benefit and of its successors and assigns as fully and entirely as the same would have been held and enjoyed by ASSIGNOR had this assignment, transfer and sale not been made. ASSIGNOR hereby authorizes and requests the Commissioner of Patents and Trademarks to issue all letters patent on said invention to ASSIGNEE. ASSIGNOR agrees to execute all instruments and documents required for the making and prosecution of applications for United States and foreign letters patent on said invention, for litigation regarding said letters patent, or for the purpose of protecting title to said invention or letters patent therefor.

3/15/2009
Date

Chris Pershing

State of Washington)
) ss.
County of King)

I certify that I know or have satisfactory evidence that Chris Pershing is the person who appeared before me, and said person acknowledged that he signed this instrument and acknowledged it to be his free and voluntary act for the uses and purposes mentioned in the instrument.



Dated May 15, 2009

Signature of Notary Public Nathan Lloyd Johnson

Printed Name Nathan Lloyd Johnson

My appointment expires July 16, 2012

1390353_1.DOC
(290115.403)

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
Docket No.	:	290115.403
Date	:	May 15, 2009

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicant hereby authorizes the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/David V. Carlson/
David V. Carlson
Registration No. 31,153

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1390423_1.DOC

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Chris Pershing
Filed	:	May 15, 2009
For	:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Docket No.	:	290115.403
Date	:	May 15, 2009

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicant wishes to make known to the U.S. Patent and Trademark Office the references set forth on the attached Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicant does not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserves the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method. Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicant's duty to disclose all information he is aware of which is believed relevant to the examination of the above-identified application, applicant believes that his invention is patentable.

Please acknowledge receipt of this Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

Roofr Exhibit 1002, Page 512

Applicant believes this Information Disclosure Statement has been timely filed, however, the Director is authorized to charge any fee due by way of this Information Disclosure Statement to our Deposit Account No. 19-1090.

Respectfully submitted,

Seed Intellectual Property Law Group PLLC

/David V. Carlson/

David V. Carlson
Registration No. 31,153

DVC:jrh

Enclosures:
Information Disclosure Statement
Cited References (9)

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1390425_1.DOC

SCORE Placeholder Sheet for IFW Content

Application Number: 12467244 Document Date: 5/15/2009

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

- Drawings – Other than Black and White Line Drawings

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Form Revision Date: February 8, 2006

PTO/SB/06 (12-04)

Filing Date: 05/15/09

Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/467,244

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	82		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	270		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	110		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	28 minus 20 =	8	x$26	208	OR	x$52	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x$110			x$220	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $270 ($135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			195			390	
			TOTAL	670		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDI-TIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDI-TIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDI-TIONAL FEE ($)	OR	RATE ($)	ADDI-TIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.