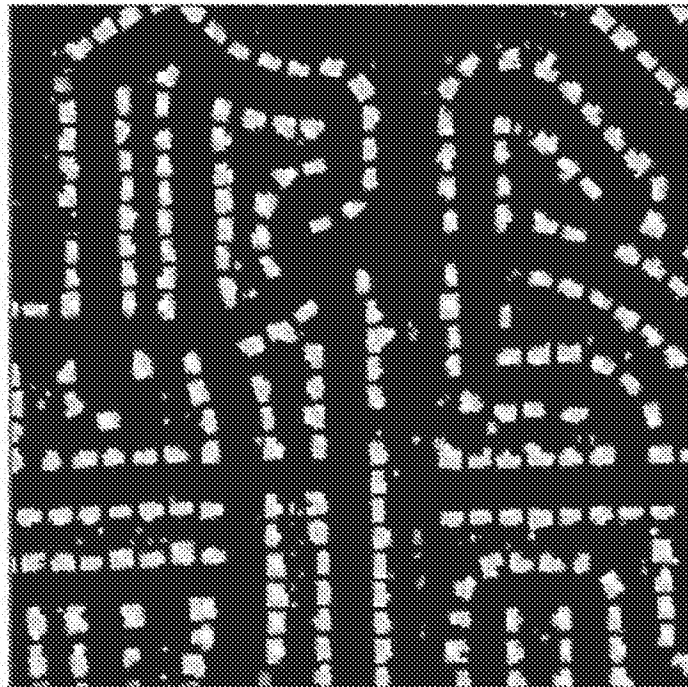
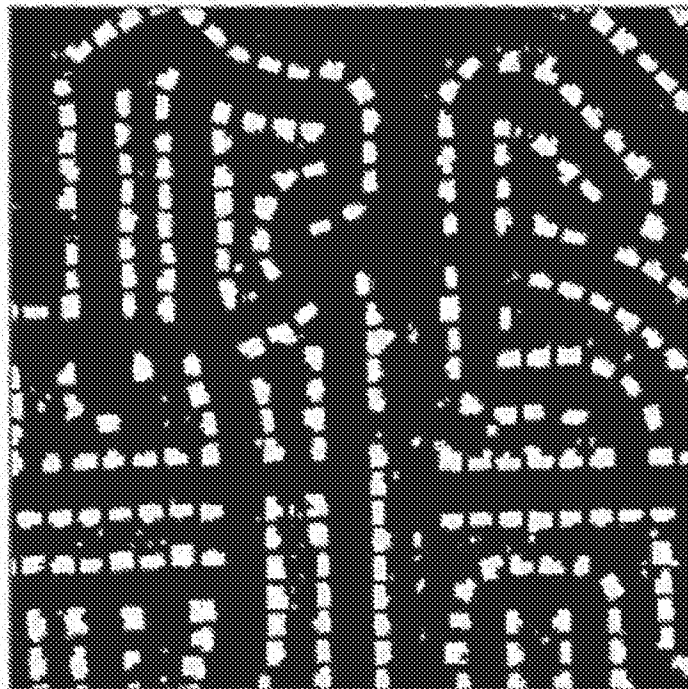


50/50



3904

FIG. 39



3902

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/49739

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 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 No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I: Claims 1-7; Group II: Claims 8-12; Group III: Claims 13-19; Group IV: Claims 20-24; Group V: Claims 25-35

Continued within extra 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 additional fees, this Authority did not invite payment of additional fees.
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.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/49739

A. CLASSIFICATION OF SUBJECT MATTER

IPC(B) - G06K 9/62, 9/66; G06T 1/40; G06N 3/02; H01Q 5/22 (2016.01)

CPC - G06K 9/62, 9/66; G06T 1/20; G06N 3/02; H01Q 5/22

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)

IPC(B) Classifications: G06K 9/62, 9/66; G06T 1/40; G06N 3/02; H01Q 5/22 (2016.01)

CPC Classifications: G06K 9/0063, 9/62, 9/66; G06T 1/20; G06N 3/02; H01Q 5/22

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)

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INFADOC Data);

IP.com; IEEE; Google/Google Scholar; Keywords: Convolution, neural, network, serial, classify, image

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 8,655,070 B1 (YANG, L et al.) 18 February 2014; column 3 lines 20-28, column 7 lines 29-35.	1-4, 6, 7 5, 12, 14, 21, 26-27, 33
X — Y	US 6,044,171 A (POLYAKOV) 28 March 2000; figure 3; column 8, lines 58-64; column 14, lines 42-49.	8-9, 11 10, 12
X — Y	CN 101549596 B (XEROX CORP) 29 August 2012; (see machine translation).	13 14-19
X — Y	US 2014/0015924 A1 (PRYOR, A.) 16 January 2014; figures 1, 16; paragraphs [0057], [0058], [0103], [0111], [0114]; claim 1.	25, 28-29, 31-32, 34 26-27, 30, 33, 35
Y	US 2014/0180989 A1 (GOOGLE INC.) 26 June 2014; paragraphs [0002], [0012], [0027].	6
Y	US 2015/0131852 A1 (SWEETSER, J. et al.) 14 May 2015; figure 1a; paragraph [0037].	10, 15-17, 19-24
Y	US 2012/0141014 A1 (LEPIKHIN, M. et al.) 07 June 2012; paragraph [0005].	18-19
Y	US 2013/0121571 A1 (GOKTURK, S. et al.) 16 May 2013; figure 7; paragraphs [0062], [0121].	20-24
Y	US 6,349,616 B1 (HASHIMOTO, R.) 19 June 2001; column 7, lines 32-45.	30, 35

☐ Further documents are listed in the continuation of Box C.☐ See patent family 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 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

"-2"

document member of the same patent family

Date of the actual completion of the international search

14 December 2016 (14.12.2016)

Date of mailing of the international search report

13 JAN 2017

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
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Authorized officer

Shane Thomas

PCT Helpdesk: 571-272-4300
PCT O&P: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/49739

-Continued from Box III: Observations where unity of invention is lacking-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-7 are directed towards a method of identifying a class of a pixel in a target image.

Group II: Claims 8-12 are directed towards a method of generating a label image based on a parameter set.

Group III: Claims 13-19 are directed towards a method of determining heights of one or more regions in a target image.

Group IV: Claims 20-24 are directed towards a method of determining a geometric object property in a target image.

Group V: Claims 25-36 are directed towards methods of aligning images.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include at least identifying the class of each pixel based on the training images and the labels; dividing, at the object detector, the target image into a plurality of divisions, wherein each division includes a plurality of pixels; selecting, at the object detector, a target pixel from the plurality of pixels; and determining, at the object detector using the classifier, a target class for the target pixel of the target image by comparing the target pixel to neighboring pixels from the plurality of pixels, which are not present in Groups II-V.

The special technical features of Group II include at least a transformed representation of one or more labels; determining a parameter set for an image based on the training images and the training parameter sets; a target transformed representation of the one or more target labels; and applying an inverse target parameter set to the target image, wherein the inverse target parameter set corresponds to an inverse transformation of a transformation represented by the target parameter set, which are not present in Groups I and III-V.

The special technical features of Group III include at least wherein each of the training images includes one or more regions, wherein each region includes one or more pixels; indicating a height for each pixel of the one or more regions of each training image; determining a height of a region based on the training images; and determining, at the extractor using the regression model, a height of the target region in the target image, which are not present in Groups I-II and IV-V.

The special technical features of Group IV include at least identifying a corresponding geometric object; one or more parameters related to orientation of illumination source that associates formation of the training images for the training images; and determining a geometric object property for an image based on the training images, the geometric object, the training geometric object properties, and the first one or more parameters, which are not present in Groups I-III and V.

The special technical features of Group V include at least receiving, at an aligning device, N first type of image sets, wherein $N > 1$, wherein each of the N first type of image sets includes one or more first type of images; receiving, at the aligning device, N second type of image sets, wherein each of the N second type of image sets includes different one or more second type of images, wherein each of the N second type of image sets is aligned with a different one of the N first type of image sets; creating, at the aligning device, a regressor configured to identify parameters of a transformation that maps a second type of image set to a first type of image set, wherein the regressor is created based on the N first type of image sets, the M transform parameters, and the $N * M$ total transformed second type of image sets; receiving, at the aligning device, a target first type of image set and a target second type of image set; and generating, at the aligning device, a transformed target second type of image set by transforming the target second type of image set using the target transform parameter so that the transformed target second type of image set is aligned with the target first type of image set, which are not present in Groups I-IV.

The common technical features shared by Groups I-V are identifying a class of a pixel in a target image; receiving, at an object detector, training images; receiving labels; creating, at the object detector, a classifier; receiving, at the object detector, a target image; and creating, at an extractor, a regression model.

However, these common features are previously disclosed by US 2009/0148072 A1 to BRAND et al. (hereinafter "Brand"). Brand discloses identifying a class of a pixel in a target image (a low-level pixel classifier estimates evidence for a number of classes of image transforms specialized for pixel classes; paragraph [0014]); receiving, at an object detector, training images (obtaining training images at low-level pixel classifier; paragraph [0014]; claim 6); receiving labels (the classes have associated labels; paragraph [0014]); creating, at the object detector, a classifier (low-level pixel classifier produces evidence vectors; paragraph [0044]); receiving, at the object detector, a target image (yield a re-synthesized target image; paragraph [0014]); and creating, at an extractor, a regression model (li target tiles belonging to any specific label are regressed affinely onto the corresponding source tiles; paragraph [0049]).

Since the common technical features are previously disclosed by the Brand reference, these common features are not special and so Groups I-V lack unity.

(10) International Publication Number
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8 September 2017 (08.09.2017)(51) International Patent Classification:
G06K 9/62 (2006.01) G06T 3/00 (2006.01)(21) International Application Number:
PCT/US2017/020032(22) International Filing Date:
28 February 2017 (28.02.2017)

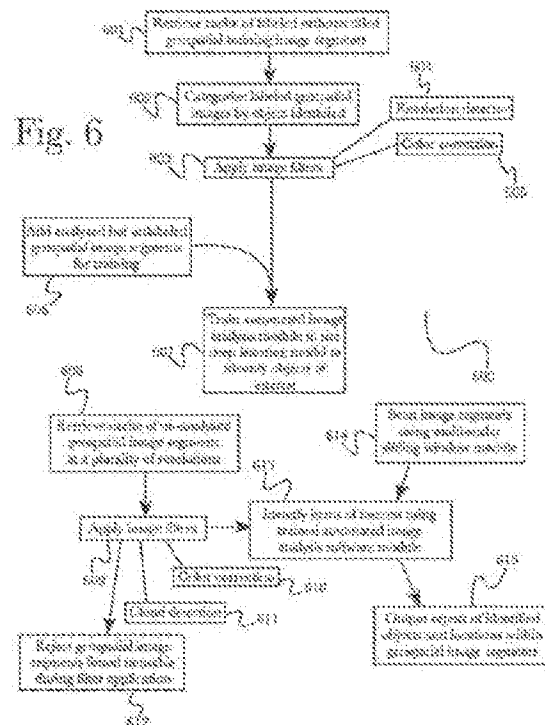
(25) Filing Language: English

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62/301,554 29 February 2016 (29.02.2016) US
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AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
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DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
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[Continued on next page]

(54) Title: SYNTHESIZING TRAINING DATA FOR BROAD-AREA GEOSPATIAL OBJECT DETECTION



(57) Abstract: A system for broad area geospatial object recognition, identification, classification, location and quantification, comprising an image manipulation module to create synthetically-generated images to imitate and augment an existing quantity of orthorectified geospatial images; together with a deep learning module and a convolutional neural network serving as an image analysis module, to analyze a large corpus of orthorectified geospatial images, identify and demarcate a searched object of interest from within the corpus, locate and quantify the identified or classified objects from the corpus of geospatial imagery available to the system. The system reports results in a requestor's preferred format.



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, BI, CF, CG, CI, CM, GA,
GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

SYNTHESIZING TRAINING DATA FOR BROAD AREA GEOSPATIAL OBJECT DETECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[001] The present application is a PCT of, and claims priority to, United States patent application
5 serial number 15/194,541, titled "SYNTHESIZING TRAINING DATA FOR BROAD AREA
GEOSPATIAL OBJECT DETECTION", and filed on June 27, 2016, and also claims the benefit
of and priority to United States provisional patent application serial number 62/301,554, titled
"SYNTHESIZING TRAINING DATA FOR BROAD AREA GEOSPATIAL OBJECT
10 DETECTION", filed on February 29, 2016, the entire specifications of each of which are
incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Art

[002] The present invention is in the field of image analysis, and more particularly in the field of
the use of deep learning model computer vision systems for automated object identification from
15 geospatial imagery.

Discussion of the State of the Art

[003] Image analysis has been an important field of technology at least since the period of World
War 2, when extensive use of image analysis, photogrammetry, and related technologies were used
in conjunction with aerial photography for intelligence and bombing damage assessment purposes
20 (among others). However, the extent of the use of image analysis (particularly image analysis of
remotely-sensed images), particularly for identifying or locating targets of interest, has always been
limited by the need for highly-trained, specialized image analysts or interpreters. The need for
specialized (and expensive) skills has limited the use of image analysis to a correspondingly limited
range of applications (notably military, homeland defense, and law enforcement).

25 [004] The market for image analysis has also historically been limited by the high cost of
obtaining images to analyze. In the military arena, the benefits were sufficiently apparent that large
numbers of military reconnaissance flights have been made over regions of interest since World
War 2. But the cost of such flights virtually excluded all commercial applications of image analysis.
Starting in the 1970s with the Landsat satellite, this began to change as low resolution satellite
30 images became publicly available. A series of new satellites has opened up progressively more

applications as the resolution, spectral coverage, geographic coverage, and cost per image have all continuously improved; accordingly, a significant market in commercial remote sensing imagery has emerged. But even this market has been limited from achieving its full potential because of the still-present requirement for expensive, scarce image analysis talent.

5 [005] One common type of geospatial image analysis task is the "search and locate" task. In this task, one or more targets of interest need to be identified and precisely located. A well known example of "search and locate" is the discovery and pinpointing of warships, tanks, or other military targets of interest. Recently, focused geospatial image analysis of geographically specific data has been used for search and rescue efforts of downed planes or lost shipping. However, these
10 efforts have required the work of image analysts, limiting what could be done. Development of a method to identify targets of interest rapidly, using less resources would allow the pursuit of less urgent but promising applications which include assessing the scope of a refugee crisis by for example counting tents in an area of interest, analyzing the change in infrastructure in developing nations, assessing numbers of endangered species, finding military hardware in areas previously not
15 expected to contain such equipment, identifying previously unknown airstrips or camps where crime or terrorism may be in operation. The ability to extend "search and locate" like tasks to large geological areas and efficiently perform them repetitively over time would allow the use of geospatial imagery to map remote regions, to track deforestation and re-forestation and to detect natural disasters in remote areas of the world.

20 [006] The notion of computer vision, specifically the reliable identification by a computer of particular objects has been an active pursuit within the field of computer science since the late 1960s. Unfortunately, until recently, this pursuit has met with little success except when both the object of interest and the background against which it is presented have been tightly controlled. Barriers to advancement in computer object identification have been both technological and
25 logical. The technological barriers have been present because, like its biological counterpart, computer visual processing requires computational power and amounts of memory storage that have been prohibitive up until the last 15 years. Advancement in the ability to pack more transistors into the same volume while also reducing cost and the development of such specialized components as the graphics processing unit, which is optimized to perform calculations
30 encountered during manipulation of visual data has brought current hardware to the point where rapid, even real time, object identification is possible. There has also been a significant maturation process in how computer scientists in the field program computers to analyze objects of interest. Some of these early methods have been to break each object of interest into a unique grouping of

simple geometric shapes or to take advantage of unique shading patterns of each object to identify new instances of the desired object. All of these early attempts gave results that were extremely sensitive to such variables as lighting, exact object placement in the field of sample, and exact object orientation, sometimes to the degree that the object of interest was not identifiable in the original image without great care. Currently, after great advancement in computer capabilities, advances in our understanding of biological vision, and advances in computer vision theory, a method of training computers to reliably identify specific objects of interest has emerged. This method combines a convolutional neural network with deep learning to train the system to recognize an existing object of interest both when presented against many backgrounds and when the object is in different orientations. The convolutional neural network which consists of several layers of filters with partial, local field interconnections between layers interspersed with data complexity reduction pooling layers affords computer learning of object recognition with a minimum of pre-supposition on the part of the programmer as the convolutional neural network determines the best filters to use to identify the target object. Deep learning consists of a period of "supervised learning" which uses a moderate sized set of training images where each image contains an example of the object to identify, for example, the human face, which is clearly demarcated or "labeled" followed by a period of "unsupervised learning" on a very large number of unlabeled images, a portion of which do not have the object to identify present. The number of training images is proportional to the overall system's accuracy, specifically the precision and recall of the classification results. Accordingly, the number of training images is inversely proportional to the amount of time the convolutional neural network - deep learning model spends training and further, searching and accurately finding objects of interest. This convolutional neural network - deep learning model method has given rise to computer systems that have been reliably used in human facial recognition, optical character recognition, and identification of complex sets of parts during manufacturing. Indeed, the convolutional neural network- deep learning model method has been found so widely useful for object identification that there are multiple programming libraries now publicly available for download and use for that purpose. These include, for example, the Caffe library (BerkeleyVision and Learning Center), the Torch7 library (Nagadomi) and the cuda-cornet2 library (Alex Krizhevsky). While the convolutional neural network- deep learning model method has been widely and very successfully applied to ground based photography and video, it has not found application in the field of geospatial image analysis.

[007] What is needed in the art is an automated system that generates synthetic training images to augment the number of real training images needed for an automated system to both identify and determine the precise location of a number of objects of interest from geospatial imagery.

SUMMARY OF THE INVENTION

5 [008] The inventor has developed a computing system for analysis of satellite images to geolocate one or more targets of interest, or to identify objects or their types.

[009] According to a preferred embodiment of the invention, a system for broad area geospatial object detection using synthetically generated training images comprising an image manipulation software module, a deep learning model training software module and, a convolutional neural
10 network serving as an image analysis software module. Following a search prompt for an object of interest, the image manipulation software module: retrieves a 3-dimensional modeled replica of the object of interest from an established data store; creates a flattened, nadir directional 2-dimensional image from the 3-dimensional model; compares the flattened image to a real geospatial image and its associated background of the same object of interest; scales the flattened modeled image to align
15 with the real geospatial image of the same object and upon successful alignment, separates the modeled image from the background of the real image in order to fine tune components of the flattened modeled image, which may include smoothing edges and/or color matching to assimilate the real image; applies a plurality of environmental effects to replicate seasonal, timestamps, associated brightness, and environmental factors consistent with a geographic location of the real
20 background image to create a plurality of modified synthetic images; creates a plurality of shadowed, modified 2-dimensional synthetic images for the 3-dimensional object as if it were physically located and oriented where it would be affected by real-time and real-world shadowing; compares and adjusts the shadowed, modified synthetic 2-dimensional images by pixelating and blurring or focusing to resemble the real image; identifies and demarcates a footprint associated
25 with each of the shadowed, modified synthetic 2-dimensional images; overlays the demarcated footprint onto a real image and masks the background colors surrounding the synthetic image to become transparent such that overlay onto the real image does not obscure existing images to create a manipulated synthetic image; and generates a labeled corpus of manipulated synthetic training data comprising a plurality of modified images for use by a deep learning model training
30 software module. The deep learning model training software module receives training data comprising a plurality of both synthetic, manipulated images and real orthorectified geospatial images with a plurality of objects present therein, a first subset of the plurality of objects being a

labeled corpus including the synthetic training data and a second subset of objects being unlabeled; aggregates the training data and classifies the training data into a plurality of predefined categories; optimizes the training data for deep learning model training; discards images unsuitable for analysis; and generates an object classification model by using a deep learning method comprising
5 separate processing of the first and second subsets of the training data through a convolutional neural network system. The convolutional neural network system working as an image analysis software module uses the object classification model generated from the deep learning model training software module to automatically identify and label all objects of interest as a featured item or plurality of items within a received data set comprising a plurality of unanalyzed orthorectified
10 geospatial imagery, regardless of the orientation or scale of the featured item within the section, and accounting for differences in item scale by using a multi-scale sliding window algorithm; and outputs the locations of the identified objects of interest in a form dictated by the parameters of the original search request.

[010] According to another preferred embodiment of the invention, a method for an automated
15 system to identify, classify, locate and quantify an object of interest from geospatial imagery, regardless of quantity of existing images of the object of interest, within a given set of geospatial images, comprising the following steps: creating a large corpus of synthetically generated training images, of which only a small number of real images exist, by generating a realistic 2-dimensional image of an object of interest from a replica of the same object of interest; using an image
20 manipulation software module, and manipulating the synthetically generated 2-dimensional image to create a plurality of synthetic images of the object of interest, placing the synthetic image in a plurality of locations, environments, orientations, scales, exposures, and foci in order to create a large corpus of training images for use by a deep learning training module; creating a classification engine using the deep learning training module by using synthetic training images as labeled images
25 to train the deep learning module how to identify and classify the object within a plurality of sets of unlabeled images; and analyzing a large set of unlabeled images using a convolutional neural network serving as an image analysis software module to compare labeled images to unlabeled images, thus generating an output file in a requestor's preferred format, comprising location, classification, and quantity of the searched object of interest.

30 BRIEF DESCRIPTION OF THE DRAWING FIGURES

[011] The accompanying drawings illustrate several embodiments of the invention and, together with the description, serve to explain the principles of the invention according to the embodiments.

One skilled in the art will recognize that the particular embodiments illustrated in the drawings are merely exemplary, and are not intended to limit the scope of the present invention.

[012] Fig. 1 is a block diagram illustrating an exemplary hardware architecture of a computing device used in various embodiments of the invention.

5 [013] Fig. 2 is a block diagram illustrating an exemplary logical architecture for a client device, according to various embodiments of the invention.

[014] Fig. 3 is a block diagram illustrating an exemplary architectural arrangement of clients, servers, and external services, according to various embodiments of the invention.

10 [015] Fig. 4 is a block diagram illustrating an exemplary overview of a computer system as may be used in any of the various locations throughout the system

[016] Fig. 5 is a diagram of an exemplary architecture for a system for automated image analysis that uses the deep learning model and a convolutional neural network, according to a preferred embodiment of the invention.

15 [017] Fig. 6 is a process flow diagram of a method for geospatial image analysis that uses the deep learning model and a convolutional neural network using a system of the invention.

[018] Fig. 7 is an example of image obstructing cloud detection by the image correction and optimization module, which is part of an automated system for geospatial image analysis of the invention.

20 [019] Fig. 8 is a diagram that illustrates the use of a sliding window module to translate the coordinate system used within the cache of geospatial images being analyzed and the geographical longitude and latitude system as part of the automated system for geospatial image analysis of the invention.

25 [020] Fig. 9 is made up of two panels which show examples of trained image analysis software module identifying two types of objects of interest as part of the automated system for geospatial image analysis of the invention.

[021] Fig. 10 is a diagram depicting an exemplary architecture for a system for automated image analysis that uses synthetic training data in an image manipulation module, a deep learning module and an image analysis module, according to a preferred embodiment of the invention.

30 [022] Fig. 11 is a process flow diagram of a method for synthesizing training data using a system of the invention, according to a preferred embodiment.

[023] Fig. 12 depicts three pairs of images; within each pair of images, a circled object of interest on one of the images identifies a synthesized object overlain onto a real geospatial image.

[024] Fig. 13 comprises three images which exemplify how a synthetic modeled image may be overlain on existing imagery to create synthetic geospatial images.

5

DETAILED DESCRIPTION

[025] The inventor has conceived, and reduced to practice, various systems and methods for advanced broad area geospatial object detection using autogenerated deep learning models trained by actual and/or virtual images.

[026] One or more different inventions may be described in the present application. Further, for one or more of the inventions described herein, numerous alternative embodiments may be described; it should be understood that these are presented for illustrative purposes only. The described embodiments are not intended to be limiting in any sense. One or more of the inventions may be widely applicable to numerous embodiments, as is readily apparent from the disclosure. In general, embodiments are described in sufficient detail to enable those skilled in the art to practice one or more of the inventions, and it is to be understood that other embodiments may be utilized and that structural, logical, software, electrical and other changes may be made without departing from the scope of the particular inventions. Accordingly, those skilled in the art will recognize that one or more of the inventions may be practiced with various modifications and alterations. Particular features of one or more of the inventions may be described with reference to one or more particular embodiments or figures that form a part of the present disclosure, and in which are shown, by way of illustration, specific embodiments of one or more of the inventions. It should be understood, however, that such features are not limited to usage in the one or more particular embodiments or figures with reference to which they are described. The present disclosure is neither a literal description of all embodiments of one or more of the inventions nor a listing of features of one or more of the inventions that must be present in all embodiments.

25

[027] Headings of sections provided in this patent application and the title of this patent application are for convenience only, and are not to be taken as limiting the disclosure in any way.

[028] Devices that are in communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices that are in communication with each other may communicate directly or indirectly through one or more intermediaries, logical or physical.

30

[029] A description of an embodiment with several components in communication with each other does not imply that all such components are required. To the contrary, a variety of optional components may be described to illustrate a wide variety of possible embodiments of one or more of the inventions and in order to more fully illustrate one or more aspects of the inventions.

5 Similarly, although process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may generally be configured to work in alternate orders, unless specifically stated to the contrary. In other words, any sequence or order of steps that may be described in this patent application does not, in and of itself, indicate a requirement that the steps be performed in that order. The steps of described processes may be
10 performed in any order practical. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step). Moreover, the illustration of a process by its depiction in a drawing does not imply that the illustrated process is exclusive of other variations and modifications thereto, does not imply that the illustrated process or any of its steps are necessary to one or more of the
15 invention(s), and does not imply that the illustrated process is preferred. Also, steps are generally described once per embodiment, but this does not mean they must occur once, or that they may only occur once each time a process, method, or algorithm is carried out or executed. Some steps may be omitted in some embodiments or some occurrences, or some steps may be executed more than once in a given embodiment or occurrence.

20 [030] When a single device or article is described, it will be readily apparent that more than one device or article may be used in place of a single device or article. Similarly, where more than one device or article is described, it will be readily apparent that a single device or article may be used in place of the more than one device or article.

[031] The functionality or the features of a device may be alternatively embodied by one or more
25 other devices that are not explicitly described as having such functionality or features. Thus, other embodiments of one or more of the inventions need not include the device itself.

[032] Techniques and mechanisms described or referenced herein will sometimes be described in singular form for clarity. However, it should be noted that particular embodiments include multiple iterations of a technique or multiple instantiations of a mechanism unless noted otherwise.
30 Process descriptions or blocks in figures should be understood as representing modules, segments, or portions of code which include one or more executable instructions for implementing specific logical functions or steps in the process. Alternate implementations are included within the scope of embodiments of the present invention in which, for example, functions may be executed out of

order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those having ordinary skill in the art.

Definitions

- 5 [033] As used herein, “orthorectified geospatial image” refers to satellite imagery of the earth that has been digitally corrected to remove terrain distortions introduced into the image by either angle of incidence of a particular point from the center of the satellite imaging sensor or significant topological changes inherent to the region of the earth that the image depicts. This correction is accomplished using a digital elevation model. One example of a digital elevation model in use
10 today is Shuttle Radar Topography Mission (SRTM) 90m DEM data set, but others of equal or greater precision have also been created using high definition stereoscopic satellite imagery of the same regions as are being analyzed or using topographical maps of sufficient detail available for that region. Geospatial images used as part of the invention may be orthorectified using digital elevation model datasets obtained by any method known to the art.
- 15 [034] A “database” or “data storage subsystem” (these terms may be considered substantially synonymous), as used herein, is a system adapted for the long-term storage, indexing, and retrieval of data, the retrieval typically being via some sort of querying interface or language. “Database” may be used to refer to relational database management systems known in the art, but should not be considered to be limited to such systems. Many alternative database or data storage system
20 technologies have been, and indeed are being, introduced in the art, including but not limited to distributed non-relational data storage systems such as Hadoop, column-oriented databases, in-memory databases, and the like. While various embodiments may preferentially employ one or another of the various data storage subsystems available in the art (or available in the future), the invention should not be construed to be so limited, as any data storage architecture may be used
25 according to the embodiments. Similarly, while in some cases one or more particular data storage needs are described as being satisfied by separate components (for example, an expanded private capital markets database and a configuration database), these descriptions refer to functional uses of data storage systems and do not refer to their physical architecture. For instance, any group of data storage systems or databases referred to herein may be included together in a single database
30 management system operating on a single machine, or they may be included in a single database management system operating on a cluster of machines as is known in the art. Similarly, any single database (such as an expanded private capital markets database) may be implemented on a single machine, on a set of machines using clustering technology, on several machines connected by one

or more messaging systems known in the art, or in a master/slave arrangement common in the art. These examples should make clear that no particular architectural approaches to database management is preferred according to the invention, and choice of data storage technology is at the discretion of each implementer, without departing from the scope of the invention as claimed.

5 [035] As used herein, “search and locate” refers to a general class of tasks wherein a set of images is searched for particular classes of stationary targets (such as buildings, tanks, railroad terminals, downed airplanes, etc.) or relocatable targets (such as missile launchers, aircraft carriers, oil rigs, earthmovers, tower cranes, etc). It is common that the set of images may be searched to find more than one class of targets (for example, to find all targets of military interest), although single target
10 class searches may also be performed (“find all cars”). The second part of the search and locate task is to precisely locate any resulting targets of interest (where is the air base or refugee camp?).

[036] As used herein, “image manipulation” refers to a way of generating artificial, “manipulated images” and respectively labeling them to simulate real geospatial images, such that a plurality of synthetic images can be automatically generated without the need for manual effort. Image
15 manipulation greatly reduces the extensive manual effort currently required to extract and label existing data, even when it is relatively abundant. Further, image manipulation may be utilized to create synthetic data for an object class for rare or even theoretical items. By using synthetic data, any object that can be simulated, modeled or otherwise created by computer-aided design (CAD), can be searched by a preferred embodiment of the invention.

20 [037] As referenced herein, “manipulated images” refer to synthetic images, which may be modeled, flattened, or otherwise virtually generated or modified images, to replicate real, existing orthorectified geospatial images created from image manipulation. These images can be used to generate a collection of training images for a searchable object class.

[038] As used herein, “cache of pre-labeled geospatial images” refers to any source of a plurality
25 of orthorectified geospatial image segments that have been pre-analyzed and have had instances of one or more objects of interest tagged or labeled in such a way that the recipient computer system is able to associate a specific region of that image with the object of interest for the purpose of subsequent identification of like objects. These images may be stored in an image database, either relational or flat file, or within a directory of image files, any of which may be stored on the same
30 computer on which the images are being used, a storage device or storage system directly connected to that computer or may be on a computer or storage system connected to the recipient computer through any of the networking methods as are known in the art.

[039] As used herein, "cache of multi-scale geospatial images" refers to any source of a plurality of overlapping orthorectified geospatial image segments that, due to optical differences at the time of capture or processing differences at the time of transmission, storage or analysis, show the same geographical region at different functional resolutions. There is the further requirement that the correspondence of coordinate system used to catalog these segments within the cache, whether proprietary or open, to standard geographic latitude and longitude coordinates be known so that the location being analyzed on a given image segment from the cache is known at all times. These images may be stored in an image database, either relational or flat file, or within a directory of image files, any of which may be stored on the same computer on which the images are being used, a storage device or storage system directly connected to that computer or may be on a computer or storage system connected to the recipient computer through any of the networking methods as are known in the art.

[040] As used herein, "image analysis" refers to the analysis of images obtained from one or more image sensors; generally, a single analysis task focuses on a set of images of a single region of interest on the earth, but image analysis may be done on multiple contiguous regions as captured by several image sensors. Satellite and aerial imagery are common examples of imagery that are subjected to large scale image analysis.

[041] As used herein "image correction and optimization module" refers to a set of programming functions that during its operation receives a plurality of orthorectified geospatial images from a cache of pre-labeled geospatial images, normalizes these images to account for image quality differences which include but are not limited to variations in color balance, brightness, and contrast. This module also analyzes images for aberrations which might include cloud cover, lens artifact, mechanical obstruction of portions of the image and the software within the module may then reject the image from analysis when certain pre-set thresholds are exceeded.

[042] As used herein "category" refers to a set of specific objects that are of the same type and function, but which may vary to some degree in appearance. An example of this might be the United States Capitol Building, the White House and the Pentagon in Washington DC all appear different in geospatial images but are all in the category "buildings." Another example might be that the Airbus 310, Lockheed L1011, Boeing 727, Boeing 777 and Boeing 747 all differ in size and fine level configuration, but are all in the category "airliners."

Hardware Architecture

[043] Generally, the techniques disclosed herein may be implemented on hardware or a combination of software and hardware. For example, they may be implemented in an operating system kernel, in a separate user process, in a library package bound into network applications, on
5 a specially constructed machine, on an application-specific integrated circuit (ASIC), or on a network interface card.

[044] Software/hardware hybrid implementations of at least some of the embodiments disclosed herein may be implemented on a programmable network-resident machine (which should be understood to include intermittently connected network-aware machines) selectively activated or
10 reconfigured by a computer program stored in memory. Such network devices may have multiple network interfaces that may be configured or designed to utilize different types of network communication protocols. A general architecture for some of these machines may be described herein in order to illustrate one or more exemplary means by which a given unit of functionality may be implemented. According to specific embodiments, at least some of the features or
15 functionalities of the various embodiments disclosed herein may be implemented on one or more general-purpose computers associated with one or more networks, such as for example an end-user computer system, a client computer, a network server or other server system, a mobile computing device (e.g., tablet computing device, mobile phone, smartphone, laptop, or other appropriate
20 computing device), a consumer electronic device, a music player, or any other suitable electronic device, router, switch, or other suitable device, or any combination thereof. In at least some embodiments, at least some of the features or functionalities of the various embodiments disclosed herein may be implemented in one or more virtualized computing environments (e.g., network
computing clouds, virtual machines hosted on one or more physical computing machines, or other appropriate virtual environments).

[045] Referring now to Fig. 1, there is shown a block diagram depicting an exemplary computing
25 device 10 suitable for implementing at least a portion of the features or functionalities disclosed herein. Computing device 10 may be, for example, any one of the computing machines listed in the previous paragraph, or indeed any other electronic device capable of executing software- or
hardware-based instructions according to one or more programs stored in memory. Computing
30 device 10 may be configured to communicate with a plurality of other computing devices, such as clients or servers, over communications networks such as a wide area network a metropolitan area network, a local area network, a wireless network, the Internet, or any other network, using known protocols for such communication, whether wireless or wired.

[046] In one embodiment, computing device 10 includes one or more central processing units (CPU) 12, one or more interfaces 15, and one or more busses 14 (such as a peripheral component interconnect (PCI) bus). When acting under the control of appropriate software or firmware, CPU 12 may be responsible for implementing specific functions associated with the functions of a specifically configured computing device or machine. For example, in at least one embodiment, a computing device 10 may be configured or designed to function as a server system utilizing CPU 12, local memory 11 and/or remote memory 16, and interface(s) 15. In at least one embodiment, CPU 12 may be caused to perform one or more of the different types of functions and/or operations under the control of software modules or components, which for example, may include an operating system and any appropriate applications software, drivers, and the like.

[047] CPU 12 may include one or more processors 13 such as, for example, a processor from one of the Intel, ARM, Qualcomm, and AMD families of microprocessors. In some embodiments, processors 13 may include specially designed hardware such as application-specific integrated circuits (ASICs), electrically erasable programmable read-only memories (EEPROMs), field-programmable gate arrays (FPGAs), and so forth, for controlling operations of computing device 10. In a specific embodiment, a local memory 11 (such as non-volatile random access memory (RAM) and/or read-only memory (ROM), including for example one or more levels of cached memory) may also form part of CPU 12. However, there are many different ways in which memory may be coupled to system 10. Memory 11 may be used for a variety of purposes such as, for example, caching and/or storing data, programming instructions, and the like. It should be further appreciated that CPU 12 may be one of a variety of system-on-a-chip (SOC) type hardware that may include additional hardware such as memory or graphics processing chips, such as a Qualcomm SNAPDRAGON or Samsung EXYNOS CPU as are becoming increasingly common in the art, such as for use in mobile devices or integrated devices.

[048] As used herein, the term "processor" is not limited merely to those integrated circuits referred to in the art as a processor, a mobile processor, or a microprocessor, but broadly refers to a microcontroller, a microcomputer, a programmable logic controller, an application-specific integrated circuit, and any other programmable circuit.

[049] In one embodiment, interfaces 15 are provided as network interface cards (NICs). Generally, NICs control the sending and receiving of data packets over a computer network; other types of interfaces 15 may for example support other peripherals used with computing device 10. Among the interfaces that may be provided are Ethernet interfaces, frame relay interfaces, cable interfaces, DSL interfaces, token ring interfaces, graphics interfaces, and the like. In addition,

various types of interfaces may be provided such as, for example, universal serial bus (USB), Serial, Ethernet, FIREWIRE[®], THUNDERBOLT[®], PCI, parallel, radio frequency (RF), BLUETOOTH[®], near-field communications (e.g., using near-field magnetics), 802.11 (WiFi), frame relay, TCP/IP, ISDN, fast Ethernet interfaces, Gigabit Ethernet interfaces, Serial ATA (SATA) or external SATA (ESATA) interfaces, high-definition multimedia interface (HDMI), digital visual interface (DVI), analog or digital audio interfaces, asynchronous transfer mode (ATM) interfaces, high-speed serial interface (HSSI) interfaces, Point of Sale (POS) interfaces, fiber data distributed interfaces (FDDIs), and the like. Generally, such interfaces 15 may include physical ports appropriate for communication with appropriate media. In some cases, they may also include an independent processor (such as a dedicated audio or video processor, as is common in the art for high-fidelity A/V hardware interfaces) and, in some instances, volatile and/or non-volatile memory (e.g., RAM).

[050] Although the system shown and described above illustrates one specific architecture for a computing device 10 for implementing one or more of the inventions described herein, it is by no means the only device architecture on which at least a portion of the features and techniques described herein may be implemented. For example, architectures having one or any number of processors 13 may be used, and such processors 13 may be present in a single device or distributed among any number of devices. In one embodiment, a single processor 13 handles communications as well as routing computations, while in other embodiments a separate dedicated communications processor may be provided. In various embodiments, different types of features or functionalities may be implemented in a system according to the invention that includes a client device (such as a tablet device or smartphone running client software) and server systems (such as a server system described in more detail below).

[051] Regardless of network device configuration, the system of the present invention may employ one or more memories or memory modules (such as, for example, remote memory block 16 and local memory 11) configured to store data, program instructions for the general-purpose network operations, or other information relating to the functionality of the embodiments described herein (or any combinations of the above). Program instructions may control execution of or comprise an operating system and/or one or more applications, for example. Memory 16 or memories 11, 16 may also be configured to store data structures, configuration data, encryption data, historical system operations information, or any other specific or generic non-program information described herein.

[052] Because such information and program instructions may be employed to implement one or more systems or methods described herein, at least some network device embodiments may include nontransitory machine-readable storage media, which, for example, may be configured or designed to store program instructions, state information, and the like for performing various operations described herein. Examples of such nontransitory machine-readable storage media include, but are not limited to, magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM disks; magneto-optical media such as optical disks, and hardware devices that are specially configured to store and perform program instructions, such as read-only memory devices (ROM), flash memory (as is common in mobile devices and integrated systems), solid state drives (SSD) and "hybrid SSD" storage drives that may combine physical components of solid state and hard disk drives in a single hardware device (as are becoming increasingly common in the art with regard to personal computers), memristor memory, random access memory (RAM), and the like. It should be appreciated that such storage means may be integral and non-removable (such as RAM hardware modules that may be soldered onto a motherboard or otherwise integrated into an electronic device), or they may be removable such as swappable flash memory modules (such as "thumb drives" or other removable media designed for rapidly exchanging physical storage devices), "hot-swappable" hard disk drives or solid state drives, removable optical storage discs, or other such removable media, and that such integral and removable storage media may be utilized interchangeably. Examples of program instructions include both object code, such as may be produced by a compiler, machine code, such as may be produced by an assembler or a linker, byte code, such as may be generated by for example a JAVA[™] compiler and may be executed using a Java virtual machine or equivalent, or files containing higher level code that may be executed by the computer using an interpreter (for example, scripts written in Python, Perl, Ruby, Groovy, or any other scripting language).

[053] In some embodiments, systems according to the present invention may be implemented on a standalone computing system. Referring now to Fig. 2, there is shown a block diagram depicting a typical exemplary architecture of one or more embodiments or components thereof on a standalone computing system. Computing device 20 includes processors 21 that may run software that carry out one or more functions or applications of embodiments of the invention, such as for example a client application 24. Processors 21 may carry out computing instructions under control of an operating system 22 such as, for example, a version of Microsoft's WINDOWS[™] operating system, Apple's Mac OS/X or iOS operating systems, some variety of the Linux operating system, Google's ANDROID[™] operating system, or the like. In many cases, one or more shared services

23 may be operable in system 20, and may be useful for providing common services to client applications 24. Services 23 may for example be WINDOWS[®] services, user-space common services in a Linux environment, or any other type of common service architecture used with operating system 21. Input devices 28 may be of any type suitable for receiving user input, including for example a keyboard, touchscreen, microphone (for example, for voice input), mouse, touchpad, trackball, or any combination thereof. Output devices 27 may be of any type suitable for providing output to one or more users, whether remote or local to system 20, and may include for example one or more screens for visual output, speakers, printers, or any combination thereof. Memory 25 may be random-access memory having any structure and architecture known in the art, for use by processors 21, for example to run software. Storage devices 26 may be any magnetic, optical, mechanical, memristor, or electrical storage device for storage of data in digital form (such as those described above). Examples of storage devices 26 include flash memory, magnetic hard drive, CD-ROM, and/or the like.

[054] In some embodiments, systems of the present invention may be implemented on a distributed computing network, such as one having any number of clients and/or servers. Referring now to Fig. 3, there is shown a block diagram depicting an exemplary architecture 30 for implementing at least a portion of a system according to an embodiment of the invention on a distributed computing network. According to the embodiment, any number of clients 33 may be provided. Each client 33 may run software for implementing client-side portions of the present invention; clients may comprise a system 20 such as that illustrated above. In addition, any number of servers 32 may be provided for handling requests received from one or more clients 33. Clients 33 and servers 32 may communicate with one another via one or more electronic networks 31, which may be in various embodiments any of the Internet, a wide area network, a mobile telephony network (such as CDMA or GSM cellular networks), a wireless network (such as WiFi, Wimax, LTE, and so forth), or a local area network (or indeed any network topology known in the art; the invention does not prefer any one network topology over any other). Networks 31 may be implemented using any known network protocols, including for example wired and/or wireless protocols.

[055] In addition, in some embodiments, servers 32 may call external services 37 when needed to obtain additional information, or to refer to additional data concerning a particular call. Communications with external services 37 may take place, for example, via one or more networks 31. In various embodiments, external services 37 may comprise web-enabled services or functionality related to or installed on the hardware device itself. For example, in an embodiment

where client applications 24 are implemented on a smartphone or other electronic device, client applications 24 may obtain information stored in a server system 32 in the cloud or on an external service 37 deployed on one or more of a particular enterprise's or user's premises.

[056] In some embodiments of the invention, clients 33 or servers 32 (or both) may make use of one or more specialized services or appliances that may be deployed locally or remotely across one or more networks 31. For example, one or more databases 34 may be used or referred to by one or more embodiments of the invention. It should be understood by one having ordinary skill in the art that databases 34 may be arranged in a wide variety of architectures and using a wide variety of data access and manipulation means. For example, in various embodiments one or more databases 34 may comprise a relational database system using a structured query language (SQL), while others may comprise an alternative data storage technology such as those referred to in the art as "NoSQL" (for example, Hadoop Cassandra, Google BigTable, and so forth). In some embodiments, variant database architectures such as column-oriented databases, in-memory databases, clustered databases, distributed databases, or even flat file data repositories may be used according to the invention. It will be appreciated by one having ordinary skill in the art that any combination of known or future database technologies may be used as appropriate, unless a specific database technology or a specific arrangement of components is specified for a particular embodiment herein. Moreover, it should be appreciated that the term "database" as used herein may refer to a physical database machine, a cluster of machines acting as a single database system, or a logical database within an overall database management system. Unless a specific meaning is specified for a given use of the term "database", it should be construed to mean any of these senses of the word, all of which are understood as a plain meaning of the term "database" by those having ordinary skill in the art.

[057] Similarly, most embodiments of the invention may make use of one or more security systems 36 and configuration systems 35. Security and configuration management are common information technology (IT) and web functions, and some amount of each are generally associated with any IT or web systems. It should be understood by one having ordinary skill in the art that any configuration or security subsystems known in the art now or in the future may be used in conjunction with embodiments of the invention without limitation, unless a specific security 36 or configuration system 35 or approach is specifically required by the description of any specific embodiment.

[058] Fig. 4 shows an exemplary overview of a computer system 40 as may be used in any of the various locations throughout the system. It is exemplary of any computer that may execute code to

process data. Various modifications and changes may be made to computer system 40 without departing from the broader scope of the system and method disclosed herein. Central processor unit (CPU) 41 is connected to bus 42, to which bus is also connected memory 43, nonvolatile memory 44, display 47, input/output (I/O) unit 48, and network interface card (NIC) 53. I/O unit 48 may, typically, be connected to keyboard 49, pointing device 50, hard disk 52, and real-time clock 51. NIC 53 connects to network 54, which may be the Internet or a local network, which local network may or may not have connections to the Internet. Also shown as part of system 40 is power supply unit 45 connected, in this example, to a main alternating current (AC) supply 46. Not shown are batteries that could be present, and many other devices and modifications that are well known but are not applicable to the specific novel functions of the current system and method disclosed herein. It should be appreciated that some or all components illustrated may be combined, such as in various integrated applications, for example Qualcomm or Samsung system-on-a-chip (SOC) devices, or whenever it may be appropriate to combine multiple capabilities or functions into a single hardware device (for instance, in mobile devices such as smartphones, video game consoles, in-vehicle computer systems such as navigation or multimedia systems in automobiles, or other integrated hardware devices).

[059] In various embodiments, functionality for implementing systems or methods of the present invention may be distributed among any number of client and/or server components. For example, various software modules may be implemented for performing various functions in connection with the present invention, and such modules may be variously implemented to run on server and/or client components.

Conceptual Architecture

[060] Fig. 5 is a block diagram of an exemplary architecture for a system 500 for automated image analysis that uses the deep learning model and a convolutional neural network, according to a preferred embodiment of the invention. According to the embodiment, a cache of pre-labeled, orthorectified geospatial image segments 510 is employed by deep learning training module 520 for the purpose of training the system 500 to identify feature items of interest to those running the analysis. This cache of pre-labeled geospatial image segments 510 could be stored within a directory or part of a database of geospatial image segments stored on a disk system within the computer running the deep learning model training module 520, stored in a directory, or in a database on a disk system directly connected to the computer running the deep learning model training module 520 by an external bus such as the universal serial bus or eSATA. Image cache might also be stored on one or more computers other than that running the deep learning model

module and connected to the deep learning module by a local internal network, the internet or by any other means known to the art as the system does not rely on any one method of image delivery whether server - client or peer to peer in nature. The system is also not restricted to specific mechanisms by which feature items of interest found in orthorectified geospatial image segments to be used in training of the system are identified and labeled prior to use in training. One preferred embodiment might use cache 510 where feature items of interest are labeled prior to training by many participants in a crowdsourcing campaign to tag one or more feature items in each image segment found within the cache. Image segments tagged in this way where tagging accuracy of items is known to be high could then be added to the training cache for that feature item category (building, airliner, storage tank, truck). Another preferred embodiment might use cache of geospatial images 510 where feature items of interest are labeled by trained image analysts, either specifically for use in the deep learning model training module or as part of other analyses and then re-purposed later for deep learning model training module 520. Caches of pre-labeled geospatial images used to train the system 500 could contain mixtures of image segments obtained crowdsourcing, image analyst generated effort, as well as image segments where specific feature items are identified and pre-labeled by any other method known to those skilled in the art, as the invention does not rely on any specific mode of identification and labeling for deep level training model module operation.

[061] Prior to use in the training of the image analysis software module 540 image segments from the cache of pre-labeled geospatial image segments 510 undergo one or more steps of digital image correction and optimization 521. A digital correction that might be done to image segments to be used by deep learning model training module is conversion from color to grayscale as this correction reduces image segment complexity, which aids in the training process. In a preferred embodiment of the system the conversion is done by first converting the image from the RGB colorspace to the YCrCb colorspace and then discarding all but Y channel data which results in a grayscale image of tonal quality known to work well in deep learning model training of convolutional neural net used in the invention. The method of color to grayscale image conversion outlined here is meant only to be exemplary and should not be seen to limit conversion method that could be used, including the absence of this color to grayscale conversion in the training image preparation process. Another type of image correction that may be employed to prepare pre-labeled geospatial images for use in training is histogram normalization which often increases image contrast and serves to reduce the effects of exposure by producing sets of image segments with similar dynamic range profiles prior to use in training of the image analysis module 540. Examples of histogram normalization filters that may be used to prepare geospatial images for training are

linear histogram normalization, histogram equalization, adaptive histogram equalization, and contrast limiting adaptive histogram equalization. One skilled in the art will realize that while the use of these image histogram manipulation methods may produce image segments significantly better suited for the supervised stage of deep learning 520, the system described herein does not absolutely rely on histogram normalization in its generalized form or and of the exemplary histogram manipulation methods specifically. In addition to or in lieu of to those mentioned in some depth, image filters such as Gaussian, median filter, and bilateral filter to enhance edge contrast may be applied to pre-labeled geospatial image segments as is common in the art, however the listing of these filters is meant only to provide examples and should not be taken to bar the use of other filters that are not listed as part of the invention.

[062] As is appreciated by those skilled in the art, much of this recent success in the recognition of specific objects in digital images by computers using trained convolutional neural networks is due to the use of the deep learning method. Under this method of training, the convolutional neural network is first trained with a set of images where the item to be identified, ideally in conjunction with a large plurality of backgrounds and in a large plurality of orientations, is clearly demarcated digitally. This stage of deep learning is referred to by the art as “supervised.” The number of images where the object of interest has been clearly demarcated is often limited and often gives rise to trained convolutional neural networks that are excellent in recognizing the object of interest in the training set but otherwise recognize the object of interest poorly. Object recognition reliability is significantly increased by exposure of the convolutional neural network to sets of images, much larger in image number than the labeled-training set, where the object of interest is present but not labeled or where the object may not be present. This stage of learning is referred to by the art as “unsupervised.” One method to generate large sets of images for unsupervised learning is to screen very large repositories of general images for suitable examples. Another method of generating the unsupervised learning image set is to start with the set of images used for supervised learning stage and modify them by linearly translating or rotationally transforming the object of interest; changing the appearance of the object of interest or background through image histogram modification, Gaussian filter, bilateral filter or median blur filter; or both using object placement and filter modification to create a plurality of images useful in the unsupervised learning stage from each image used in the supervised learning stage. In one preferred embodiment of the system 500 it is this second method, manipulating the geospatial images used in the supervised learning stage to augment the training image set, which is depicted 522. The choice to depict this one method was for figure simplification only as system training by deep learning method training module can use geospatial images generated by either method,

identification of new images, or manipulation of the supervised learning image set, even some mixture of both methods, to train image analysis software module 540.

[063] The trained image analysis software module 540 can and often does have the ability to identify multiple categories of objects of interest from geospatial imagery. For example a first image analysis software module may identify items from a set comprising buildings, tents, cars, airliners, oil refineries, and soccer fields from geospatial images. Other image analysis software modules may have identification repertoires that differ partially or completely from the first image analysis software module as the invention. Physically, the image analysis software module can be present on the same computer as the deep learning model training module 520, or could be placed anywhere in the world, as once training is complete, no connection between the server running the deep learning module training module 520 and the image analysis software module 540 is necessary. The trained convolutional neural network can even be programmatically cloned such that a plurality of instances of image analysis software modules 540 with the same object identification repertoire may be present concurrently with no specific geographical relationship, the only stipulation being that there is access to a cache of orthorectified, multi-scale, geospatial image segments tagged with information that allows the geographical location of image capture and the scaling factor to be determined 530. In a preferred embodiment of the system, image correction filters 541 taken from a set that comprises histogram normalization, edge enhancement and cloud detection. A cloud detection filters is present to allow removal of images when occlusion prevents analysis of the ground below. These filters 541 are depicted as applied on the same computer on which the image analysis software module resides but filters can be applied on any remote computer that is logically between the cache of multi-scale unanalyzed geospatial image segments 530 and the image analysis software module 540. During image analysis, geospatial image segments of the same region but differing scale factors are scanned by sliding window multi-scale analysis module 542 which converts between any internal coordinate system used by the cache of geospatial images in use to geographical latitude and longitude while tracking all changes in fine positioning coordinates as the window of focus changes. While each image segment is scanned, all features of interest that are identified are given a confidence factor number reflecting correspondence between the newly detected item and the image analysis software module's set of characteristics for the item. Feature items of interest detected by the image analysis software module 540 during the scan of geospatial image segments from cache 530 are then reported by the system 550 in a format specified by the requester. As examples, reports may be in the form of appropriately scaled geospatial images tagged with either tokens or color shading which represent each feature item of

interest, or may be rows of text providing such information as item type, latitude and longitude, but may take any format dictated by the needs of the analysis and known to the art.

[064] Fig. 10 is a block diagram of an exemplary architecture for a system 1000 for automated image analysis that uses an image manipulation software module along with a deep learning model and a convolutional neural network, according to a preferred embodiment of the invention.

5 According to the embodiment, a database 1010 of 3-dimensional models is tapped to provide simulated models which are manipulated by the image manipulation software 1020 to create synthetic training images 1035 for use by the deep learning model training module 1040 in addition to a cache of pre-labeled, orthorectified geospatial image segments 1050 for the purpose of training

10 the system 1000 to identify feature objects of interest. The simulated synthetic images 1035 created by the image manipulation software module 1020 may be stored within the deep learning training module 1040 or within a separate collection point 1037. Both the cache of pre-labeled geospatial image segments 1050 and or the simulated synthetic images 1037 may be stored within a directory or within a database of geospatial image segments stored on a disk system within the computer

15 running the deep learning model training module 1040, stored in a directory, or in a database on a disk system directly connected to the computer running the deep learning model training module 1040 by an external bus such as the universal serial bus, eSATA, or the like. Image caches 1050, 1037 might also be stored on one or more computers other than that running the deep learning model module 1040 and connected to the deep learning module by a local internal network, the

20 internet or by any other means known to the art as the system does not rely on any one method of image delivery whether server - client or peer to peer in nature. The system is also not restricted to specific mechanisms by which feature objects of interest found in orthorectified geospatial image segments, whether real or synthetic, to be used in training of the system are identified and labeled prior to use in training. One preferred embodiment might use simulated synthetic images 1035,

25 created and labeled by the image manipulation software module 1020 to augment or replace images available from cache 1050, as significant effort is required to identify and label existing images or not enough existing images are available to conduct training. In another preferred embodiment of the invention, cache 1050 may label feature objects of interest prior to training by many participants in a crowdsourcing campaign to tag one or more feature items in each image

30 segment found within the cache. Another preferred embodiment might use cache of geospatial images 1050 where feature items of interest are labeled by trained image analysts, either specifically for use in the deep learning model training module 1040 or as part of other analyses and then re-purposed later for deep learning model training module 1040. Yet another preferred embodiment may use only synthetic images created from image manipulation software 1020 in cases where the

item of interest is rare in existence or to bypass the manual work required to generate the cache 1050 associated with the specific object of interest. Caches of pre-labeled geospatial images used to train the system 1000 may contain mixtures of image segments obtained from image manipulation 1020, crowdsourcing, image analyst generated effort, as well as image segments where specific 5 feature items are identified and pre-labeled by any other method known to those skilled in the art, as the invention does not rely on any specific mode of identification and labeling for deep level training model module operation.

[065] Prior to use in the training of the image analysis software module 1050, image segments created by image manipulation software 1020 may undergo one or more steps of digital image 10 correction and optimization 1030. For example, a digital correction that may be done to synthetic image segments to be used by deep learning model training module is conversion from CAD renderings to color to enhance realism in the modeled image or and color to grayscale as this correction reduces image segment complexity, both of which aid in the training process. In a preferred embodiment of the system 1000 the color to grayscale conversion may be done by first 15 converting the image from the RGB colorspace to the YCrCb colorspace and then discarding all but Y channel data which results in a grayscale image of tonal quality known to work well in deep learning model training of convolutional neural net used in the invention. The method of color to grayscale image conversion outlined here is meant only to be exemplary and should not be seen to limit conversion method that could be used, including the absence of this color to grayscale 20 conversion in the training image preparation process. In another embodiment, image correction that may be employed to prepare synthetic images for use in training may be histogram normalization which may often increase image contrast and may serve to reduce the effects of exposure by producing sets of image segments with similar dynamic range profiles prior to use in training of the image analysis module 1060. Examples of histogram normalization filters that may 25 be used to prepare geospatial images for training are linear histogram normalization, histogram equalization, adaptive histogram equalization, and contrast limiting adaptive histogram equalization. One skilled in the art will realize that while the use of these image histogram manipulation methods may produce image segments significantly better suited for the supervised stage of deep learning 1040, the system described herein does not absolutely rely on histogram normalization in its 30 generalized form or and of the exemplary histogram manipulation methods specifically. In addition to or in lieu of to those mentioned in some depth, image filters such as Gaussian, median filter, and bilateral filter to enhance edge contrast may be applied to synthetic image segments as is common in the art, however the listing of these filters is meant only to provide examples and should not be taken to bar the use of other filters that are not listed as part of the invention.

[066] As is appreciated by those skilled in the art, much of the recent success in the recognition of specific objects in digital images by computers using trained convolutional neural networks is due to the use of the deep learning method. Under this method of training, the convolutional neural network is first trained with a set of images where the item to be identified, ideally in conjunction with a large plurality of backgrounds and in a large plurality of orientations, is clearly demarcated digitally. This stage of deep learning is referred to by the art as "supervised." By using the synthetic training images 1035, the number of real images where the object of interest has been clearly demarcated is no longer a limiting factor which affects performance classification reliability and success, and therefore gives rise to trained convolutional neural networks that are excellent in recognizing the object of interest in the training by utilizing synthetic images in lieu of or partially in lieu of real training images. Object recognition reliability is further increased by exposure of the convolutional neural network to sets of images, much larger in image number than the labeled-training set, where the object of interest is present but not labeled or where the object may not be present. This stage of learning is referred to by the art as "unsupervised." One method to generate large sets of images for unsupervised learning is to screen very large repositories 1070 of general images for suitable examples. Another method of generating the unsupervised learning image set is to start with the set of images 1037 or and 1050 used for supervised learning stage, be they real or synthetic or a mixture of both, and modify them by linearly translating or rotationally transforming the object of interest; changing the appearance of the object of interest or background through image histogram modification, Gaussian filter, bilateral filter or median blur filter; or both using object placement and filter modification to create a plurality of images useful in the unsupervised learning stage from each image used in the supervised learning stage. The choice to depict this one method is for figure simplification only as system training by deep learning method training module 1040 may use geospatial images generated by either method, identification of new images, or manipulation of the supervised learning image set, even some mixture of both methods, to train image analysis software module 1060.

[067] The trained image analysis software module 1060 may have the ability to identify multiple categories of objects of interest from geospatial imagery. For example a first image analysis software module may identify items from a set comprising, for example, buildings, tents, cars, airliners, oil refineries, and soccer fields from real and/or synthetic geospatial images. Other image analysis software modules may have identification repertoires that differ partially or completely from the first image analysis software module as the invention. In some embodiments, image analysis software module 1060 may be part of the same device as deep learning model training module 1040. In other embodiment, image analysis software module 1060 and deep learning model

training module 1040 may be separate devices connected by network 9876. Once training is complete, a connection between deep learning module training module 1040 and image analysis software module 1060 is not necessary. In some embodiment, the trained convolutional neural network may operate as a plurality of instances of image analysis software modules 1060 with the same object identification repertoire being present concurrently with no specific geographical relationship, provided that there is access to a cache of orthorectified, multi-scale, geospatial image segments tagged with information that allows the geographical location of image capture and the scaling factor to be determined 1070. In a preferred embodiment of the system, image correction filters 1080 taken from a set that comprises histogram normalization, edge enhancement and cloud detection. A cloud detection filters is present to allow removal of images when occlusion prevents analysis of, for example, the ground below. These filters 1080 are depicted as applied on the same computer on which the image analysis software module 1060 resides but filters can be applied on any remote computer that is logically between the cache of multi-scale unanalyzed geospatial image segments 1070 and the image analysis software module 1060. During image analysis, geospatial image segments of the same region but differing scale factors are scanned by sliding window multi-scale analysis module 1085 which converts between any internal coordinate system used by the cache of geospatial images in use to geographical latitude and longitude while tracking all changes in fine positioning coordinates as the window of focus changes. While each image segment is scanned, all features of interest that are identified are given a confidence factor number reflecting correspondence between the newly detected item and image analysis software module's set of characteristics for the item. Feature items of interest detected by the image analysis software module 1060 during the scan of geospatial image segments from cache 1070 are then reported by system 1090 in a format specified by the requester. As examples, reports may be in the form of appropriately scaled geospatial images tagged with either tokens or color shading which represent each feature item of interest, or may be rows of text providing such information as item type, latitude and longitude, but may take any format dictated by the needs of the analysis and known to the art.

Description of Method Embodiments

[068] Fig. 6 is a process flow diagram of a method 600 for geospatial image analysis that uses the deep learning model and a convolutional neural network using a system of the invention. According to the embodiment, orthorectified geospatial image segments that have been previously analyzed and where feature items of a specific type which may include, but are not limited to trucks, fighter aircraft, oil wells, missile launchers or elephants have been clearly demarcated and

labeled are retrieved from a cache of images 601. The mechanism that results in the labeling of specific objects within geospatial image segments available from the cache 601 whether that mechanism be analysis and labeling by trained image analysts, intended for use in the method 600 or for some other purpose but then re-purposed for the method 600; those segments are labeled
5 by a crowdsourcing where a plurality participants, paid or volunteer, analyze the same image segments from a set of image segments in campaign to identify and precisely demarcate the same feature item and then image segments where the labeling accuracy is calculated to be statistically very high are placed in the cache 601; or labeled by some means not listed; should not be seen to limit method 600 as the method is envisioned to utilize all of those mechanisms either separately
10 or together. As feature item types that might be of interest to the requester of geospatial image analysis often can be further divided into multiple subtypes, the feature items are frequently, though not always, placed into categories 602 prior to training of image analysis software module 540. For example, a "truck" could be "dump truck", "delivery truck", "tanker truck" "tractor trailer truck" or "tow truck", to name just a few. All of these "trucks" appear different in geospatial images
15 and for the method 600, "trucks" of the same subtype ("delivery truck") but with widely different paint schemes might vary sufficiently to require additional cues be added prior to system training 609. The method 600, therefore, accounts for the need that geospatial image segments may need to be categorized by the generalized form of object that is labeled 602. One with ordinary skill in the art will understand that all categories used by method 600 are arbitrary and the discrete level of
20 categorization depends upon the specifications of the search. For instance, using the "truck" example, one could envision an embodiment of the method 600 where the requestor may want to identify only "tanker trucks", so there would be no "truck" category. In another embodiment of the method 600 the requestor may want to identify "trucks" in general and "dump trucks" as a separate group. Whether placed into categories 602 or not placed into categories, orthorectified geospatial
25 image segments that have been labeled to identify feature items which will be used to train the image analysis software module 540 may be optimized for the training process through the application of digital image filters 603. The scale or resolution of images to be used in training will be determined from metadata included with the image segments 604. Adjustment of image segment scale 603 might then occur because training the image analysis software module 540 relies
30 on image segments bearing instances of the target feature item of interest presenting that object within narrowly controlled size range. In embodiment of the method 600, color correction filters may also be applied to image segments to be used to train the image analysis software module 540. One modification commonly applied to images used in deep learning model training 607 of convolutional neural networks used in image analysis software module 540 is conversion of color

images to grayscale images 605 which serves to simplify the image significantly and also greatly simplifies the application of subsequent filters that may be used to optimize image for training. Color images may be converted to grayscale by first converting the image from the RGB colorspace to the YCrCb colorspace and then discarding all but Y channel data which results in a grayscale image of tonal quality known to work well in deep learning model training of convolutional neural net used in the invention. Other methods of color to grayscale conversion that might be used are linear desaturation by averaging the R, G, and B intensities of each pixel into a single grayscale intensity value, and weighted conversion where the intensities of the R, G, and B are multiplied by different weighting values based upon a pre-determined desired end result and those weighted values then averaged into on single grayscale intensity value. Methods of color to grayscale image conversion 605 outlined here are meant only to be exemplary and should not be interpreted to limit conversion methods that could be used, including the absence of color to grayscale conversion in the training image preparation process. Another type of image correction 605 that may be employed to prepare pre-labeled geospatial images for use in deep learning model training 607 is histogram normalization which often increases image contrast and serves to reduce the effects of differences in lighting during exposure by producing sets of image segments with similar dynamic range profiles prior to use in training of the image analysis module 540. Examples of histogram normalization filters that might be used to prepare geospatial images for training are linear histogram normalization, histogram equalization, adaptive histogram equalization, and contrast limiting adaptive histogram equalization. One skilled in the art will realize that while the use of these image histogram manipulation methods may produce image segments significantly better suited for the supervised stage of deep learning 607, the method 600 described herein does not absolutely rely on histogram normalization in its generalized form or of the exemplary histogram manipulation methods specifically. In addition to, or in lieu of, those methods mentioned in some depth, image filters such as Gaussian, median filter, and bilateral filter may be applied to enhance edge contrast of pre-labeled geospatial image segments as is common in the art, however the listing of these filters is meant only to provide further examples and should not be taken to bar the use of other filters that are not listed as part of the invention or to suggest that the method 600 relies on any of these filters.

[069] As is appreciated by those skilled in the art, much of the recent success in the recognition of specific objects in digital images by computers using trained convolutional neural networks is due to the use of the deep learning method 607. Under this method of training, the convolutional neural network is first trained with a set of images where the item to be identified, ideally in collocation with a large plurality of backgrounds and in a large plurality of orientations, is clearly

demarcated digitally. This stage of deep learning is referred to by the art as "supervised." The number of images where the object of interest has been clearly demarcated is often limited and often gives rise to trained convolutional neural networks that are excellent in recognizing the object of interest in the training set but otherwise recognize the object of interest poorly. Object

5 recognition reliability is significantly increased by exposure of the convolutional neural network to sets of images 606, much larger in image number than the labeled-training set, where the object of interest is present but not labeled or where the object may not be present. This stage of learning is referred to by the art as "unsupervised." One approach to generate large sets of images 606 for unsupervised learning is to screen very large repositories of general images for suitable examples.

10 Another approach of generating the unsupervised learning image set 606 is to start with the set of images used for supervised learning stage 601 and modify them by linearly translating or rotationally transforming the object of interest; changing the appearance of the object of interest or background through image histogram modification, Gaussian filter, bilateral filter or median blur filter 603; or both using object placement and filter modification to create a plurality of images 606

15 useful in the unsupervised learning stage from images 601 used in the supervised learning stage. The method 600 depicted here can use geospatial images generated by either approach, identification of new images, or manipulation of the supervised learning image set, even some mixture of both methods, in the deep learning model training 607 of the automated image analysis module 540.

20 [070] Once trained, image analysis software module 540 can and often does have the ability to identify multiple categories of objects of interest 613 from caches of unanalyzed geospatial image segments 608. A first set may comprise buildings, tents, cars, airliners, oil refineries, and soccer fields. Another set may comprise zebra, elephants, tents, villages, light aircraft, and trucks. Items listed are merely a very short list of easily imagined examples, the model described herein allows

25 the identification of any object that can be discerned from geospatial images by all means known to the art either with or without the use of digital image filters 609 which may be selected from a set comprising color to grayscale conversion, histogram correction or equalization, or contrast enhancement filters 610. Image segments may also be passed through cloud detection filter 611 which analyzes images for cloud cover that occludes a percentage of the image deemed to make the

30 image unsuitable for further analysis and removes those images analysis 612. Model 600 can also allow for the automated identification and location determination of feature items of interest that vary greatly in size by using caches of unanalyzed source images that contain image segments of the same region stored at multiple scales. Sliding window software 614 that is part of 600 scans the images that are at different scales and precisely keeps track of the geographical coordinates by

converting scaling factor and internal segment coordinate system information of the image segment cache into latitude and longitude. This, for instance, for the purpose of example only, a single automated image analysis module 540 might locate all of the cities and oil wells within the same region during a single analysis. By using caches of image segments taken of the same region over
5 known intervals of time, the system might also be used to track migrations of animal herds, the movement of groups of people, or the movement of equipment, to name just a few of the many possible examples that one skilled in the art might envision, which are of significant interest but for which occupying the scarce and potentially costly talents of image analysts makes the study impractical. In all types of analysis, the system will generate some form of report 615. The format
10 of the report, whether it be a set of geospatial images marked in some manner to show the locations of items of interest, numeric output showing some code for each item category plus latitude and longitude coordinates, item codes with internal geospatial image segment cache coordinates which might also include segments rejected due to image occlusion or any other format either physical or electronic which is known to the art and desired by the requestor of the survey as
15 the system does not depend on one particular form of output.

[071] Fig. 7 is a three-panel example 700 of cloud detection by image correction and optimization module 541 depicted in the exemplary system architecture block diagram of Fig. 5. When system 500 loads an image 701 from the cache of multi-scale unanalyzed geospatial image segments 530 for analysis, several image filters from a set including, but not limited to, color correction, artifact
20 removal and resolution data determination may be applied. One such filter is specifically written to determine whether one or more portions of the field of view of the ground are occluded, for example by thick cloud cover. This software filter identifies subregions of the current working geospatial region that are obstructed by cloud cover using characteristics common to clouds in such images which include but are not limited to brightness, color uniformity and lack of image detail.
25 After establishing the edges of cloud using one of the many edge detection methods known within the art, the filter changes all pixels constituent to the cloud to a single color value 702 to clearly demarcate the portion of the image that is obstructed. Further software within the image correction and optimization module 541 may then reject the image from image analysis for object identification 540 based upon a pre-selected threshold 703.

30 [072] Fig. 8 is a three-panel diagram 800 depicting the operation of exemplary sliding window search and locate subroutines that are part of image analysis software module 540 of the invention depicted in Fig. 5. Establishment of the location of any identified objects of interest generally requires that conversion of the coordinate system used internal to the cache of multi-scale

unanalyzed geospatial image segments 530 to the coordinates of earth latitude and longitude takes place. Cached orthorectified geospatial image segments, or tiles 810, are regularly stored in caches using cache-internal coordinate systems 811, 812 of which the tile map service system and the web map tile service are two standardized examples that the invention might encounter. It should be clear, however, that the mention of these two systems should not be construed as the only possible coordinate systems that method 600 might use, as the invention does not depend on any specific system and tiles encoded by any coordinate system known to those skilled in the art may be used, provided that that system supplies a conversion pathway to geographical latitude and longitude and also includes scaling information. In one embodiment of this design, the image cache service might provide internal row and column numbers of an image segment's origin 813 in addition to a scaling factor of the segment that is supplied. From this segment-specific information and any additional cache coordinate system specification information, sliding window subroutines of the invention can easily and accurately convert from the cache's coordinate system to standard geographical longitude 821 and latitude 822 for any point of the ~~an~~ image segment that is undergoing analysis 820.

Specifically this is done by subroutines in the sliding window software module which, as the window of focus scans a first image segment for objects of interest 830, keeps track of the change in latitude and longitude using the equation $\Delta \text{new} = \text{asin}(\sin \Delta \text{old} \times \cos \theta + \cos \Delta \text{old} \times \sin \theta \times \cos \phi)$ for change in latitude and the equation $\Delta \text{new} = \Delta \text{old} + \text{atan2}(\sin \theta \times \sin \phi \times \cos \Delta \text{old} \times \cos \theta - \sin \Delta \text{old} \times \sin \Delta \text{new})$ for longitude where θ is latitude, ϕ is longitude, θ is bearing (clockwise from north) and ϕ is angular distance traveled ((scale corrected distance traveled/radius of the earth)) 831.

[073] Fig. 9 is a two-panel figure 900 showing two examples of the results that might be obtained upon analysis of image segments from one or more caches of orthorectified image segments by exemplary trained image analysis software module 540 of the invention. The left panel 910 of 900 shows an orthorectified geospatial image that has been scaled and tagged with yellow to allow those who receive the report to confirm a grouping of airliner category objects 912, 913, 914, 915. The legend for this panel 911 shows that image analysis software module in one embodiment of the system was trained to identify a plurality of object categories some of which were airliner, building, fighter aircraft, helicopter, road and refinery tank. This listing is exemplary of what might be part of a particular search report of this type and does not indicate that those items encompass the entire identification repertoire of the trained image analysis software module 540 employed to generate the report as one skilled in the art will understand that the listed categories are only a small subset of possible categories that might be identified by the invention. The right panel of Fig. 9, 920, again shows an orthorectified geospatial image that has been scaled and tagged this time with purple to allow those who receive the report to confirm a grouping of fighter aircraft category objects 922,

923, 924. The legend for this panel 921 shows that image analysis software module in this embodiment of the system was trained to identify a plurality of object categories that include airliner, bridge, fighter aircraft, helicopter, refinery tank, soccer field, baseball field. As in Panel 910, this listing is meant only to be exemplary of what might be included in a particular type of search report and not to indicate that those items encompass the entire identification repertoire of trained image analysis software module 540 used in the system. That the format of the reports found in Fig. 9, an orthorectified geospatial image scaled to show individual airliners or fighter aircraft and color coded to highlight those items as objects of interest, is just one easily discerned example of report types that could be generated by the system and is meant as such. These reports can take a plurality of forms depending upon requirements of the specifications of those who perform the search. One search might produce a report made up solely of rows of numbers, one to designate the specific object of interest that has been identified, a second for and third the latitude and the longitude at which that object or objects were found. Another embodiment might use further logic to produce identify the probable function of a particular grouping of objects. A grouping of airliners within a given area might get a single tag as an airport, or a grouping of automobiles tagged as a parking lot. When the invention is used to analyze the same specific region over some period of time, a report text only, tagged image of combinations of both may be generated only to record changes in the numbers of specific items drawn from a vast plurality of categories such as tents, cars, submarines, zebra, or tree cover. The invention is not constrained or defined by any particular report type.

[074] Fig. 11 is a process flow diagram of a method 1100 for geospatial image analysis that uses a method similar to that of 600, described above; however, the deep learning models 520, 1040 and the image analysis software 540, 1060 are combined with an image manipulation software module 1020 using a system of the invention. According to the embodiment, a search and locate function 1101 is conducted to identify and locate an object or item of interest from orthorectified geospatial imagery, regardless of whether the object is real or imaginary, so long as the searched object of interest was, is or could be, now or in the future, tangible and occupy 3-dimensional space. Method 600 is limited to searching for only objects or items which are known and have been previously identified and pre-labeled on real, existing geospatial imagery for the purpose of generating the training set for the deep learning module. Method 1100 allows for a "search and locate" action 1101 to be executed on any pre-labeled searchable object or set of objects. The search function 1101 may return data on any number of tagged, pre-labeled items from either real, pre-labeled imagery 1050 or synthetic images 1035 or synthetic imagery storage 1037 or any combination thereof. Using method 1100, a synthetic image can be generated for a specified object or item of

interest, as specified in the search function 1101. Searchable objects are retrieved from a database of modeled objects 1105 in response to the search function 1101 for the object of interest. By searching the 3-dimensional database of models 1105, the image manipulation software module 1020 retrieves a 3-dimensional model 1110 of the object of interest, creates a flattened 2-dimensional synthetic image 1120 from the selected 3-dimensional model and compares 1130 the 2-dimensional synthetic image 1120 to real, geospatial imagery of the same object, such that the image manipulation software module 1020 can scale, orient, or and align the flattened 2-dimensional image to replicate 1140 the real orthorectified geospatial image. Once the synthetic image has been initially replicated 1140, the image manipulation software module 1020 separates the synthetic image layer from the real image layer, such that pre-overlay filters 1160, color correction 1162 and resolution correction 1161 may be applied for initial tuning of the synthetic image to a plurality of backgrounds. Once the pre-overlay filters 1160 have been applied to the separated synthetic image layer 1150, the module 1020 will again overlay the synthetic image on the real geospatial image 1165 before adjusting the initial image to replicate a plurality of geographic locations, environmental factors, seasonal effects, and or shadowing effects accounting for sun angle, time of day, year as well as shadowing from localized light sources 1170. Post-overlay image filters 1175, such as color correction 1177 and resolution correction, smoothing, blurring or pixelating 1176, finalize the synthetic image before a synthetic footprint is demarcated 1180. The synthetic footprint demarcation 1180 is important as it may contain not only the synthetic image but also any associated shadowing associated with the synthetic object. The demarcated synthetic image 1180 is overlaid onto existing real imagery background, and using a masking function 1185 to set the background of the synthetic image to transparent such that existing imagery is not occluded. Finally, the software module 1020 runs a check 1190, to ascertain whether the synthetic image matches the pre-labeled real image, and if so, created a labeled synthetic image 1035 to be deposited into a labeled corpus training set 1037.

[075] Fig. 12 depicts a comparison panel 1200 comprising three pairs of images: 1201, 1202, 1203; within each pair of images, a circled object of interest 1225, 1245, 1265, 1267 on one of the images 1220, 1240, 1260 identifies a synthesized object that has been inserted. In image pair 1201, a synthetic image of a re-locatable type of object, in this case, a truck 1225 is shown on both images 1210 and 1220, with the synthetic truck 1225 being identified on image 1220. Similarly, image pair 1202 depicts a stationary item, a synthesized lattice-framed tower including its associated shadow 1245, identified on image 1240 but shown on both images in the pair 1202. Image pair 1203 illustrates a plurality of synthetic images 1265, 1267, and is provided to illustrate how more than one synthetic image may occur.

[076] Fig. 13 comprises a panel 1300 of three images 1301, 1302, 1303 which depict a real geospatial image 1301 of a roadway intersection resembling a traffic circle; a flattened 2-dimensional synthetic image 1302 of a tractor-trailer truck, in this case, already having been manipulated from its 3-dimensional state and oriented to match a predisposed turning radius aligned with traffic flow in the traffic circle; and a synthetically manipulated geospatial image 1303 showing synthetic image 1302 scaled, aligned, masked and overlain onto geospatial image 1301 merged into synthetic image overlay area 1330. Area 1310 on real image 1301 is demarcated for comparison to identify the area 1330 in which synthetic image 1302 is placed. Real vehicle 1320 is identified on image 1301 as reference for scale and alignment of vehicles within the circle, as well as associated shadowing. As in the case of synthetic image overlay 1330, shadowing of the synthetic tractor-trailer truck 1302 has not been applied.

[077] The skilled person will be aware of a range of possible modifications of the various embodiments described above. Accordingly, the present invention is defined by the claims and their equivalents.

What is claimed is:

1. A system for broad area geospatial object detection using synthetically-generated training images comprising an image manipulation software module comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor, wherein the
5 plurality of programming instructions:

(a) retrieves 3-dimensional model of an object of interest from an established data store;

(b) creates a flattened, ~~nadir-directional~~ 2-dimensional image from the 3-dimensional model;

(c) compares the flattened image to a real geospatial image and associated background of the same object of interest;

10 (d) scales the flattened modeled image to align with the real geospatial image of the same object and upon successful alignment, separates the modeled image from the background of the real image in order to fine tune components of the flattened modeled image, which may include smoothing edges and/or color matching to assimilate the real image;

(e) applies a plurality of environmental effects to replicate seasonal, timestamps, associated
15 brightness, and environmental factors consistent with a geographic location of the real background image to create a plurality of modified synthetic images;

(f) creates a plurality of shadowed, modified 2-dimensional synthetic images for the 3-dimensional object as if it were physically located and oriented where it would be affected by real-time and real-world shadowing;

20 (g) compares and adjusts the shadowed, modified synthetic 2-dimensional images by pixelating and blurring or focusing to resemble the real image;

(h) identifies and demarcates a footprint associated with each of the shadowed, modified synthetic 2-dimensional images;

(i) overlays the demarcated footprint onto a real image and masks the background colors surrounding the synthetic image to become transparent such that overlay onto the real image does not obscure existing images to create a manipulated synthetic image; and

(j) generates a labeled corpus of manipulated synthetic training data comprising a plurality of modified images for use by a deep learning model training software module.

2. A system for broad area geospatial object classification using the system of Claim 1, further comprising a deep learning software module comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor, wherein the plurality of programming instructions:

(a) receives training data comprising a plurality of orthorectified geospatial images with a plurality of objects present therein, at least a first subset of the plurality of objects being the labeled corpus of Claim 1-(j) and a second subset of objects being unlabeled;

(b) aggregates the training data and classifies the training data into a plurality of predefined categories;

(c) optimizes the training data for deep learning model training;

(d) discards images unsuitable for analysis; and

(e) generates an object classification model from the system of Claim 1 by using a deep learning method comprising separate processing of the first and second subsets of the training data through a convolutional neural network system.

3. A system for broad area geospatial object recognition and identification using the synthetically-generated training system of Claim 1 with the classification system of Claim 2, to analyze a large set of orthorectified geospatial images, further comprising an image analysis software module comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor, wherein the plurality of programming instructions:

(a) uses the object classification model generated in Claim 2-(e) to automatically identify and label all objects of interest as featured items in a received data set comprising a plurality of unanalyzed orthorectified geospatial imagery, regardless of the orientation or scale of the feature item within the section, and accounting for differences in item scale by using a multi-scale sliding window algorithm;
5 and

(b) outputs the locations of the identified objects of interest in a form dictated by the parameters of the original search request.

4. A method for creating a large corpus of synthetically generated training images for a specified object of interest, of which only a small number of real images exist, the method comprising the steps of:

- 10 (a) generating a realistic 2-dimensional image of an object of interest from a replica of the same object of interest, using an image manipulation software module, comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor; and
(b) manipulating the synthetically generated 2-dimensional image to create a plurality of synthetic images of the object of interest, placing the synthetic image in a plurality of locations, environments,
15 orientations, scales, exposures, and foci in order to create a large corpus of training images for use by a deep learning training module.

5. A method for an automated system to identify, classify, locate and quantify an object of interest from geospatial imagery, regardless of rarity of existing images of the object of interest within a given set of geospatial images, comprising the following steps:

- 20 (a) create a large corpus of synthetically generated training images as per Claim 4;
(b) create a classification using a deep learning training module, comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor, by using synthetic training images as labeled images to train the deep learning module how to identify and classify the object within a plurality of sets of unlabeled images; and

(c) analyze a large set of unlabeled images using a convolutional neural network serving as an image analysis software module, comprising a processor, a memory, and a plurality of programming instructions stored in the memory and operable on the processor, to compare labeled images to unlabeled images, thus generating an output file in a requestor's preferred format, comprising location, classification, and quantity of the object of interest.

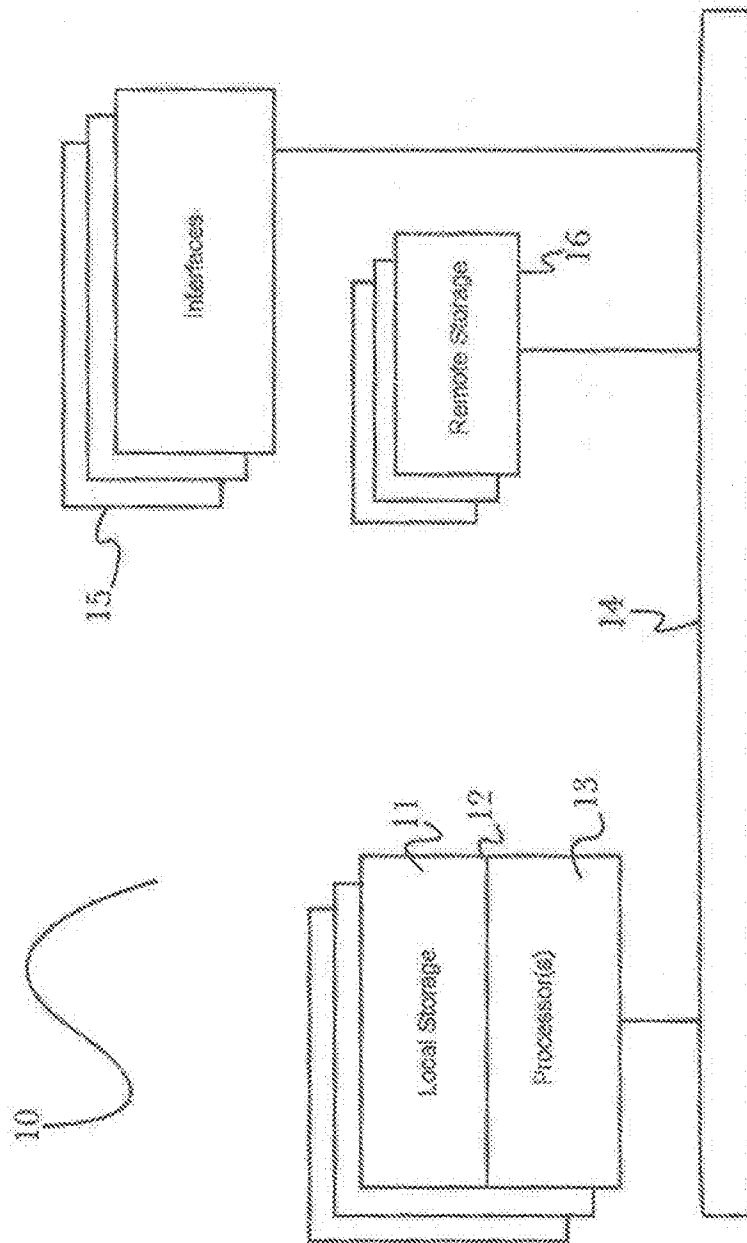


Fig. 1

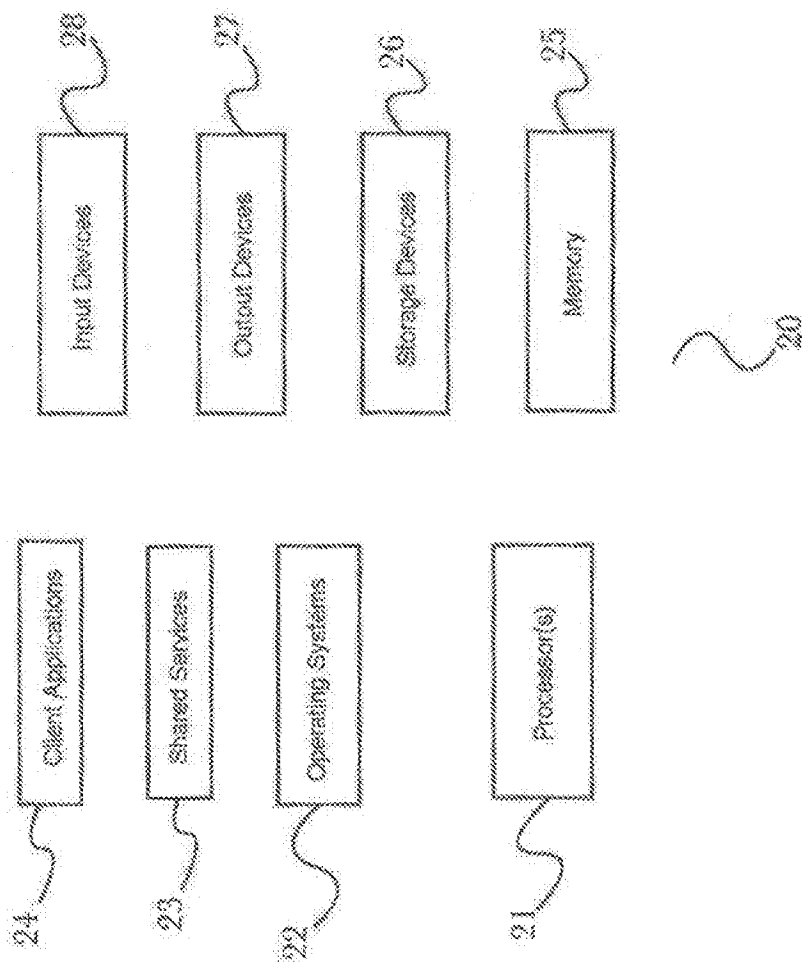


Fig. 2

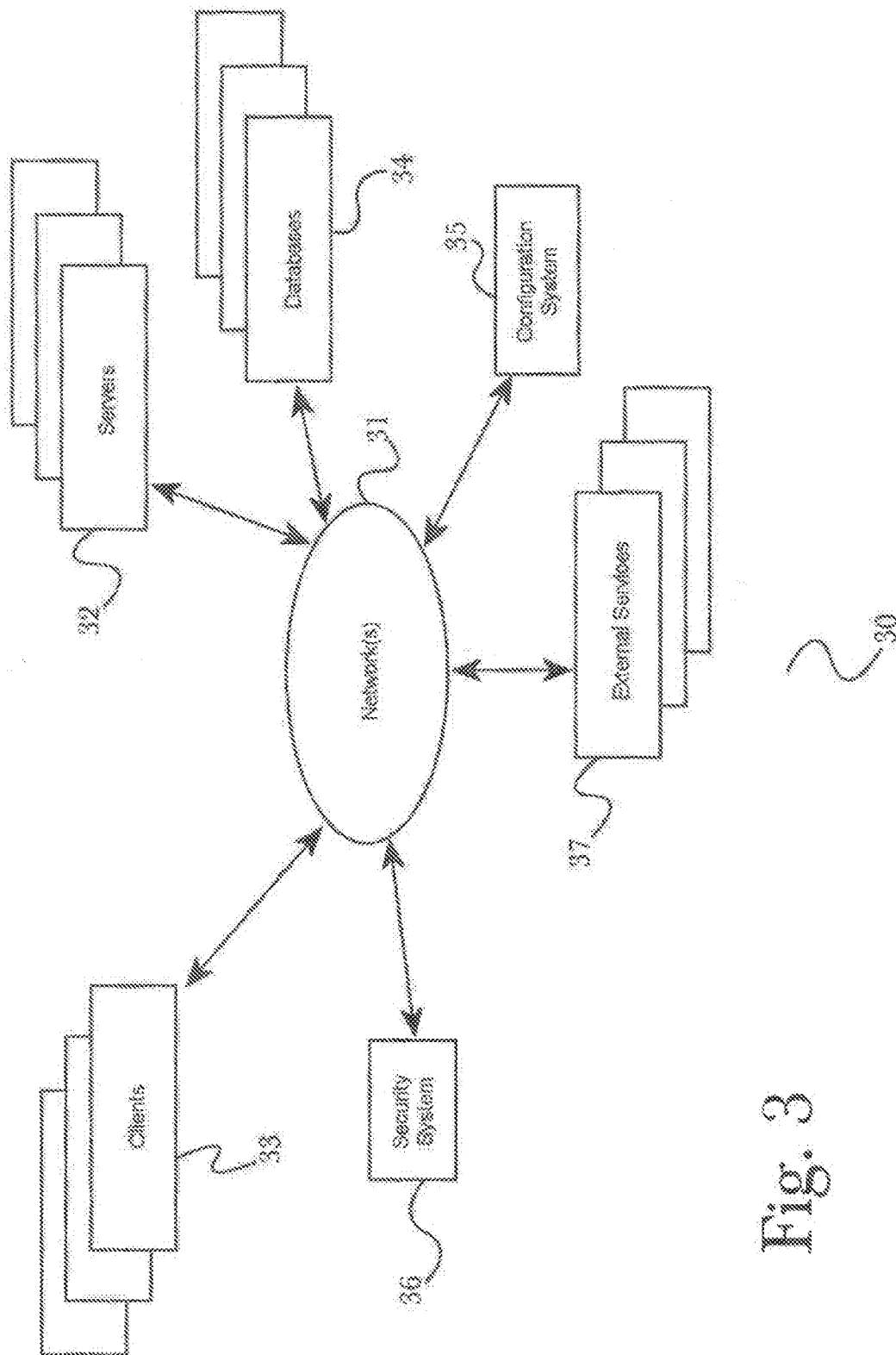


Fig. 3

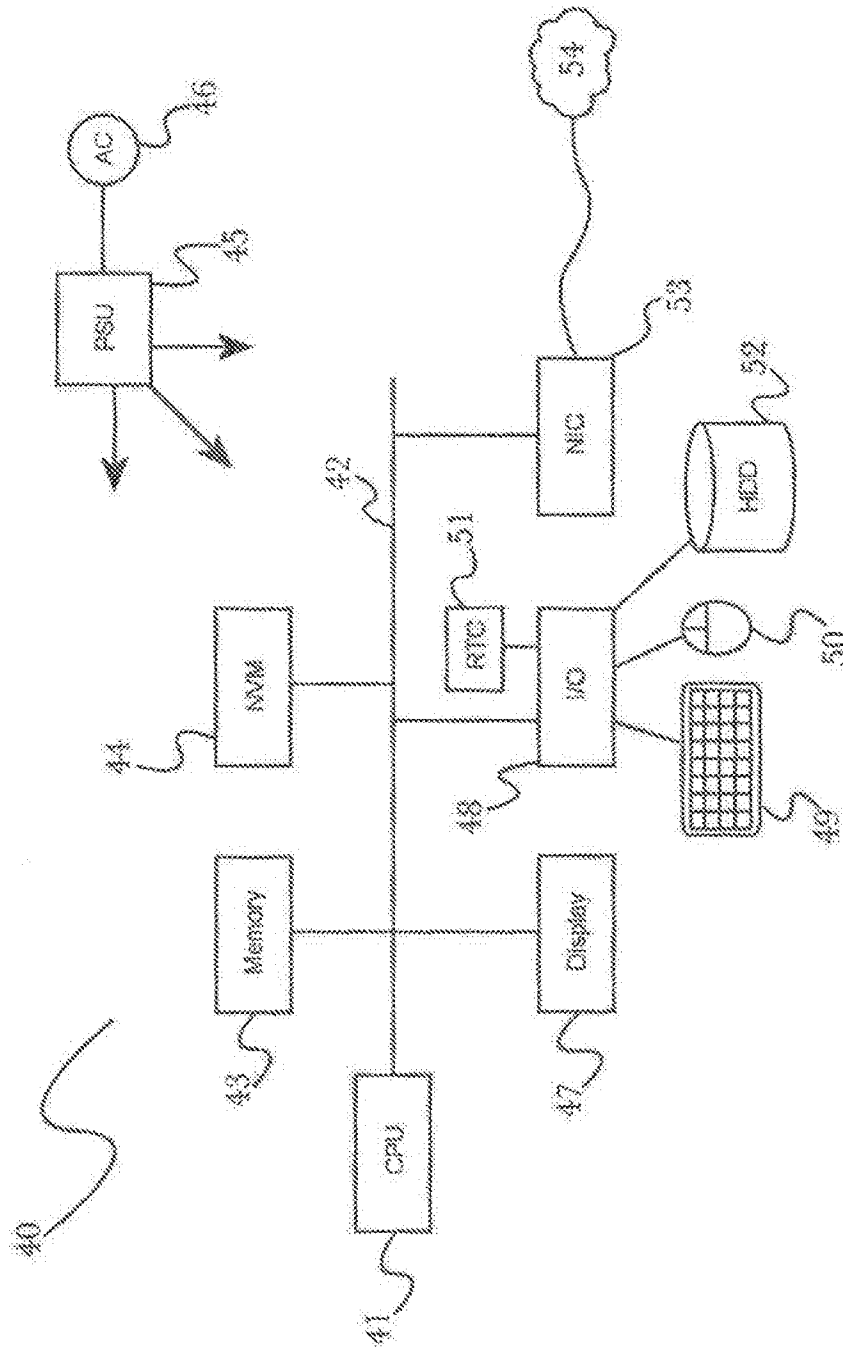


Fig. 4

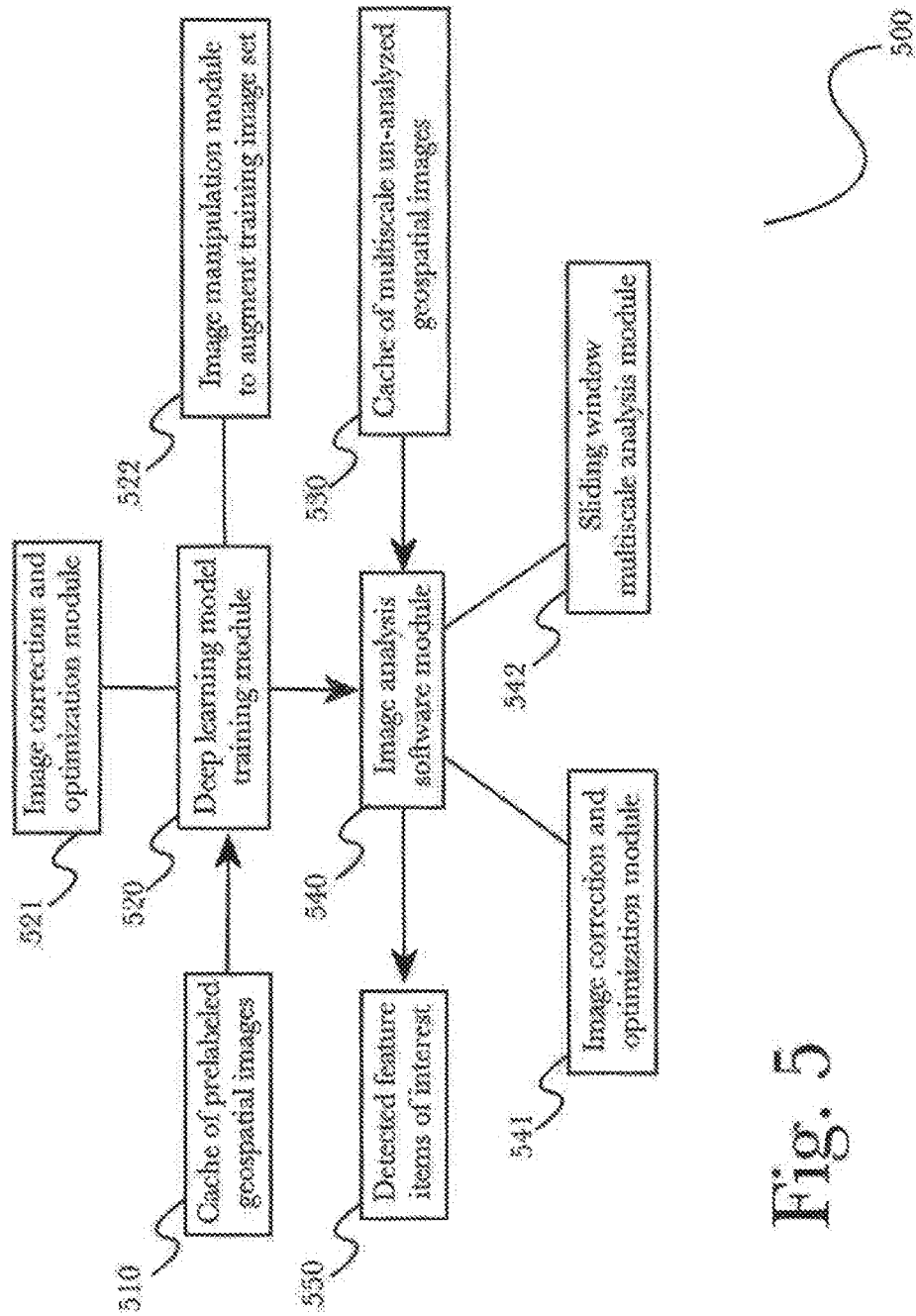
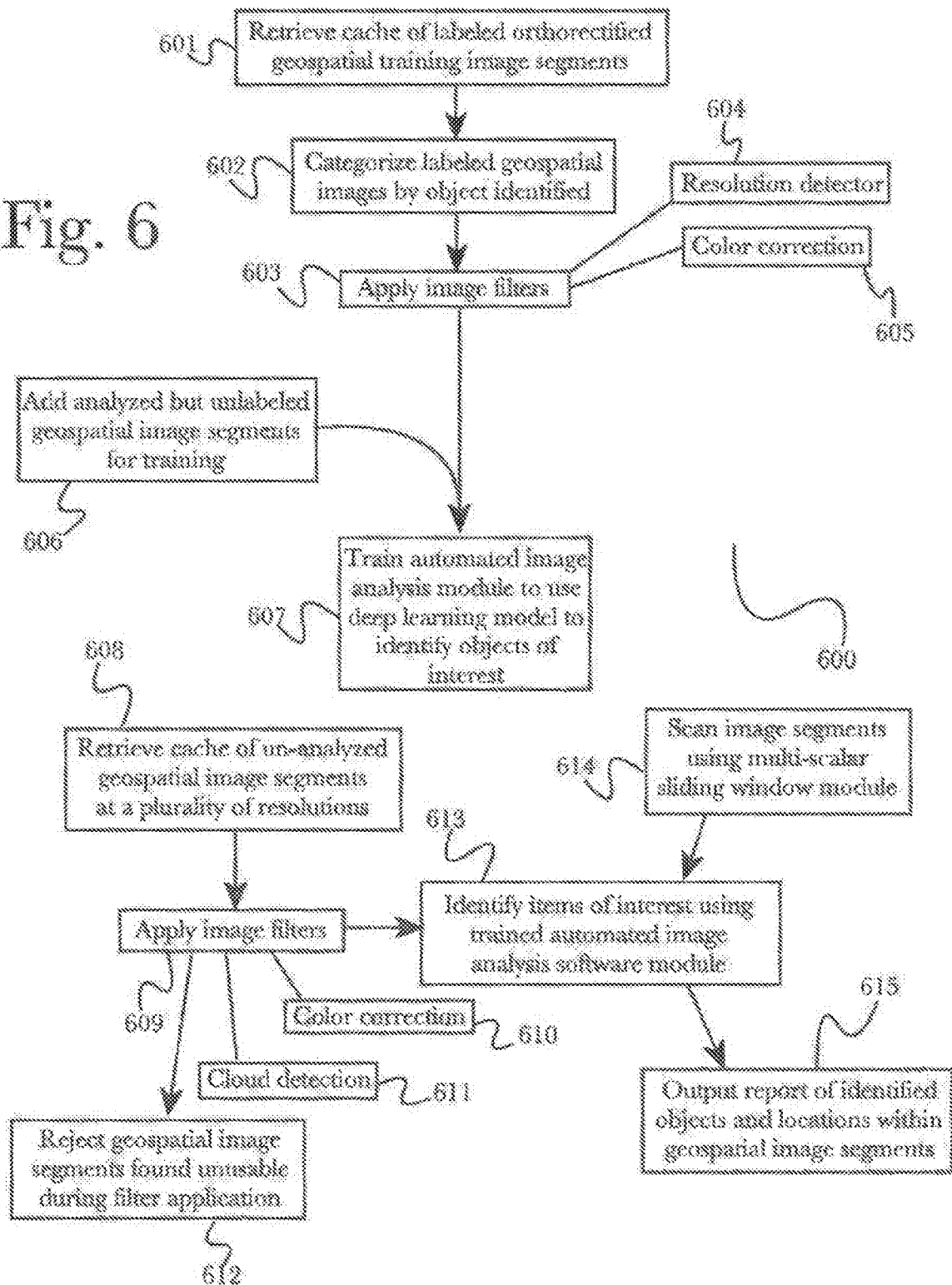


Fig. 5

6/13

Fig. 6



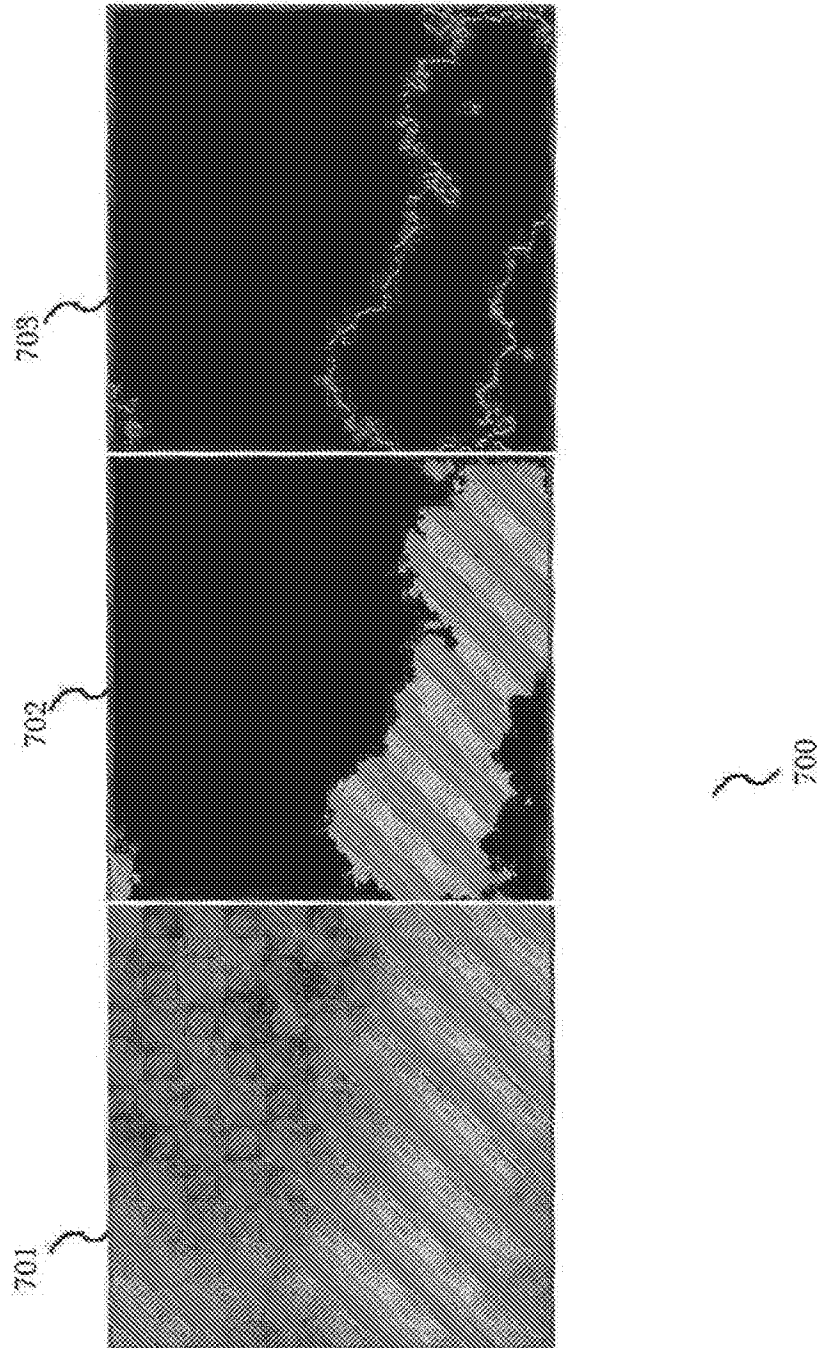


Fig. 7

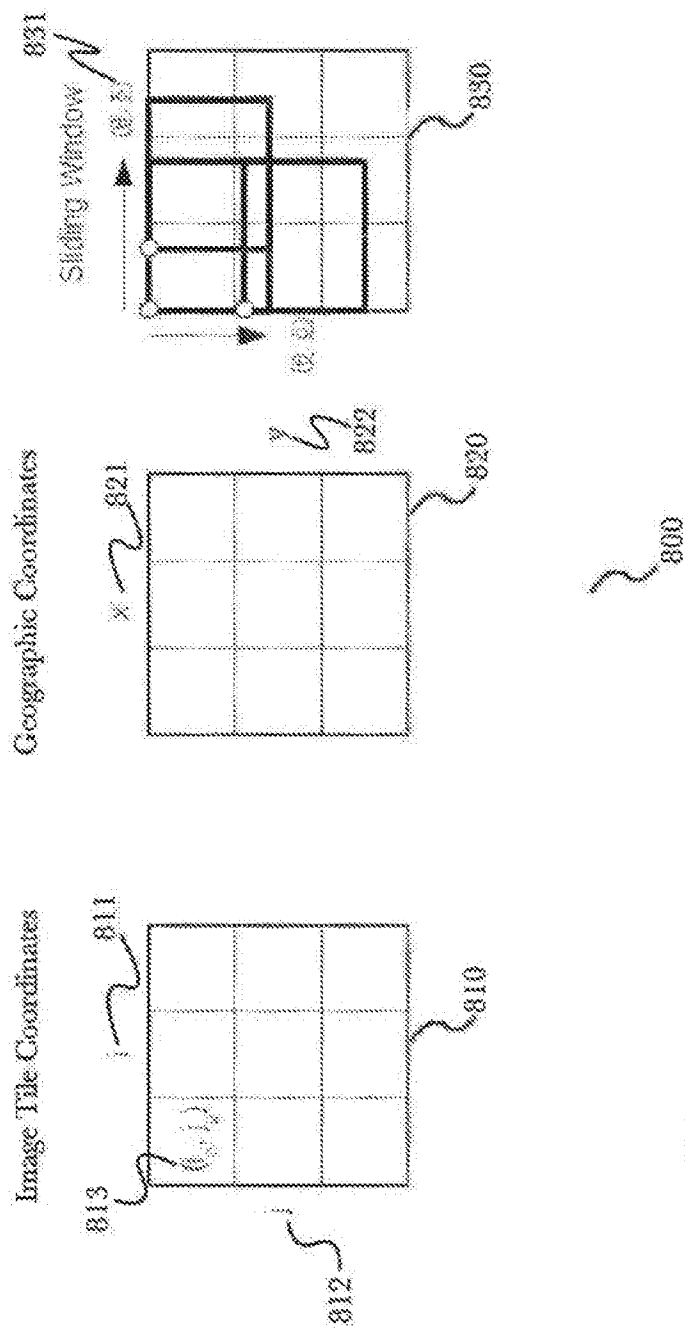


Fig. 8

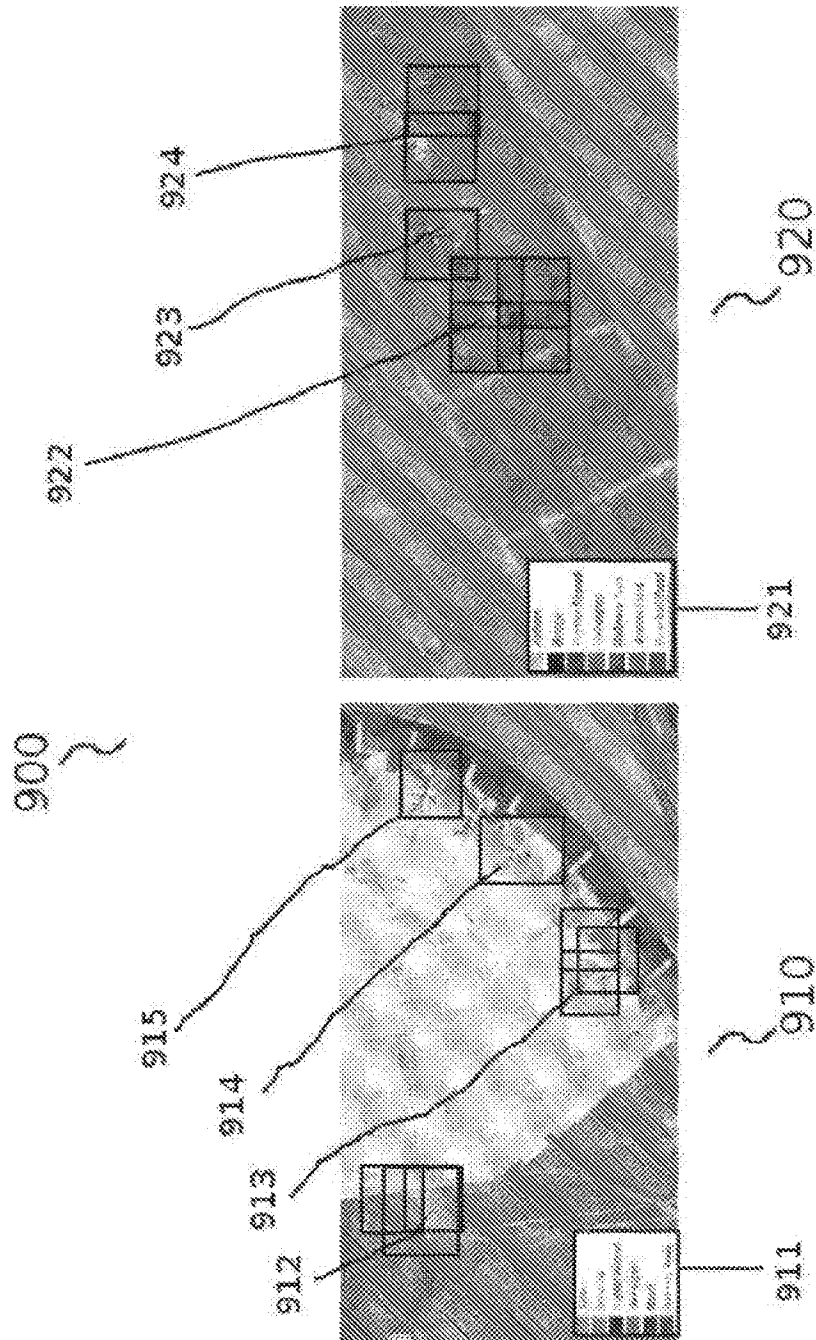


Fig. 9

10/13

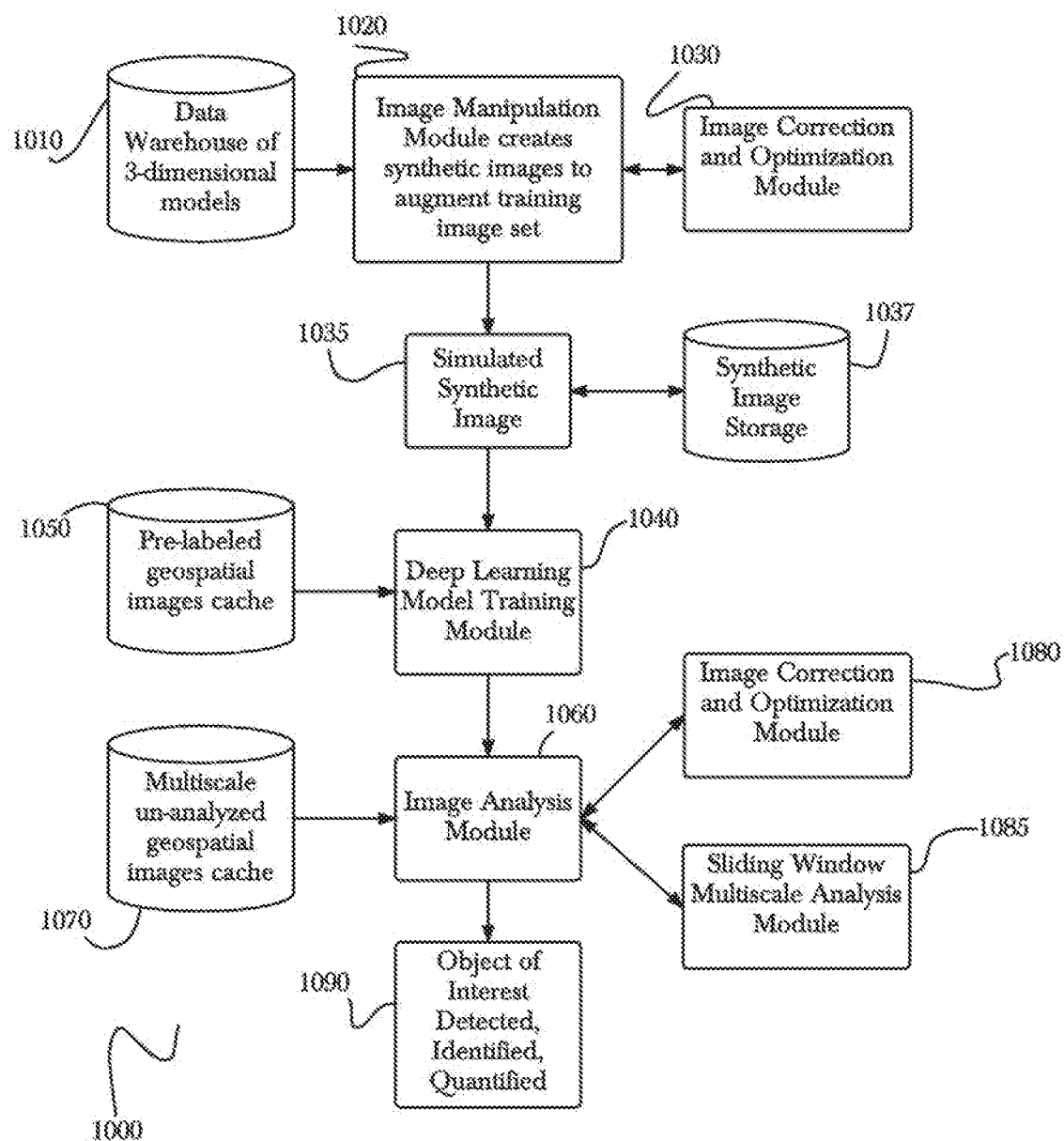


Fig. 10

11/13

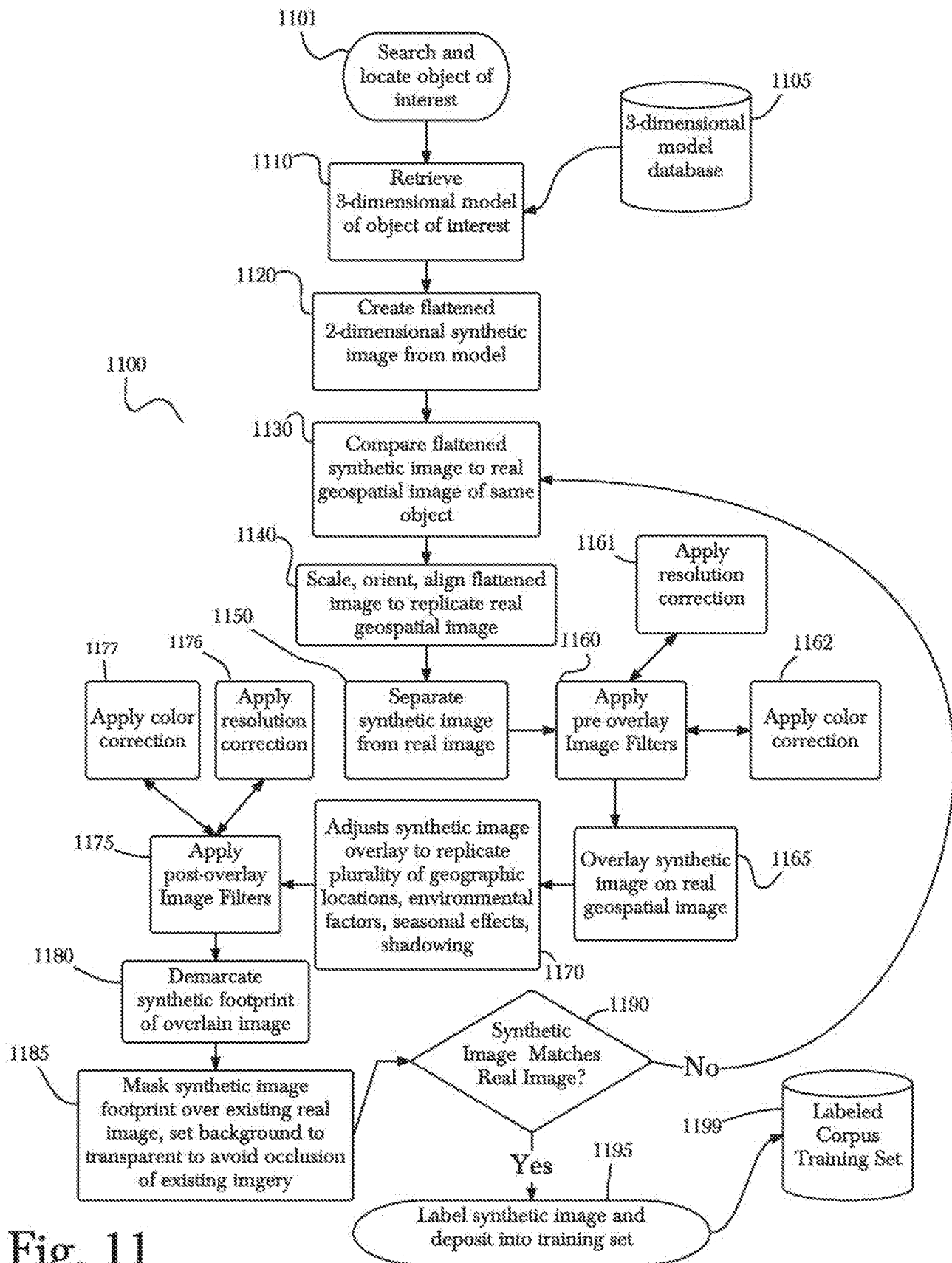


Fig. 11

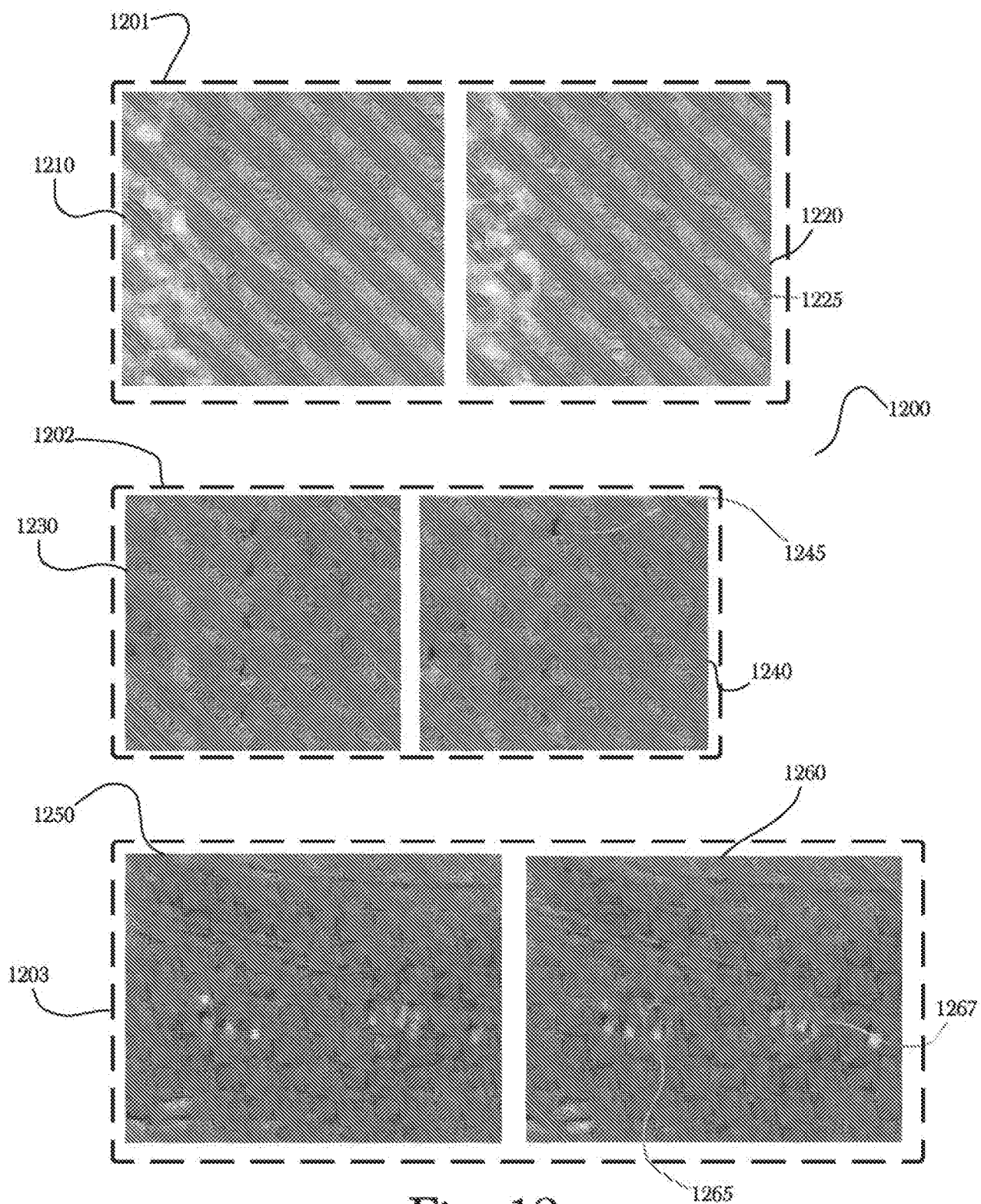


Fig. 12

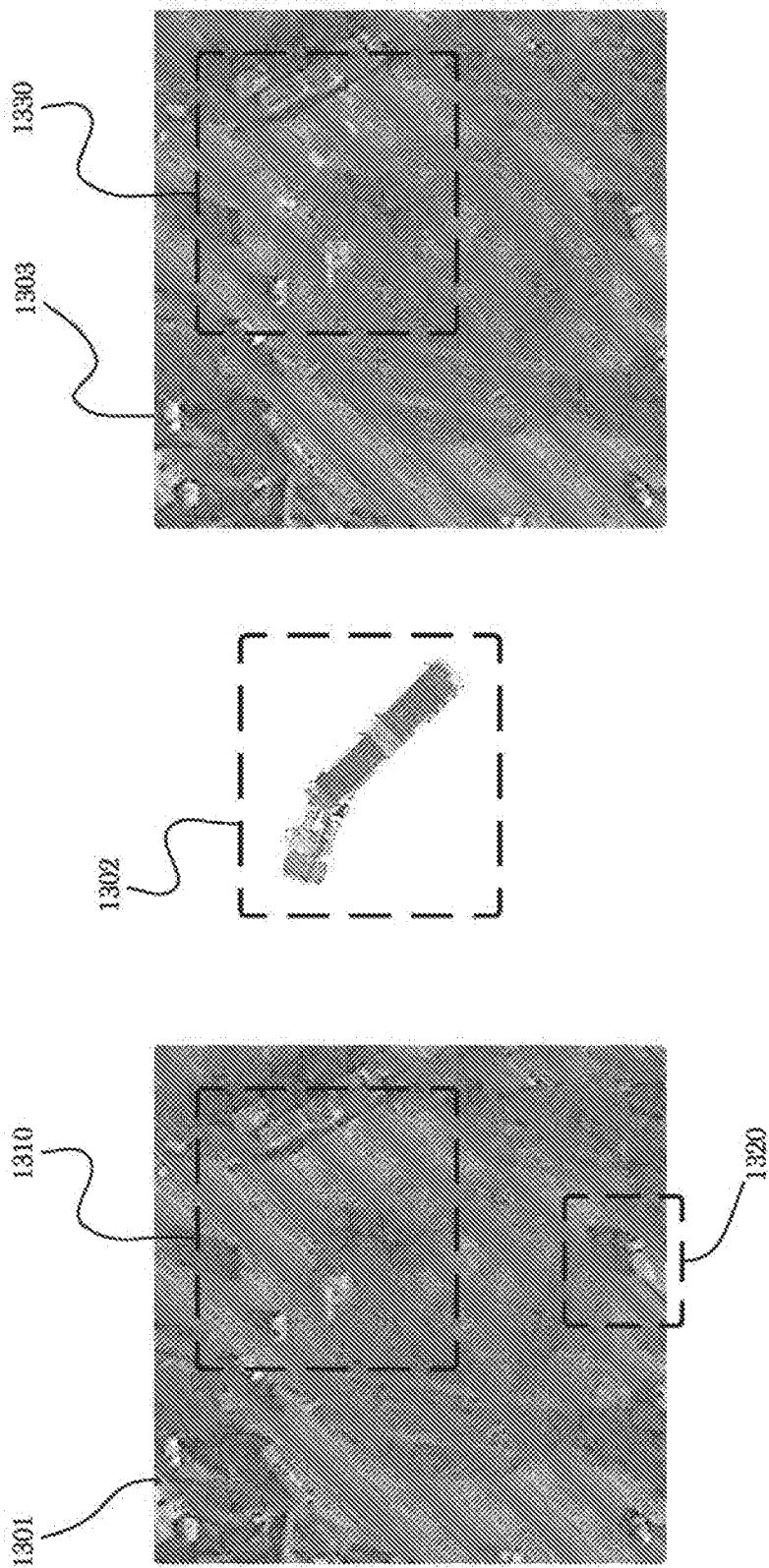


Fig. 13

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International application No.

PCT/US 2017/020032

A. CLASSIFICATION OF SUBJECT MATTER

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G06T 3/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

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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)

PatSearch (RUPTO internal), USPTO, PAJ, K-PION, Esp@cenet, Information Retrieval System of EIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/0079314 A1 (YAKUBOVICH YURY) 20.03.2014, abstract, paragraphs [0013], [0048], [0051], [0058], [0063]-[0078], [0083], [0092], [0107], [0112], [0123]-[0125], [0129], [0131], [0138], [0143]-[0160], [0175]-[0178], [0188]	4, 5
Y		1-3
Y	US 2002/0106114 A1 (MICROSOFT CORP) 08.08.2002, abstract, paragraphs [0005], [0010], [0067]	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

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document member of the same patent family

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(81) Bestimmungsstaaten (Soweit nicht anders angegeben, für
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(54) Title: AIRCRAFT FOR SCANNING AN OBJECT, AND SYSTEM FOR DAMAGE ANALYSIS FOR THE OBJECT

(54) Bezeichnung: FLUGMOBIL ZUM SCANNEN EINES OBJEKTS UND SYSTEM ZUR SCHADENSANALYSE DES OBJEKTS

FIG 1A

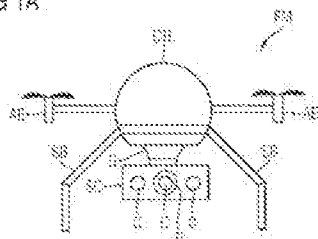
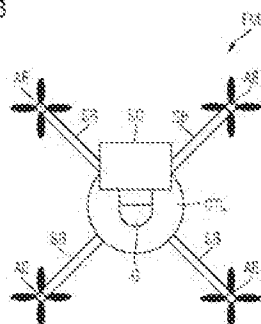


FIG 1B



(57) Abstract: The aircraft (FM) according to the invention comprises a helicopter
drone (HD) on which a 3D scanner (SC) is mounted via an actively rotatable joint
(G). The 3D scanner (SC) has at least one high-resolution camera (C) for recording a
multiplicity of overlapping images (IMG) of the object (OBJ) from different recording
positions and recording directions, so that comparison of the images allows a position
and orientation of the 3D scanner (SC) relative to the object (OBJ) to be ascertained.
In addition, the aircraft (FM) according to the invention has a coordination device
(CO) for coordinated control of the 3D scanner (SC), the joint (G) and the helicopter
drone (HD). The system for damage analysis according to the invention has an aircraft
(FM) according to the invention and an image processing module (IP) generating a
data representation of a surface profile (OBV) of the object (OBJ) on the basis of the
recorded images (IMG). In addition, the system comprises a rating device (EV) for
checking the surface profile (OBV) and for outputting a damage statement (DAM) on
the basis of the check.

(57) Zusammenfassung: Das erfindungsgemäße Flugmobil (FM) umfasst eine He-
likopter-Drohne (HD), an der über ein aktiv drehbares Gelenk (G) ein 3D-Scanner
(SC) montiert ist. Der 3D-Scanner (SC) weist mindestens eine hochauflösende Kame-
ra (C) zum Aufnehmen einer Vielzahl von überlappenden Bildern (IMG) des Objekts
(OBJ) aus verschiedenen Aufnahmepositionen und Aufnahmerichtungen auf, so dass
durch Vergleich der Bilder eine Position und Orientierung des 3D-Scanners (SC) rela-
tiv zum Objekt (OBJ) ermittelbar ist. Weiterhin verfügt das erfindungsgemäße Flug-
mobil (FM) über eine Koordinationsseinrichtung (CO) zum koordinierten Steuern des
3D-Scanners (SC), des Gelenks (G) und der Helikopter-Drohne (HD). Das erfindungs-
gemäße System zur Schadensanalyse verfügt über ein erfindungsgemäßes Flugmobil
(FM) sowie über ein Bildverarbeitungsmodul (IP) zum Generieren einer Datendarstel-
lung eines Oberflächenverlaufs (OBV) des Objekts (OBJ) anhand der aufgenomme-
nen Bilder (IMG). Weiterhin umfasst das System eine Bewertungseinrichtung (EV)
zum Prüfen des Oberflächenverlaufs (OBV) und zum Ausgeben einer Schadensangabe
(DAM) abhängig von der Prüfung.

[Fortsetzung auf der nächsten Seite]

SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, EG, KZ, RU, TJ, TM), europäisches (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, KM, ML, MR, NE, SN, TD, TG).

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— mit internationalem Recherchebericht (Artikel 21 Absatz 2).

Beschreibung

Flugmobil zum Scannen eines Objekts und System zur Schadensanalyse des Objekts

5

Eine Inspektion von schwer zugänglichen technischen Objekten wie z.B. Flugzeug- oder Schiffsrümpfen oder Rotorblättern von Windkraftanlagen erweist sich häufig als sehr aufwändig. Im Falle von Schiffsrümpfen bedarf es bei größeren Schäden eines längeren Aufenthaltes in einem Dock, weil eine Schadensanalyse häufig eine genaue Kenntnis einer Schadensgeometrie voraussetzt. Im Falle von Windkraftanlagen werden zur visuellen Inspektion von Rotorblättern neuerdings kamerabasierte Drohnensysteme verwendet. Eine solche visuelle Inspektion ist jedoch häufig nicht ausreichend genau, um Schäden mit der gebotenen Sicherheit zu erkennen oder auszuschließen. Im Zweifel sind die Rotorblätter in der Regel mit großem Aufwand zu demontieren, um am Boden eine genaue Vermessung der Schadensgeometrie durchzuführen. Eine solche Demontage ist häufig sehr kostenintensiv und hat zudem einen temporären Ausfall der Windkraftanlage zur Folge.

Es ist Aufgabe der vorliegenden Erfindung, Anordnungen anzugeben, mit denen sich ein Zustand oder Schaden insbesondere großer Objekte genauer erfassen lässt.

Gelöst wird diese Aufgabe durch ein Flugmobil mit den Merkmalen des Patentanspruchs 1 sowie durch ein System mit den Merkmalen des Patentanspruchs 7.

30

Gemäß einem ersten Aspekt der Erfindung ist ein Flugmobil zum Scannen eines Objekts vorgesehen. Das Flugmobil umfasst eine Helikopter-Drohne, an der über ein aktiv drehbares Gelenk ein 3D-Scanner montiert ist. Der 3D-Scanner weist mindestens eine hochauflösende Kamera zum Aufnehmen einer Vielzahl von überlappenden Bildern des Objekts aus verschiedenen Aufnahmepositionen und Aufnahmerichtungen auf, so dass durch Vergleich der Bilder eine Position und Orientierung des 3D-Scanners re-

lativ zum Objekt ermittelbar ist. Weiterhin verfügt das erfindungsgemäße Flugmobil über eine Koordinationseinrichtung zum koordinierten Steuern des 3D-Scanners, des Gelenks und der Helikopter-Drohne.

5

Gemäß einem weiteren Aspekt der Erfindung ist ein System zur Schadensanalyse eines Objekts vorgesehen. Dieses System verfügt über ein erfindungsgemäßes Flugmobil sowie über ein Bildverarbeitungsmodul zum Generieren einer Datendarstellung eines Oberflächenverlaufs des Objekts anhand der aufgenommenen Bilder. Weiterhin umfasst das System eine Bewertungseinrichtung zum Prüfen des Oberflächenverlaufs und zum Ausgeben einer Schadensangabe abhängig von der Prüfung. Die Prüfung kann beispielsweise durch Vergleich des Oberflächenverlaufs mit einem vorgegebenen Sollverlauf erfolgen.

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Die Nutzung einer mit einem 3D-Scanner versehenen Helikopter-Drohne ist insofern vorteilhaft, als letztere in der Regel zum Schwebeflug fähig ist und auch rückwärts oder seitwärts fliegen kann. Dies erlaubt ein genaues und vollständiges Scannen auch großer Objekte, wie z.B. von Rotoren von Windkraftanlagen ohne aufwendige Demontage. Durch die Verwendung eines 3D-Scanners können Oberflächen großer Objekte sehr genau vermessen werden und genaue, zur Schadensanalyse geeignete Geometriemodelle erstellt werden.

20
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Vorteilhafte Ausführungsformen und Weiterbildungen der Erfindung sind in den abhängigen Ansprüchen angegeben.

Nach einer vorteilhaften Ausführungsform kann der 3D-Scanner ein mobiles 3D-Scansystem mit mehreren räumlich versetzten Kameras sein. Insbesondere kann 3D-Scantechnologie für handgeführte 3D-Scanner, z.B. mit Weiß-/Blau-/Blitzlichttechnik eingesetzt werden. Aktuell erhältliche mobile 3D-Scansysteme können auch bei moderaten Bewegungsschwankungen eine Scangeauigkeit von Bruchteilen von Millimetern erreichen, z.B. ca. 1/30 mm. Derartige mobile 3D-Scansysteme erlauben genaue Scans auch beim Transport durch eine Helikopter-Drohne, die

30
35

naturgemäß gewissen Bewegungsschwankungen durch Windböen unterworfen ist.

Vorzugsweise kann der 3D-Scanner einen Projektor zum Projizieren von strukturiertem Licht auf das Objekt aufweisen. Die
5 mindestens eine Kamera kann entsprechend dazu ausgelegt sein, auf das Objekt projizierte Lichtstrukturen aufzulösen. Die Erfassung von auf das Objekt projizierten Lichtstrukturen verbessert in der Regel eine Erfassung eines dreidimensionalen
10 Oberflächenverlaufs erheblich.

Nach einer vorteilhaften Weiterbildung der Erfindung kann das Flugmobil eine Markierungseinrichtung zum optischen Markieren von spezifischen Stellen einer Oberfläche des Objekts aufwei-
15 sen. Eine solche Markierung kann z.B. durch Aufsprühen von Farbe auf das Objekt erfolgen. Derartige Markierungen können insbesondere an Stellen mit geringer eigener visueller Strukturierung eine Erfassung eines dreidimensionalen Oberflächenverlaufs erheblich verbessern.

20 Darüber hinaus kann die Koordinationseinrichtung dazu eingerichtet sein, abhängig von den aufgenommenen Bildern eine Position und/oder Orientierung des Flugmobils relativ zum Objekt zu ermitteln und abhängig davon Fluganweisungen an die
25 Helikopter-Drohne, Drehanweisungen an das Gelenk, Scan-Anweisungen an den 3D-Scanner, Aufnahmeanweisungen an die mindestens eine Kamera und/oder Markierungsanweisungen an die Markierungseinrichtung zu übermitteln. Auf diese Weise kann eine Position, Orientierung und/oder ein bevorzugter Abstand
30 des Flugmobils und/oder des 3D-Scanners relativ zum Objekt durch geeignete Fluganweisungen autonom oder teilautonom geregelt und/oder stabilisiert werden. Zudem kann die Ausrichtung des 3D-Scanners durch geeignete Drehanweisungen an das Gelenk autonom oder teilautonom geregelt und/oder stabilisiert
35 werden. Hierdurch können insbesondere Positionsschwankungen des Flugmobils in koordinierter, autonomer oder teilautonomer Weise ausgeglichen werden. Weiterhin können noch nicht gescannte Teile des Objekts autonom oder teilautonom

erkannt, angeflogen und gescannt werden. Dies erleichtert insbesondere ein Scannen von bewegten Objekten.

5 Ferner kann das Flugmobil über eine von der Helikopter-Drohne und dem 3D-Scanner gemeinsam zu nutzende Batterie verfügen. Die gemeinsame Nutzung der Batterie ist gegenüber einer Nutzung separater Batterien insofern vorteilhaft, als vermieden werden kann, dass eine erste Batterie leer ist und die Mission damit beendet wäre, wenn eine andere Batterie noch Ener-
10 giereserven hätte.

Nach einer vorteilhaften Ausführungsform des erfindungsgemäßen Systems zur Schadensanalyse kann das Bildverarbeitungsmo-
15 dulo dazu eingerichtet sein, in verschiedenen überlappenden Bildern gemeinsame Bildmuster im Überlappungsbereich zu erfassen, die verschiedenen Bilder bezüglich des gemeinsamen Bildmusters einander zuzuordnen und anhand der einander zugeordneten Bilder einen bildübergreifenden Oberflächenverlauf zu ermitteln. Als Bildmuster kann insbesondere eine geometri-
20 sche Struktur und/oder Textur der Objektoberfläche und/oder eine auf das Objekt projizierte Lichtstruktur erfasst werden. Ein solches bildmustertreues Zuordnen und Zusammensetzen verschiedener Bilder zu einem bildübergreifenden Oberflächenverlauf wird häufig auch als „Stitching“ bezeichnet.

25 Nach einer vorteilhaften Weiterbildung der Erfindung kann das erfindungsgemäße System eine Simulationseinrichtung aufweisen zum Simulieren eines statischen und/oder dynamischen Verhaltens des Objekts anhand des Oberflächenverlaufs. Die Bewertungseinrichtung kann dann dazu eingerichtet sein, das simu-
30 lierte Verhalten mit einem vorgegebenen Sollverhalten des Objekts zu vergleichen und die Schadensangabe abhängig vom Vergleichsergebnis auszugeben. Die Simulation kann hierbei z.B. mittels eines numerischen Finite-Elemente-Verfahrens durchge-
35 führt werden. Insbesondere kann die Simulationseinrichtung dazu eingerichtet sein, anhand des Oberflächenverlaufs ein Volumenmodell des Objekts zu generieren und das Verhalten anhand des Volumenmodells zu simulieren. Mittels der Simulation

kann der Oberflächenverlauf automatisch hinsichtlich seiner Auswirkungen auf eine Funktion des Objekts geprüft werden. Dies erleichtert eine automatische Schadensbewertung erheblich.

5

Ein Ausführungsbeispiel der Erfindung wird nachfolgend anhand der Zeichnung näher erläutert. Dabei zeigen jeweils in schematischer Darstellung:

10 Figur 1A eine Vorderansicht eines erfindungsgemäßen Flugmobils,

Figur 1B eine Untersicht des erfindungsgemäßen Flugmobils und

15

Figur 2 ein Blockdiagramm eines erfindungsgemäßen Systems zur Schadensanalyse eines Objekts.

Die Figuren 1A und 1B zeigen jeweils ein erfindungsgemäßes Flugmobil FM zum Scannen eines Objekts in schematischer Darstellung. Während Figur 1A eine Vorderansicht des Flugmobils FM zeigt, ist in Figur 1B eine Untersicht desselben Flugmobils FM dargestellt.

25 Das Flugmobil FM umfasst eine interaktiv fernsteuerbare Helikopter-Drohne, an der über ein aktiv drehbares Gelenk G ein 3D-Scanner SC montiert ist. Die Helikopter-Drohne verfügt beispielhaft über vier Auftriebseinheiten AE mit jeweils einem Elektromotor, durch den ein senkrecht wirkender Propeller angetrieben wird. Alternativ kann auch eine Helikopter-Drohne mit einer anderen Anzahl von Auftriebseinheiten, z.B. eine sog. Octocopter-Drohne mit 8 Auftriebseinheiten verwendet werden. Die Helikopter-Drohne verfügt weiterhin über vier Standbeine SB.

35

Als 3D-Scanner SC wird ein mobiles, hochgenaues 3D-Scansystem z.B. mit Weiß-/Blau-/Blitzlichttechnik verwendet. Derartige mobile 3D-Scansysteme sind erst seit kurzem verfügbar und

werden häufig in handgeführten 3D-Scannern eingesetzt. Die mobilen 3D-Scansysteme können auch bei moderaten Bewegungsschwankungen Scan-Genauigkeiten von ca. 1/30mm erreichen, was innerhalb der Zeichnungstoleranzen vieler hochgenau gefertigter Bauteile liegt. Zudem können mobile 3D-Scanner weniger als ein Kilogramm wiegen und in ihrer größten Abmessung unter 30cm bleiben. Eine solche kompakte Bauform ermöglicht überhaupt erst einen Transport per Helikopter-Drohne. Der Scanabstand derartiger 3D-Scanner kann ca. einen Meter erreichen, so dass es in der Regel nicht schwierig ist, Kollisionen des Flugmobils FM mit einem zu scannenden Objekt zu vermeiden. Ein räumlicher Versatz der Helikopter-Drohne durch Windböen kann mit zeitgemäßer mobiler 3D-Scantechnik korrigiert werden, da sowohl Geometrie- und Texturinformation des gescannten Objekts als auch eine Projektion strukturierten Lichtes verwendet werden können, um Scan-Abschnitte zusammenzufügen. Ein mobiler 3D-Scanner kann eine genaue Geometriebeschreibung einer Oberfläche des gescannten Objekts in Form einer Triangulierung, zum Beispiel im sogenannten stl-Format ausgeben.

Das Gelenk G hat eine horizontale und eine vertikale Drehachse, die jeweils per Elektromotor drehbar ist. Hierdurch kann der 3D-Scanner SC sowohl um die horizontale Drohnenachse als auch um die vertikale Drohnenachse gedreht werden, so dass durch geeignete Ansteuerung des Gelenks G das Objekt auch von oben gescannt werden kann.

Der 3D-Scanner SC umfasst mehrere hochauflösende (nur in Figur 1A dargestellte) Kameras C. Im vorliegenden Ausführungsbeispiel verfügt der 3D-Scanner SC über drei räumlich versetzte, hochauflösende Kameras C mit unterschiedlicher Blickrichtung zum Aufnehmen einer Vielzahl von überlappenden Bildern des zu scannenden Objekts aus verschiedenen Aufnahmepositionen und Aufnahmerrichtungen. Die Kameras C weisen eine derart hohe Auflösung auf, dass eine Scangenauigkeit von Bruchteilen eines Millimeters, z.B. 1/30mm erreicht werden kann, und dass eine Position und eine Orientierung des 3D-Scanners SC relativ zur Oberfläche des zu scannenden Objekts

durch Erkennung und Vergleich von in verschiedenen Bildern enthaltenen Bildmustern möglich ist.

Darüber hinaus weist der 3D-Scanner SC einen (nur in Figur 1A dargestellten) Projektor P auf zum Projizieren von strukturiertem Licht auf das zu scannende Objekt. Der Projektor P ist im vorliegenden Ausführungsbeispiel ringförmig um eine mittlere der drei Kameras C angeordnet.

10 Weiterhin verfügt das Flugmobil FM über eine Steuerung CTL zum Steuern des Flugmobils FM. Die Steuerung CTL ist zum Schutz vor Niederschlag und anderen Witterungseinflüssen mit einem Gehäuse umgeben.

15 Figur 2 zeigt ein Blockdiagramm eines erfindungsgemäßen Systems zur Schadensanalyse eines Objekts OBJ. Das System umfasst ein erfindungsgemäßes Flugmobil FM, eine Fernsteuerung RC sowie eine Analyseeinrichtung AN. Das Flugmobil FM ist wie im Zusammenhang mit den Figuren 1A und 1B beschrieben implementiert und dient zum Scannen und zur Schadensanalyse des
20 Objekts OBJ. Das zu analysierende Objekt OBJ kann zum Beispiel ein Rotorblatt einer Windkraftanlage sein.

Das Flugmobil FM umfasst eine Helikopter-Drohne HD mit einer
25 wiederaufladbaren Batterie BAT, durch die der Antrieb der Helikopter-Drohne mit Energie versorgt wird. An der Helikopter-Drohne HD ist, wie oben bereits ausgeführt, über ein Gelenk G ein 3D-Scanner SC montiert. Der 3D-Scanner SC und das Gelenk G sind wie im Zusammenhang mit den Figuren 1A und 1B beschrieben implementiert.
30

Darüber hinaus verfügt das Flugmobil FM über eine Markierungseinrichtung M, einen Speicher MEM, eine drahtlose Sendempfangs-Einrichtung TX/RX sowie über eine Steuerung CTL.

35 Auch der 3D-Scanner SC sowie die Steuerung CTL werden durch die Batterie BAT mit Energie versorgt. Die gemeinsame Nutzung der Batterie BAT ist gegenüber einer Nutzung separater Batterien insofern vorteilhaft, als vermieden werden kann, dass

eine erste Batterie leer ist und die Mission damit beendet ist, wenn eine andere Batterie noch Energiereserven hätte. Dies gilt insbesondere, da die Helikopter-Drohne HD und der 3D-Scanner SC häufig unabhängig voneinander jeweils einen
5 stark schwankenden Energiebedarf haben.

Wie in Figur 2 durch einen punktierten Doppelpfeil angedeutet, projiziert der 3D-Scanner SC strukturiertes Licht auf das zu analysierende Objekt OBJ und nimmt währenddessen durch
10 die Kameras C eine Vielzahl von überlappenden hochaufgelösten Bildern IMG des Objekts OBJ aus verschiedenen Aufnahmepositionen und Aufnahmerichtungen auf. Insbesondere werden die Bilder IMG räumlich und zeitlich versetzt aufgenommen. Die aufgenommenen Bilder IMG werden durch den 3D-Scanner SC zunächst
15 im Speicher MEM gespeichert, um eine zur Funkkommunikation mit der Fernsteuerung RC oder ggf. mit der Analyseeinrichtung AN erforderliche Bandbreite zu verringern.

Die Markierungseinrichtung M dient zum optischen Markieren von spezifischen Stellen einer Oberfläche des Objekts OBJ. So
20 können zum Beispiel an spezifisch vorgegebenen und/oder exponierten Stellen einer Oberfläche des Objekts OBJ und/oder an Stellen mit geringer visueller Strukturierung Markierungen, zum Beispiel durch Aufsprühen von Farbe aufgebracht werden.

Die Sende-Empfangs-Einrichtung TX/RX dient zum Fernsteuern des Flugmobils FM sowie zum Übertragen von aufgenommenen Bildern. Vorzugsweise werden die vom 3D-Scanner SC aufgenommenen hochaufgelösten Bilder IMG in reduzierter Auflösung oder
25 niedriger aufgelöste Bilder einer zu diesem Zweck vorgesehenen Kamera übertragen, um die erforderliche Funkübertragungsbandbreite zu verringern. Die Auflösung der zu übertragenden Bilder wird vorzugsweise so gewählt, dass das Flugmobil FM anhand der übertragenen Bilder durch einen Operateur des
30 Flugmobils FM noch sicher fernsteuerbar ist.

Die Fernsteuerung RC dient entsprechend zum interaktiven Fernsteuern des Flugmobils FM durch den Operateur und zum Empfang sowie zur Anzeige der übertragenen Bilder.

- 5 Die Steuerung CTL umfasst eine Koordinationseinrichtung CO zum koordinierten Steuern des 3D-Scanners SC, des Gelenks G, der Helikopter-Drohne HD sowie der Markierungseinrichtung M. Die Koordination erfolgt insbesondere anhand der aufgenommenen Bilder IMG, die zu diesem Zweck vom 3D-Scanner SC zur
- 10 Koordinationseinrichtung CO übermittelt werden. Abhängig von den aufgenommenen Bildern IMG ermittelt die Koordinationseinrichtung CO Position und Orientierung des Flugmobils FM relativ zum Objekt OBJ. Abhängig davon werden dann durch die Koordinationseinrichtung CO Fluganweisungen FA an die Heli-
- 15 kopter-Drohne HD, spezifische Drehanweisungen für die Drehachsen des Gelenks G an das Gelenk G, Scan-Anweisungen SA an den 3D-Scanner SC und/oder Markierungsanweisungen MA an die Markierungseinrichtung M in koordinierter Weise übermittelt. Die Scan-Anweisungen SA können hierbei Aufnahmeanweisungen an
- 20 eine jeweilige Kamera C umfassen.

- Die Analyseeinrichtung AN wertet die aufgenommenen hochaufgelösten Bilder IMG aus, um eine Schadensanalyse durchzuführen. Die Analyseeinrichtung AN kann als separates System implemen-
- 25 tiert sein oder ganz oder teilweise in das Flugmobil FM oder die Fernsteuerung RC integriert sein. Die Analyseeinrichtung AN umfasst einen oder mehrere Prozessoren PROC zum Ausführen aller Analyseschritte.

- 30 Zum Ausführen der Schadensanalyse werden die aufgenommenen hochaufgelösten Bilder IMG aus dem Speicher MEM ausgelesen und zu einem Bildverarbeitungsmodul IP der Analyseeinrichtung AN übermittelt. Durch das Bildverarbeitungsmodul IP wird eine Datendarstellung eines Oberflächenverlaufs OBV des gescannten
- 35 Objekts OBJ anhand der aufgenommenen Bilder IMG generiert. Die Datendarstellung beschreibt vorzugsweise einen Verlauf einer zweidimensionalen Oberfläche des Objekts OBJ im dreidimensionalen Raum, zum Beispiel in Form einer Triangulierung.

Eine solche Triangulierung kann insbesondere im sogenannten stl-Format dargestellt werden.

Zur Generierung des Oberflächenverlaufs OBV versucht das
5 Bildverarbeitungsmodul IP in verschiedenen der überlappenden
Bilder IMG gemeinsame Bildmuster im Überlappungsbereich mit-
tels eines Mustererkennungsverfahrens zu erkennen und zu er-
fassen. Als Bildmuster können hierbei insbesondere geometri-
sche Strukturen und/oder Texturen der Objektoberfläche
10 und/oder eine auf das Objekt OBJ projizierte Lichtstruktur
oder darauf aufgebrachte Markierungen erfasst werden. Sofern
ein gemeinsames Bildmuster in verschiedenen Bildern erkannt
wird, können diese bezüglich des gemeinsamen Bildmusters ei-
nander zugeordnet werden, so dass die Bildmuster dieser Bil-
15 der abbildungstreu aufeinander abgebildet werden. Anhand der
einander zugeordneten Bilder kann dann ein bildübergreifender
Oberflächenverlauf ermittelt werden. Ein solches abbildungs-
treues bzw. bildmustertreues Zuordnen und Zusammensetzen ver-
schiedener Bilder zu einem bildübergreifenden Oberflächenver-
20 lauf wird häufig auch als „Stitching“ bezeichnet.

Anhand der einander zugeordneten Bilder können auch Position
und Orientierung des 3D-Scanners SC relativ zum Objekt OBJ
ermittelt werden.

25 Das Bildverarbeitungsmodul IP kann unabhängig von anderen
Komponenten der Analyseeinrichtung AN separat im Flugmobil FM
oder im 3D-Scanner SC integriert werden. Dies erlaubt eine
Vorverarbeitung der hochaufgelösten Bilder IMG im Flugmobil
30 FM bzw. im 3D-Scanner SC.

Das Bildverarbeitungsmodul IP übermittelt die generierte Da-
tendarstellung des Oberflächenverlaufs OBV zu einer Simulati-
onseinrichtung SIM zum Simulieren eines statischen oder dyna-
35 mischen Verhaltens V des Objekts OBJ anhand des Oberflächen-
verlaufs OBV. Dabei wird durch die Simulationseinrichtung SIM
anhand des Oberflächenverlaufs OBV zunächst ein Volumenmodell
VM des Objekts OBJ generiert und schließend das Verhalten V

anhand des Volumenmodells VM simuliert. Mittels der Simulation können Struktur und strömungsmechanische Auswirkungen eines Schadens und damit eine Schwere des Schadens automatisch bewertet werden.

5

Das simulierte Verhalten V wird in Form einer geeigneten Datendarstellung vom Simulationsmodul SIM zu einer Bewertungseinrichtung EV der Analyseeinrichtung AN übermittelt. Weiterhin wird ein vorgegebenes Sollverhalten SV des Objekt OBJ
10 durch die Bewertungseinrichtung EV eingelesen. Letztere vergleicht dann das simulierte Verhalten V mit dem vorgegebenen Sollverhalten SV und gibt abhängig vom Vergleichsergebnis eine Schadensangabe DAM aus. Hierbei kann ein Abstandsmaß für eine Abweichung zwischen Sollverhalten SV und simuliertem
15 Verhalten V vorgegeben sein, das mit einem Schwellwert verglichen wird. Bei Überschreitung des Schwellwertes kann dann ein bestehender oder drohender Schaden durch eine entsprechende Schadensangabe DAM angezeigt werden. Darauf basierend kann entschieden werden, ob ein betroffenes Bauteil auszutauschen ist oder nicht.
20

Durch die Simulation und den Vergleich des simulierten Verhaltens V mit dem Sollverhalten SV wird der Oberflächenverlauf OBV hinsichtlich seiner Auswirkungen auf eine Funktion
25 des Objekts OBJ geprüft. Alternativ oder zusätzlich kann der Oberflächenverlauf OBV auch direkt mit einem vorgegebenen Sollverlauf verglichen werden, um abhängig davon die Schadensangabe DAM auszugeben.

30 Mittels der Erfindung lassen sich auch schwer zugängliche Bauteile von z.B. Windkraftanlagen, Schiffen oder Flugzeugen ohne aufwändige Demontage an Ort und Stelle inspizieren. Aufgrund der Simulation der Auswirkungen sichtbarer Schäden kann in vielen Fällen sofort entschieden werden, ob ein Schaden
35 akzeptabel ist oder nicht.

Patentansprüche

1. Flugmobil (FM) zum Scannen eines Objekts (OBJ),
mit
 - 5 a) einer Helikopter-Drohne (HD),
 - b) einem über ein aktiv drehbares Gelenk (G) an der Helikopter-Drohne (HD) montierten 3D-Scanner (SC), der mindestens eine hochauflösende Kamera (C) zum Aufnehmen einer Vielzahl von überlappenden Bildern (IMG) des Objekts (OBJ) aus
10 verschiedenen Aufnahmepositionen und Aufnahmerrichtungen aufweist, so dass durch Vergleich der Bilder (IMG) eine Position und Orientierung des 3D-Scanners (SC) relativ zum Objekt (OBJ) ermittelbar ist, und
 - c) einer Koordinationseinrichtung (CO) zum koordinierten
15 Steuern des 3D-Scanners (SC), des Gelenks (G) und der Helikopter-Drohne (HD).
2. Flugmobil nach Anspruch 1, dadurch gekennzeichnet, dass der 3D-Scanner (SC) ein mobiles 3D-Scansystem mit mehreren
20 räumlich versetzten Kameras (C) ist.
3. Flugmobil nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass der 3D-Scanner (SC) einen Projektor (P) zum Projizieren von
25 strukturiertem Licht auf das Objekt (OBJ) aufweist und die mindestens eine Kamera (C) dazu ausgelegt ist, auf das Objekt (OBJ) projizierte Lichtstrukturen aufzulösen.
4. Flugmobil nach einem der vorhergehenden Ansprüche, gekennzeichnet durch
30 eine Markierungseinrichtung (M) zum optischen Markieren von spezifischen Stellen einer Oberfläche des Objekts (OBJ).
5. Flugmobil nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass
35 die Koordinationseinrichtung (CO) dazu eingerichtet ist, abhängig von den aufgenommenen Bildern (IMG) eine Position und/oder Orientierung des Flugmobils (FM) relativ zum Objekt

(OBJ) zu ermitteln und abhängig davon Fluganweisungen (FA) an die Helikopter-Drohne (HD), Drehanweisungen (DA) an das Gelenk (G), Scan-Anweisungen (SA) an den 3D-Scanner (SC) und/oder Aufnahmeanweisungen an die mindestens eine Kamera (C) zu übermitteln.

6. Flugmobil nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine von der Helikopter-Drohne (HD) und dem 3D-Scanner (SC) gemeinsam zu nutzende Batterie (BAT).

7. System zur Schadensanalyse eines Objekts (OBJ), mit
a) einem Flugmobil (FM) nach einem der vorhergehenden Ansprüche,
b) einem Bildverarbeitungsmodul (IP) zum Generieren einer Darendarstellung eines Oberflächenverlaufs (OBV) des Objekts (OBJ) anhand der aufgenommenen Bilder (IMG) und
c) einer Bewertungseinrichtung (EV) zum Prüfen des Oberflächenverlaufs (OBV) und zum Ausgeben einer Schadensangabe (DAM) abhängig von der Prüfung.

8. System zur Schadensanalyse nach Anspruch 7, dadurch gekennzeichnet, dass das Bildverarbeitungsmodul (IP) dazu eingerichtet ist, in verschiedenen überlappenden Bildern (IMG) gemeinsame Bildmuster im Überlappungsbereich zu erfassen, die verschiedenen Bilder (IMG) bezüglich des gemeinsamen Bildmusters einander zuzuordnen, und anhand der einander zugeordneten Bilder einen bildübergreifenden Oberflächenverlauf (OBV) zu ermitteln.

9. System zur Schadensanalyse nach Anspruch 8, dadurch gekennzeichnet, dass das Bildverarbeitungsmodul (IP) dazu eingerichtet ist, eine geometrische Struktur und/oder Textur der Objektoberfläche und/oder eine auf das Objekt (OBJ) projizierte Lichtstruktur als Bildmuster zu erfassen.

10. System zur Schadensanalyse nach einem der Ansprüche 7 bis 9, dadurch gekennzeichnet,
dass eine Simulationseinrichtung (SIM) vorgesehen ist zum Simulieren eines statischen und/oder dynamischen Verhaltens (V) des Objekts (OBJ) anhand des Oberflächenverlaufs (OBV), und
5 dass die Bewertungseinrichtung (EV) dazu eingerichtet ist, das simulierte Verhalten (V) mit einem vorgegebenen Sollverhalten (SV) des Objekts (OBJ) zu vergleichen und die Schadensangabe (DAM) abhängig vom Vergleichsergebnis auszugeben.
- 10 11. System zur Schadensanalyse nach Anspruche 10, dadurch gekennzeichnet, dass
die Simulationseinrichtung (SIM) dazu eingerichtet ist, anhand des Oberflächenverlaufs (OBV) ein Volumenmodell (VM) des
15 Objekts (OBJ) zu generieren und das Verhalten (V) anhand des Volumenmodells (VM) zu simulieren.

FIG 1A

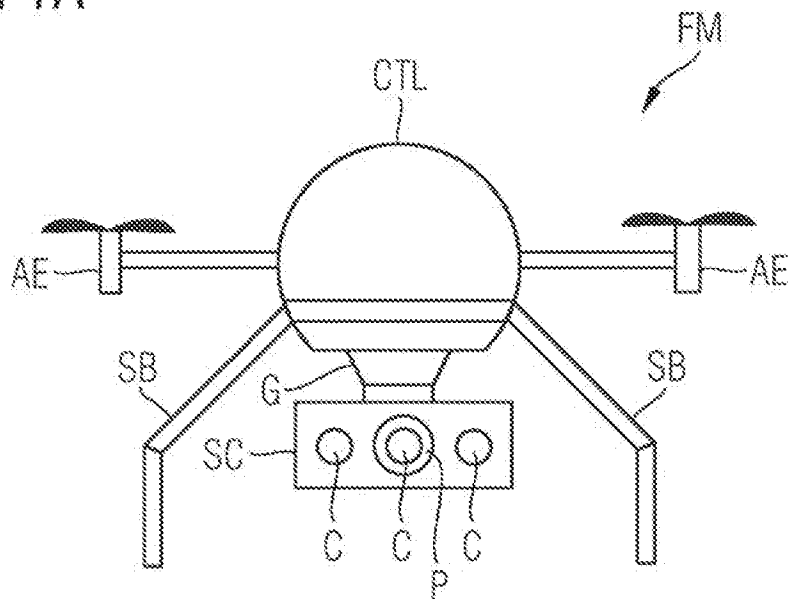


FIG 1B

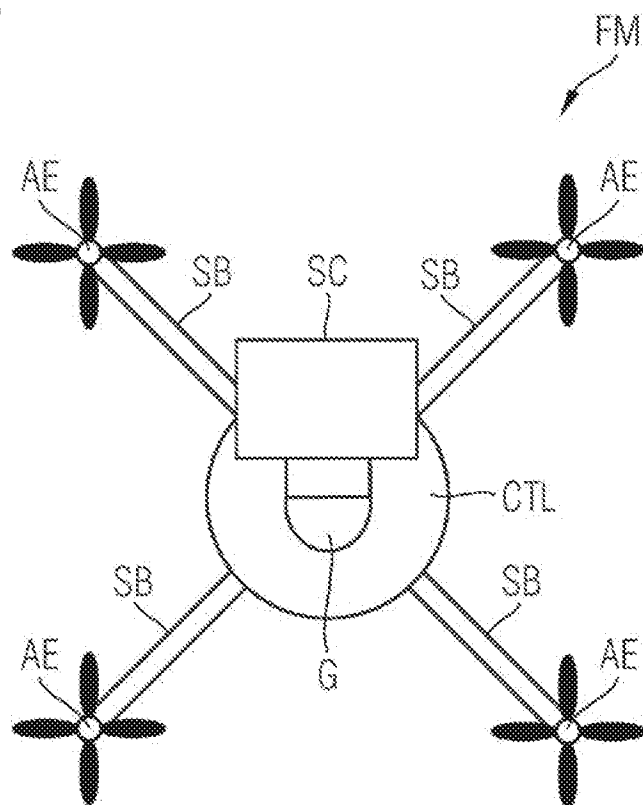
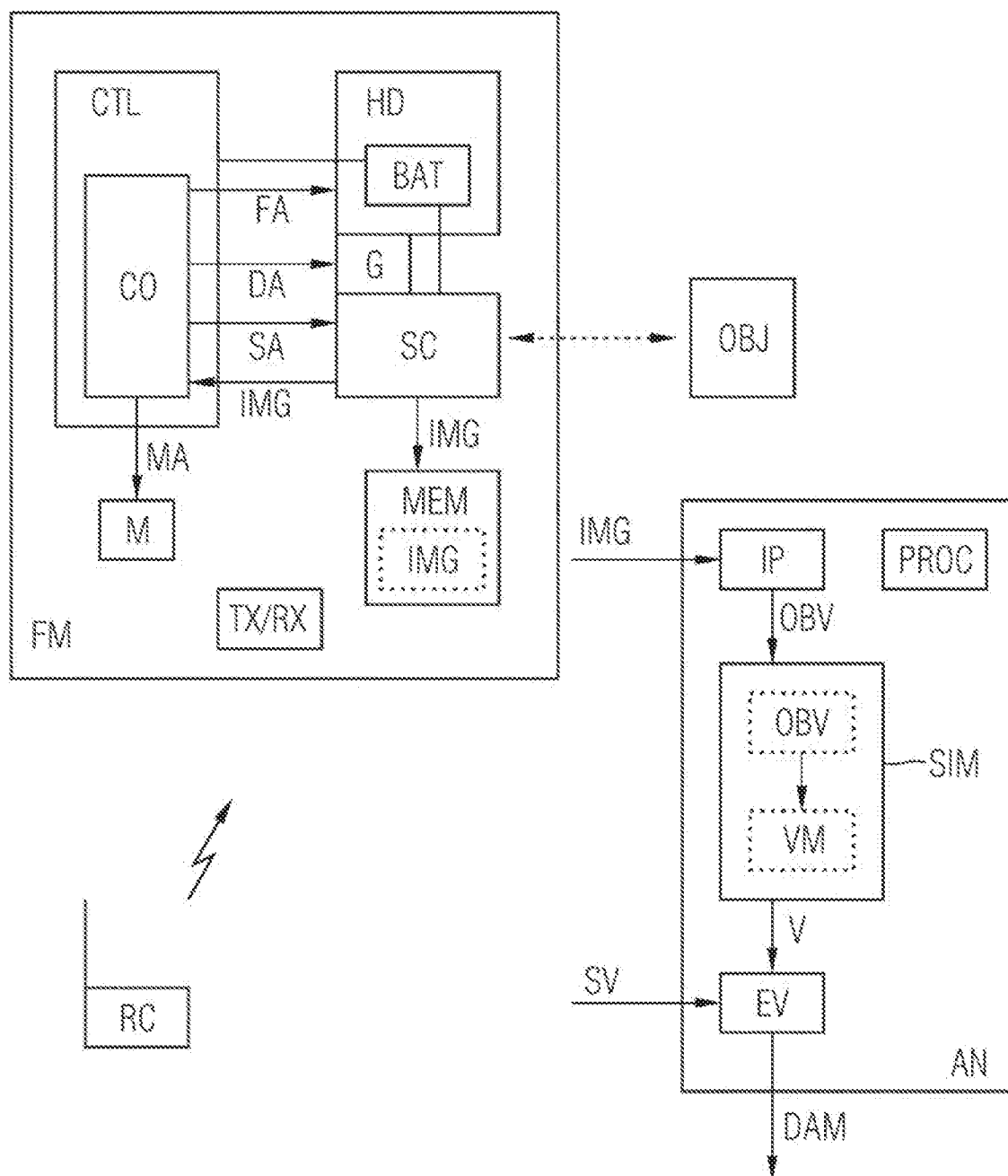


FIG 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP2017/058993

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01M5/00 B64C39/00 G01B21/04 G01M11/08 G01B11/25
 G05D1/00
 ADD.

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)

G01M B64C G01B G05D

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)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2005 020594 A1 (DOLCH STEFAN [DE]) 9 November 2006 (2006-11-09) paragraph [0037] - paragraph [0075]; figures 1-7	1-11
X	EP 2 902 744 A1 (TOPCON CORP [JP]) 5 August 2015 (2015-08-05) paragraph [0018] - paragraph [0104]; figures 1-8	1-11
X	US 2014/336928 A1 (SCOTT MICHAEL L [US]) 13 November 2014 (2014-11-13) paragraph [0019] - paragraph [0033]; figures 1-10	1-11
	----- -/-	

☒ 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

5 July 2017

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP2017/058993

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/170060 A1 (DELTA DRONE [FR]) 23 October 2014 (2014-10-23) page 2, line 18 ~ page 7, line 9; figures 1-4 -----	1-11
X	WO 2014/027097 A2 (WAIBEL MARKUS [CH]) 20 February 2014 (2014-02-20) page 11, line 16 ~ page 24, line 8; figures 1-6 -----	1-11
X	EP 2 511 656 A1 (HEXAGON TECHNOLOGY CT GMBH [CH]) 17 October 2012 (2012-10-17) paragraph [0096] ~ paragraph [0109]; figures 1-4 -----	1-11
A	DE 10 2011 017564 A1 (AEROSPY SENSE & AVOID TECHNOLOGY GMBH [AT]) 31 October 2012 (2012-10-31) the whole document -----	1-11
X,P	WO 2017/044344 A1 (FARO TECH INC [US]) 16 March 2017 (2017-03-16) the whole document -----	1-5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/058993

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102005020594 A1	09-11-2006	NONE	
EP 2902744 A1	05-08-2015	CA 2876894 A1 CN 104819706 A EP 2902744 A1 JP 2015145784 A US 2015220085 A1 US 2016049081 A1	31-07-2015 05-08-2015 05-08-2015 13-08-2015 06-08-2015 18-02-2016
US 2014336928 A1	13-11-2014	NONE	
WO 2014170060 A1	23-10-2014	FR 3004801 A1 WO 2014170060 A1	24-10-2014 23-10-2014
WO 2014027097 A2	20-02-2014	CN 104769496 A EP 2885676 A2 JP 2015531718 A US 2015212391 A1 WO 2014027097 A2	08-07-2015 24-06-2015 05-11-2015 30-07-2015 20-02-2014
EP 2511656 A1	17-10-2012	AU 2012241779 A1 CA 2831682 A1 CN 103477185 A EP 2511656 A1 EP 2697604 A1 JP 5832629 B2 JP 2014513792 A KR 20130128024 A US 2014046589 A1 WO 2012140190 A1	12-09-2013 18-10-2012 25-12-2013 17-10-2012 19-02-2014 16-12-2015 05-06-2014 25-11-2013 13-02-2014 18-10-2012
DE 102011017564 A1	31-10-2012	DE 102011017564 A1 EP 2702382 A2 US 2014168420 A1 WO 2012145780 A2	31-10-2012 05-03-2014 19-06-2014 01-11-2012
WO 2017044344 A1	16-03-2017	US 2017067734 A1 WO 2017044344 A1	09-03-2017 16-03-2017

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen

PCT/EP2017/058993

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES

INV. G01M5/00 B64C39/00 G01B21/04 G01M11/08 G01B11/25
G05D1/00
ADD.

Nach der internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierte Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)

G01M B64C G01B G05D

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, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	DE 10 2005 020594 A1 (DOLCH STEFAN [DE]) 9. November 2006 (2006-11-09) Absatz [0037] - Absatz [0075]; Abbildungen 1-7	1-11
X	EP 2 902 744 A1 (TOPCON CORP [JP]) 5. August 2015 (2015-08-05) Absatz [0018] - Absatz [0104]; Abbildungen 1-8	1-11
X	US 2014/336928 A1 (SCOTT MICHAEL L [US]) 13. November 2014 (2014-11-13) Absatz [0019] - Absatz [0033]; Abbildungen 1-10	1-11
	----- -/-	

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Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	WO 2014/170060 A1 (DELTA DRONE [FR]) 23. Oktober 2014 (2014-10-23) Seite 2, Zeile 18 - Seite 7, Zeile 9; Abbildungen 1-4 -----	1-11
X	WO 2014/027097 A2 (WAIBEL MARKUS [CH]) 20. Februar 2014 (2014-02-20) Seite 11, Zeile 16 - Seite 24, Zeile 8; Abbildungen 1-6 -----	1-11
X	EP 2 511 656 A1 (HEXAGON TECHNOLOGY CT GMBH [CH]) 17. Oktober 2012 (2012-10-17) Absatz [0096] - Absatz [0109]; Abbildungen 1-4 -----	1-11
A	DE 10 2011 017564 A1 (AEROSPY SENSE & AVOID TECHNOLOGY GMBH [AT]) 31. Oktober 2012 (2012-10-31) das ganze Dokument -----	1-11
X,P	WO 2017/044344 A1 (FARO TECH INC [US]) 16. März 2017 (2017-03-16) das ganze Dokument -----	1-5

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Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

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Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
DE 102005020594 A1	09-11-2006	KEINE	
EP 2902744 A1	05-08-2015	CA 2876894 A1	31-07-2015
		CN 104819706 A	05-08-2015
		EP 2902744 A1	05-08-2015
		JP 2015145784 A	13-08-2015
		US 2015220085 A1	06-08-2015
		US 2016049081 A1	18-02-2016
US 2014336928 A1	13-11-2014	KEINE	
WO 2014170060 A1	23-10-2014	FR 3004801 A1	24-10-2014
		WO 2014170060 A1	23-10-2014
WO 2014027097 A2	20-02-2014	CN 104769496 A	08-07-2015
		EP 2885676 A2	24-06-2015
		JP 2015531718 A	05-11-2015
		US 2015212391 A1	30-07-2015
		WO 2014027097 A2	20-02-2014
EP 2511656 A1	17-10-2012	AU 2012241779 A1	12-09-2013
		CA 2831682 A1	18-10-2012
		CN 103477185 A	25-12-2013
		EP 2511656 A1	17-10-2012
		EP 2697604 A1	19-02-2014
		JP 5832629 B2	16-12-2015
		JP 2014513792 A	05-06-2014
		KR 20130128024 A	25-11-2013
		US 2014046589 A1	13-02-2014
		WO 2012140190 A1	18-10-2012
DE 102011017564 A1	31-10-2012	DE 102011017564 A1	31-10-2012
		EP 2702382 A2	05-03-2014
		US 2014168420 A1	19-06-2014
		WO 2012145780 A2	01-11-2012
WO 2017044344 A1	16-03-2017	US 2017067734 A1	09-03-2017
		WO 2017044344 A1	16-03-2017

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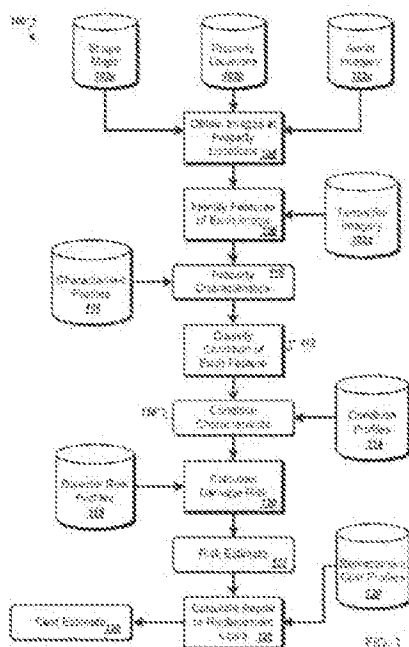
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: PLATFORM, SYSTEMS, AND METHODS FOR IDENTIFYING PROPERTY CHARACTERISTICS AND PROPERTY FEATURE MAINTENANCE THROUGH AERIAL IMAGERY ANALYSIS



(57) Abstract: In an illustrative embodiment, methods and systems for automatically categorizing a repair condition of a property characteristic may include obtaining aerial imagery of a geographic region including the property, identifying features of the aerial imagery corresponding to the property characteristic, analyzing the features to determine a property characteristic classification, and analyzing a region of the aerial imagery including the property characteristic to determine a condition classification. The methods and systems may further include determining, using the property characteristic classification and the condition classification, a risk estimate of damage to the property due to one or more disasters and/or a cost estimate of repair or replacement of the property characteristic.

PLATFORM, SYSTEMS, AND METHODS FOR IDENTIFYING PROPERTY CHARACTERISTICS AND PROPERTY FEATURE MAINTENANCE THROUGH AERIAL IMAGERY ANALYSIS

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Serial No. 62/398,665, entitled "Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis," filed September 23, 2016, hereby incorporated by reference in its entirety.

BACKGROUND

[0002] A risk exposure database contains a compilation of as many building properties or characteristics relevant to insurance as possible. These properties can include characteristics like location coordinates, address, slope, and elevation. Other characteristics include construction type, occupancy type, year built and/or year of renovation, building height, soft stories, number of stories, and floor area. Further characteristics can include roof condition, roof shape, roof covering, roof anchors, roof equipment, cladding, and pounding (distance to closest building). Some of these characteristics can only be assessed by on-site inspections or by official documentation, but others can be measured using visual imagery.

[0003] Characteristics addressed in this disclosure include roof shape and roof condition. In one example, roof shapes can be broken into five categories: gambrel roof, gable roof, hipped roof, square roof, and flat roof. Each roof shape has a unique response and damage vulnerability to different natural perils like earthquake or wind.

[0004] Deep learning involves computational models composed of multiple processing layers to learn representations of data with multiple levels of abstractions. These models can be

thought of as a way to automate predictive analytics. Representation learning is a set of methods that allows a machine to be fed with raw data and to automatically discover the representations needed for detection or classification. Use cases for deep learning include voice recognition, motion detection, translation, and medical diagnosis. By using deep learning algorithms and sample datasets, computers can learn to distinguish and classify a wide range of characteristics to high levels of accuracy, often surpassing the recognition levels of human beings.

[0005] One model used for deep learning is the Network in Network model described in the paper "Network In Network" by M. Lin et al. and published in the International Conference on Learning Representations, 2014 (arXiv:1409.1556), the contents of which are hereby incorporated by reference in its entirety. Using the Network in Network model, a number of layers of artificial perception outcomes are generated using micro neural networks with complex structures. The artificial perception outcomes are then stacked and averaged to generate a single global average pooling layer for classification.

[0006] When applied to visual recognition, deep learning algorithms can break down an observation (e.g., an image) in a number of different ways to characterize features of the observation. In some examples, deep learning algorithms can be applied to review images as a set of intensity values per pixel, or in a more abstract way as a set of edges, regions of particular shape, etc. Some representations may demonstrate superior performance to others based upon the particular learning task. One of the promises of deep learning is replacing human identification of features with efficient algorithms for unsupervised or semi-supervised feature learning and hierarchical feature extraction.

[0007] The inventors recognized that deep learning methodology could be applied to risk exposure database population to analyze aerial imagery and automatically extract characteristics of individual properties, providing fast and efficient automated classification

of building styles and repair conditions. In combining location-based vulnerabilities with individual property vulnerabilities identified in part through classification of repair conditions of one or more property features, risk of damage due to disaster can be more accurately estimated.

SUMMARY OF ILLUSTRATIVE EMBODIMENTS

[0008] The forgoing general description of the illustrative implementations and the following detailed description thereof are merely exemplary aspects of the teachings of this disclosure, and are not restrictive.

[0009] Systems, methods, and computing system platforms described herein support matching aerial image features of one or more properties to corresponding property conditions (e.g., maintenance levels of property features) through machine learning analysis. In a preferred application, the property condition analysis may be used in estimating damage risk in light of one or more disaster conditions, such as severe storms. The analysis may further aid in estimating costs of repair or replacement of each property, in one example, should a disaster cause the estimated damage. In another example, the analysis may be used to confirm that a property has been repaired.

[0010] In one aspect, the present disclosure relates to a method for automatically categorizing a repair condition of a property characteristic, including obtaining an aerial image of a geographic region including the property; identifying features of the aerial image corresponding to the property characteristic; analyzing the features to determine a property characteristic classification; analyzing a region of the aerial image including the property characteristic to determine a condition classification; and determining, using the property characteristic classification and the condition classification, a risk estimate of damage to the property due to one or more disasters. The property characteristic classification may be rooftop shape. Analyzing the features to determine a property characteristic may include

applying a deep learning analysis model to the features. The deep learning analysis model may be NIN.

[0011] In some embodiments, analyzing the region of the aerial image including the property characteristic to determine the condition classification includes applying a machine learning analysis model to image pixels within the region. The machine learning analysis model may include a color histogram analysis model. The condition classification may encompass classifications good and bad. Determining the risk estimate may include applying a disaster risk profile corresponding to a first disaster of the at least one disaster and the property characteristic.

[0012] In one aspect, the present disclosure relates to a system for automatically categorizing a repair condition of a property characteristic, the system including processing circuitry and a non-transitory computer-readable medium having instructions stored thereon. In some embodiments, the instructions, when executed by the processing circuitry, cause the processing circuitry to obtain an aerial image of a geographic region including the property; identify features of the aerial image corresponding to the property characteristic; analyze the features to determine a property characteristic classification; analyze a region of the aerial image including the property characteristic to determine a condition classification; and determine, using the property characteristic classification and the condition classification, a replacement cost for replacing the property characteristic. The aerial image may be a two-dimensional aerial image.

[0013] In some embodiments, the instructions, when executed by the processing circuitry, cause the processing circuitry to, prior to identifying the features, obtain a shape map image including the property; overlay the aerial image with the shape map image; and determine whether a boundary of the property as identified by the shape map matches a boundary of the property as illustrated in the aerial image. The instructions, when executed by the processing

circuitry, may cause the processing circuitry to, upon determining that the shape map does not match the boundary of the corresponding property, obtain an alternate aerial image of the property. The instructions, when executed by the processing circuitry, may cause the processing circuitry to, prior to identifying the features, assess orthogonality of the aerial imagery. The property may be a single family home.

[0014] In one aspect, the present disclosure relates to a non-transitory computer readable medium having instructions stored thereon, where the instructions, when executed by processing circuitry, cause the processing circuitry to receive identification of a property and at least one property characteristic; obtain an aerial image of a geographic region including the property; and identify respective features of the aerial image corresponding to each property characteristic of the at least one property characteristic. In some embodiments, the instructions, when executed by the processing circuitry, cause the processing circuitry to, for each property characteristic, analyze the corresponding features to determine a respective property characteristic classification, and analyze a region of the aerial image including the respective property characteristic to determine a respective condition classification. The instructions, when executed by the processing circuitry, may cause the processing circuitry to determine, using the property characteristic classification of each property characteristic and the condition classification of each property characteristic, at least one risk estimate representing risk of damage due to disaster.

[0015] In some embodiments, the instructions, when executed by the processing circuitry, cause the processing circuitry to, prior to obtaining the aerial image of the geographic region, determine, based upon the at least one property characteristic, a preferred image type corresponding to each property characteristic of the at least one property characteristic. The at least one property characteristic may include two or more property characteristics. The instructions, when executed by the processing circuitry, may cause the processing circuitry

to, responsive to determining the preferred image type corresponding to a first property characteristic of the at least one property characteristic is a terrestrial image, obtain a terrestrial image of the geographic region including the property.

[0016] In some embodiments, the instructions, when executed by the processing circuitry, cause the processing circuitry to access one or more known property characteristics.

Determining the at least one risk estimate may include determining the at least one risk estimate further based on the one or more known property characteristics. The one or more known property characteristics may include at least one of a property age, a property elevation, a property slope, a year built, a year renovated, and a building height.

[0017] In some embodiments, receiving identification of the property and the at least one property characteristic includes receiving, via a network from a remote computing device, the identification of the property. The instructions, when executed by the processing circuitry, may cause the processing circuitry to provide, via the network to the remote computing device in real-time responsive to receiving the at least one property characteristic, the at least one risk estimate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. The accompanying drawings have not necessarily been drawn to scale. Any values dimensions illustrated in the accompanying graphs and figures are for illustration purposes only and may or may not represent actual or preferred values or dimensions. Where applicable, some or all features may not be illustrated to assist in the description of underlying features. In the drawings:

[0019] FIG. 1 is a flow diagram of an example system operational flow for matching aerial image features to corresponding property maintenance levels;

[0020] FIG. 2A illustrates example characteristic classifications and corresponding risk profile data;

[0021] FIG. 2B illustrates examples of condition characteristics and corresponding example histograms;

[0022] FIG. 2C illustrates an example condition profile corresponding to an example property characteristic type;

[0023] FIG. 2D is an example error rate graph comparing training data with test data in conducting matching aerial image features to corresponding rooftop shapes;

[0024] FIG. 3 is a block diagram of an example environment for matching aerial image topographical features to corresponding property maintenance levels;

[0025] FIG. 4 is a flow chart of an example method for classifying condition characteristics of a property based on aerial image analysis;

[0026] FIG. 5A illustrates an example structure shape map of a geographic area;

[0027] FIG. 5B illustrates an example two-dimensional aerial image of the geographic area of FIG. 5A;

[0028] FIG. 5C illustrates an example overlay map image of a section of the structure shape map of FIG. 5A overlaying a corresponding section of the aerial image of FIG. 5B;

[0029] FIG. 6 is a block diagram of an example computing system;

[0030] FIG. 7 is a block diagram of an example distributing computing environment including a cloud computing environment; and

[0031] FIGs. 8A through 8C illustrate a series of example user interface screen shots for reviewing property characteristic and maintenance level information.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0032] The description set forth below in connection with the appended drawings is intended to be a description of various, illustrative embodiments of the disclosed subject matter.

Specific features and functionalities are described in connection with each illustrative embodiment; however, it will be apparent to those skilled in the art that the disclosed embodiments may be practiced without each of those specific features and functionalities.

[0033] Reference throughout the specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with an embodiment is included in at least one embodiment of the subject matter disclosed. Thus, the appearance of the phrases “in one embodiment” or “in an embodiment” in various places throughout the specification is not necessarily referring to the same embodiment. Further, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments. Further, it is intended that embodiments of the disclosed subject matter cover modifications and variations thereof.

[0034] It must be noted that, as used in the specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context expressly dictates otherwise. That is, unless expressly specified otherwise, as used herein the words “a,” “an,” “the,” and the like carry the meaning of “one or more.” Additionally, it is to be understood that terms such as “left,” “right,” “top,” “bottom,” “front,” “rear,” “side,” “height,” “length,” “width,” “upper,” “lower,” “interior,” “exterior,” “inner,” “outer,” and the like that may be used herein merely describe points of reference and do not necessarily limit embodiments of the present disclosure to any particular orientation or configuration. Furthermore, terms such as “first,” “second,” “third,” etc., merely identify one of a number of portions, components, steps, operations, functions, and/or points of reference as disclosed

herein, and likewise do not necessarily limit embodiments of the present disclosure to any particular configuration or orientation.

[0035] Furthermore, the terms “approximately,” “about,” “proximate,” “minor variation,” and similar terms generally refer to ranges that include the identified value within a margin of 20%, 10% or preferably 5% in certain embodiments, and any values therebetween.

[0036] All of the functionalities described in connection with one embodiment are intended to be applicable to the additional embodiments described below except where expressly stated or where the feature or function is incompatible with the additional embodiments. For example, where a given feature or function is expressly described in connection with one embodiment but not expressly mentioned in connection with an alternative embodiment, it should be understood that the inventors intend that that feature or function may be deployed, utilized or implemented in connection with the alternative embodiment unless the feature or function is incompatible with the alternative embodiment.

[0037] Turning to FIG. 1, a flow diagram of an example system operational flow 100 for matching aerial image features to corresponding property maintenance levels obtains images (104) at property locations 102b is illustrated. In some implementations, commencement of at least a portion of the operational flow 100 by the system may be triggered by a property classification request submitted by a user, such as an insurance carrier or real estate investment broker at a dashboard interface screen on a computing device connected to the system via a network. For example, as illustrated in FIG. 8A, a particular property or, alternatively, a neighborhood of properties, may be selected within a map view user interface 800. The operational flow 100 may be used to analyze the condition of features of each property at each property location 102b based on aerial imagery 102c. In some implementations, the operational flow 100 may aid in estimating costs of repair or replacement of each property characteristic detected in the aerial images, for example. In

another example, the operational flow 100 may be used to confirm that a property location 102b has been repaired.

[0038] The property locations 102b may represent, in some examples, locations of properties insured by a particular insurer, locations of properties recently affected by a disaster such as a tornado, hurricane, earthquake, storm surge, or explosion, locations of properties held in an investment portfolio, or locations of properties considered for addition to an investment portfolio. The property locations 102b may be identified, in some examples, by a street address, global positioning system coordinates, or other geographic coordinates.

[0039] In some implementations, the operational flow 100 obtains images (104) at each property location 102b. The images can include aerial imagery 102c stored by the system or accessed by the system from a remote networked location. The aerial imagery 102c, for example, may include a three-dimensional or two-dimensional image of a geographic location including at least one of the property locations 102b. In one example, based upon street address or geographic coordinates, the system may query a remote database to obtain recent aerial imagery 102c including an image of at least one of the property locations 102b. The remote database, in some examples, can include private industry databases such as Google® Earth images by Google, Inc. of Mountain View, CA or NTT Geospace Corporation of Japan. In other examples, the remote database can include one or more databases of publicly owned organizations such as the Geospatial Information Authority (GSI) of Japan, the United States Geological Survey, or the Federal Agency for Cartography and Geodesy of Germany. Aerial imagery can be collected from one or more remote network locations, in some embodiments, using an Open Source Geographic Information System (GIS) such as QGIS by the Open Source Geospatial Foundation (OSGeo). The format for the images of the property locations 102b, in some embodiments, depends upon the format

accepted by the various sources available for aerial imagery 102c. An example aerial image 510 of multiple property locations 102b is illustrated in FIG. 5B.

[0040] In some embodiments, the system may be configured to query multiple remote database systems to obtain at least two aerial images of a given property location 102b. The aerial images available at the various databases, for example, may differ in resolution and recency of capture. Through collecting two or more images of a particular property, for example, the system may analyze each image to determine a best quality image for use in condition analysis. The condition analysis can include balancing of multiple factors such as, in some examples, clarity, completeness, and recency.

[0041] Further, in some embodiments, the system may be configured to query multiple remote database systems to obtain both a two-dimensional aerial image and a three-dimensional aerial image. Different property characteristics may be discerned based upon whether the aerial image is captured in two-dimensional or three-dimensional format. Two-dimensional aerial images, in some examples, can be used to determine location coordinates of the property, street name, occupancy type, floor area, existence of skylights, existence of chimneys, roof condition, roof shape, roof covering, roof anchors, roof equipment, and/or pounding. Three-dimensional aerial images, in comparison, can be used to determine location coordinates, street name, construction type, occupancy type, year built, building height, soft stories, number of stories, roof condition, roof shape, roof covering, roof anchors, roof equipment, cladding, and pounding. Where there is an overlap in characteristics identifiable using either a two-dimensional image or a three-dimensional image, in some embodiments, machine learning analysis of both images can be combined to provide increase confidence in identification of the individual characteristics.

[0042] In some implementations, the system obtains (104) shape map images 102a of each of the property locations 102b. The shape map images 102a, for example, include a block shape

layout of existing properties in a municipality, such as urban planning maps used in urban planning and development. The shape map images 102a, in another example, can include block shape layout maps used in presenting information to a user of a computer-based navigation system. The shape map images 102a, in one example, can be obtained from Geospatial Information Authority of Japan or Zenrin Co. Ltd. of Japan. An example of an urban planning map 500 is illustrated in FIG. 5A (image obtained from the Geospatial Information Authority of Japan, Digital Map 2500 (Spatial Data Framework)).

[0043] The shape map images 102a, in some embodiments, are used to confirm location of a particular property. The shape map image 102a of a geographical area, for example, can be overlaid with a corresponding aerial image 102c to match properties with images. An example overlaid image 520 of planning map image 500 of FIG. 5A with aerial image 510 of FIG. 5B is illustrated in FIG. 5C. In some embodiments, the shape map image 102a may not match in shape or location with the aerial image 102c. As illustrated in FIG. 5C, for example, a shape map outline (illustrated in a thickened line) for a location 522 may not be rectangular, while a rooftop shape beneath the outline may be rectangular in shape. In some embodiments, analyzing multiple aerial images 102c to determine the best quality image may include identifying one or more aerial images 102c that substantially align with the corresponding shape map image 102a. The overlay of the aerial image 102c with the shape map image 102a, further, can be used in aiding in cropping the aerial image 102c to focus analysis on a particular property location 102b. For example, turning to FIG. 5C, property location 524 is substantially aligning with the corresponding planning map image, and the general outline can be used in aiding in cropping of the property location 524. In some examples, the property location 524 may be identified within the overlaid image 520 when the property location 524 aligns with a property in the overlaid image 520 within a

predetermined tolerance in order to account for renovations that may have been made to the property 524, such as property additions that may alter an overall shape of the property.

[0044] Returning to FIG. 1, in some embodiments, the shape map images 102a may be used to correct or compensate for alignment errors or inconsistencies of the corresponding two-dimensional aerial images 102c. For example, an aerial image representing a normal orthophoto angle may not be directly centered upon the planning map block. Using the planning map block as a guide, for example, the aerial image can be geometrically corrected to obtain a true orthophoto version of the aerial image.

[0045] As illustrated in FIG. 1, in some implementations, the system identifies (106) features of each aerial image 102c to classify property characteristics. Using machine learning for analysis, for example, the system can extract features of the aerial image of a particular property location 102b. Groupings of extracted features, such as angles, outlines, substantially homogenous fields, etc. can be used to identify property features such as rooftop, swimming pool, chimney, and sky lights. Upon extracting image-related features identifiable as a property feature (e.g., rooftop), the extracted features may be analyzed to determine one or more property characteristics of that feature (e.g., type of rooftop). In one example, a swimming pool may be identified as the property feature of a pool (e.g., various shapes of outlines of a particular size or greater bordering a substantially homogenous field of blue), then characterized as a particular shape (e.g., rectangular, round, or kidney bean, etc.), type (e.g., above ground or in-ground), and/or size (e.g., approximate area). The machine learning classifier used in the machine learning analysis, in some embodiments, includes a convolutional neural network (CNN) to preprocess the aerial image 102c of the particular property location 102b and to classify the property features as property characteristics 110. Using CNN technology, for example, the biological process of visually reviewing and identifying an object or feature of an object is mimicked through a feed-forward artificial

neural network where multilayer artificial perception minimizes preprocessing. CNN is a well-established and popular machine-learning methodology. An example of a CNN processing model is Alexnet. (See Krizhevsky et al. "ImageNet Classification with Deep Convolutional Neural Networks", Advances in neural information processing systems, 2012, the entire contents of which has been incorporated herein by reference). In other embodiments, the machine learning classifier may include a Network in Network (NIN) where a number of layers of artificial perception outcomes are generated using micro neural networks with complex structures. The artificial perception outcomes are then stacked and averaged to generate a single global average pooling layer for classification. NIN has demonstrated superior performance outcome to conventional CNN processing. Additionally, NIN processing is less storage-intensive than CNN processing.

[0046] In some implementations, property characteristic profiles 108 are used in classifying property features. The property characteristic profiles 108, for example, may be developed through training the machine learning algorithms using aerial images (and, in some embodiments, terrestrial images 102d) of known property characteristics. Each property feature, for example, may be broken down into multiple classifications. In an illustrative example involving a classification of terrestrial images, cladding can include stone, brick, stucco, shingles, vertical boards, horizontal boards, or metal. The machine learning algorithms, for example, may generate a percentage confidence in a match between a new aerial image 102c including a gambrel rooftop and the characteristic profile 108 of gambrel rooftops.

[0047] In an illustrative example, turning to FIG. 2A, extracted angular and outline features of aerial images 204 may be used to classify a roof shape 202 of the particular property location 102b. In a first example, a gable roof 202b includes a central peak upon a generally rectangular outline, as depicted in corresponding aerial image 204b. A gambrel roof 202a

includes these features of the gable roof 202b but, as illustrated in aerial image 204a, the gambrel roof additionally includes a “skirt” region surrounding the central gable-shaped portion. The “skirt” region can be identified, in part, based upon its corner edges extending from the four corners of the gable-shaped portion. A hipped roof 202c, as shown in aerial image 204c, includes a central peak and two opposing triangular ends extending from either end of the central peak. The central peak forms a top edge of two trapezoidal sections. A square roof 202d, in contrast, has no central peak. Instead, as illustrated in aerial image 204d, the square roof includes four triangular portions meeting at a central point. Finally, a flat roof 202e, as shown in aerial image 204e, is represented by a substantially flat surface outlined by a rectangle.

[0048] Turning to FIG. 2D, an example error rate graph 240 compares training data 242 with accuracy of matching test data 244 in matching aerial image rooftop characteristics to corresponding rooftop type (e.g., shape). A test was conducted using NIN deep learning algorithms to classify rooftop shape in two-dimensional aerial images including a mix of gambrel, gable, hipped, square, and flat roof shapes of assorted colors. Further tests involved differing image sizes and mini-batch sizes. In particular, images were scaled using a formula of $y = w * (x-100) + z$, where x represents a property size (e.g., building with a small border surrounding the area of the rooftop), y represents pixel size, w ranged from 0.33 to 0.40 and z ranged from 90 to 110. The error rates ranged, among initial test cases involving mini batches from 5 to 20, from about 4.3% to about 10%. As shown by the error rate graph 240, in a test situation involving 2,250 sample images in a training dataset and 250 test images in a test dataset, the minimum error rate in determining rooftop condition was 6%, corresponding to an accuracy rate of 94%.

[0049] To improve accuracy rate, in some implementations, the image can be cropped and/or resized prior to analyzing. For example, the image may be cropped to include the property of

interest, or the property of interest plus a portion of its surroundings (e.g., the lot containing the property and/or a portion of the proximate neighborhood in which the property resides). Resizing to a standard image size, in another example, can contribute to accuracy improvement.

[0050] Further to roof shape, in some embodiments, feature analysis can be used to discern additional roof features such as, in some examples, roof covering, roof anchors, roof equipment, skylights, widow's walks, turrets, towers, dormers, and/or chimneys. Furthermore, upon identifying the outline of the roof, a footprint of the property location 102b (e.g., size of the roof) can be calculated based upon a scale of the aerial image 102c.

[0051] Returning to FIG. 1, rather than exclusively analyzing the particular property locations 102b individually, in some implementations, the particular property locations 102b are each classified based in part upon nearby structures. For example, based upon property location 102b dimensions, which may include lot dimensions, machine learning can be used to identify additional structures at the property location 102b such as, in some examples, a deck, swimming pool, shed, gazebo, detached garage, tennis court, fence, retaining wall, dock, playground equipment, or greenhouse. Further, the particular property locations 102b may be classified in part based upon distance from neighboring structures (pounding).

[0052] In some implementations, terrestrial images 102d may be used to classify features difficult to recognize using aerial imagery 102c. The terrestrial images 102d, in some examples, can include street view images obtained from a street view service or real estate listing. In some examples, street view images including a street-facing view of the property location 102b may be obtained from Google® Street View by Google, Inc., Bing® Maps Streetside by Microsoft Corp. of Redmond, WA, or Mapillary by Mapillary AB of Sweden. Using a terrestrial image, for example, the system can identify features such as construction type, cladding, building height, number of soft stories, number of floors, location coordinates,

street name, slope, elevation, year built, and/or occupancy type. Where the characteristics identifiable via the terrestrial imagery 102d overlap with characteristics identifiable via two-dimensional or three-dimensional aerial imagery 102c, analysis of terrestrial imagery 102d can be combined with analysis of aerial imagery, in some embodiments, to increase confidence in identification of the particular characteristic(s). For example, house siding features may be more easily detected in terrestrial imagery 102d and/or three-dimensional aerial imagery 120c than in two-dimensional aerial imagery 102c.

[0053] In some implementations, a condition of each property feature may be classified (112) as a corresponding condition characteristic 116. New properties are in good condition, but property feature conditions can deteriorate over time due to normal wear-and-tear on the property. Further, property features can suffer damage due to external forces such as storms and natural disasters. Eventually, conditions of housing features can deteriorate to the point where repair and/or replacement may be necessary. As with property characteristics described above at block 106, machine learning algorithms can be used to classify a present condition of individual detected property features. Using machine learning for analysis, for example, the system can extract pixel intensity distributions of previously identified property features of the aerial image of the particular property location 102b. In some examples, newly constructed property features generally have sharp contrast and well-defined features in machine learning image analysis. Conversely, weathered or damaged property features can have softened edges, blurred contrasts, and asymmetrical patches of wear. The machine learning classifier used in the machine learning condition analysis, in some embodiments, includes a machine learning analysis to process the aerial image 102c of the particular property location 102b and to classify the condition of previously identified property characteristics 110 as condition characteristics 116. The machine learning analysis, in some examples, can include two-dimensional color histogram analysis or three-dimensional color

histogram analysis. In other embodiments, the machine learning analysis may be performed using pattern recognition algorithms (e.g., determining missing fence posts or missing/misaligned rooftop shingles). In other embodiments, the machine learning classifier includes deep learning analysis such as CNN or NIN.

[0054] In an illustrative example, turning to FIG. 2B, examples of condition characteristics of aerial images of hipped rooftops and corresponding example histograms generated through machine learning analysis of pixel intensity are presented. For example, a set of good condition aerial images 210a through 214a, are presented alongside corresponding good condition histograms 210b through 214b. The good condition histograms 210b through 214b, in an illustrative embodiment, illustrate probability metrics of grayscale color distribution, where a respective maximum value 210c through 214c demonstrates the peak probability of grayscale color distribution of a good condition roof. The values, for example, can range from 0 (total black) to 255 (total white).

[0055] Conversely, a set of poor condition aerial images 216a through 220a, are presented alongside corresponding poor condition histograms 216b through 220b. The poor condition histograms 216b through 220b, in an illustrative embodiment, illustrate probability metrics of grayscale color distribution, where a respective maximum value 216c through 220c demonstrates the peak probability of grayscale color distribution of a good condition roof. The maximum values 216c through 220c corresponding to the poor condition rooftops 216a through 220a are markedly lower than corresponding maximum values 210c through 214c of good condition rooftops 210a through 214a. In addition, a width of the distributions of the poor condition histograms 216b through 220b may be markedly wider than a width of the distributions of the good condition histograms 210b through 214b. As can be seen of the aerial images of the poor condition rooftops 216a through 220a, the color distribution is patchy and bleached out, while the edges of the rooftops have lost their crisp lines.

Conversely, looking to the aerial images of the good condition rooftops 210a through 214a, the rooftops are more substantially uniform in color with crisp lines on the edges.

[0056] Turning to FIG. 2C, a condition profile 230 for a rooftop condition is illustrated. In some implementations, pixel value distribution histograms such as the histograms 210b through 220b, in some implementations, can be combined to generate an example condition profile 230 corresponding to rooftop condition. The condition profile 230, for example, may be included as one of the condition profiles 114 of FIG. 1. Example reference bars 232a, 232b on the condition profile 230 illustrate values corresponding to a non-deteriorated hipped roof 214a and the deteriorated hipped roof 216a, respectively. In some examples, the closer the value of a reference bar 232 comes to 1 on the Y-axis, the better the condition of the roof, while values close to 0 represent poor condition rooftops. In one example, the reference bars 232 of the example condition profile 230 correspond to a test conditions sample data set including 2,500 images). The reference bars 232 can be combined, in some embodiments, in a logistic regression to generate a roof condition profile graph 236. The accuracy rate of the image histogram is 80% based on some validation.

[0057] Although illustrated as a single condition profile 230 corresponding to different types of rooftops (e.g., at least the hipped rooftop 216a and the gable rooftop 234), in other embodiments, individual condition profiles 114 can be generated for each property characteristic (e.g., profiles specific to gabled, gambrel, flat, hipped, square, etc.). In further refinements, in certain embodiments, individual condition profiles 114 can be generated for combinations of property characteristics (e.g., a gabled, shingled roof, a gabled, clay tiled roof, a gabled, metal roof, etc.) to increase accuracy rate based upon pixel densities corresponding to the combined characteristics. Many combinations of characteristics of property features may be used singly or in combination to generate a condition profile 114 designed to accurately identify the condition of the corresponding property feature.

[0058] Returning to FIG. 1, in some implementations, the property characteristics 110 and/or condition characteristics 116 may be analyzed to calculate (120) a risk estimate 122 corresponding to a risk of damage based upon one or more types of disasters. The types of disasters can include, in some examples, earthquake, hurricane, tornado, storm surge, straight line winds, or explosion. The types and estimated severity of disasters, in some embodiments, may depend upon the particular property location 102b. For example, properties near active fault lines may be more susceptible to earthquakes, while coastal properties may be more susceptible to storm surge damage. The risk estimate 122, in some examples, can include an actuarial percentage indicating a likelihood of damage based upon the particular property characteristics. Different property characteristics, for example, may be more susceptible than others to certain types of damage. For example, flatter rooftops may be more susceptible to damage from excessive snow build-up, while peaked rooftops may be more vulnerable to strong winds.

[0059] In some embodiments, in calculating damage risk, one or more disaster risk profiles 118 can be applied based upon property characteristics. Vulnerability to damage due to disaster can vary, in some examples, by location, altitude, slope, rooftop shape, rooftop condition, cladding type, cladding condition, and/or pounding. In a particular example, as shown in FIG. 2A, a graphical risk profile 206 ranks types of rooftops by their vulnerability to strong winds. Vulnerability to wind damage increases from lowest vulnerability (flat rooftop 202e) to square roof 202d, to hipped roof 202c, to gable roof 202b, with the greatest wind damage vulnerability in gambrel roofs 202a. Vulnerability may be mathematically modeled based upon statistical information built from past damage results due to varying types and/or severity of disaster. In combining location-based vulnerabilities with individual property characteristic-based vulnerabilities, risk of damage due to disaster can be more accurately estimated.

[0060] Referring back to FIG. 1, the risk estimates 122, in some embodiments, can be used in insurance assessments. For example, the risk estimate 122 may be used in determining whether a property is adequately insured against potential damage. Further, when tracking an impending natural disaster, an insurance company may use the risk estimates 122 to estimate claims based upon the forecast path and severity of the storm. Additionally, the risk estimates 122 may be applied by investors when selecting investment properties for an investment portfolio.

[0061] In some implementations, repair or replacement costs can be calculated (126) to determine a cost estimate 128 to place one or more property characteristics in good or “like new” condition. The cost estimates 128, in some embodiments, can be based in part on one or more replacement cost profiles 120. Replacement costs, in some examples, may vary based upon type of materials (e.g., rooftop materials, cladding materials, etc.), size of the job (e.g., estimated area of the roof, estimated length of fence, etc.), and/or additional property characteristics (e.g., contributing to the complexity of the work). The replacement profiles 120, in further examples, may be based in part on location (e.g., varying costs of material and labor regionally). In some implementations, the cost estimates 128 for repair or replacement of the property characteristics may be output to a dashboard interface screen at a remote computing device of a requester, such as an insurance carrier or real estate investment broker.

[0062] In some embodiments, cost estimates 128 can be used in automatically analyzing insurance claims. The cost estimate 128, further, may be combined with the risk estimate 122 in analyzing adequacy of insurance coverage for a particular property location 102b. Further, the cost estimates 128 may be used by investors in determining cost of maintaining/upgrading a particular investment property.

[0063] Although the operational flow is illustrated as a series of computational stages, in other implementations, more or fewer computational stages may be included. For example,

aerial imagery 102c may be analyzed after an insurance claim has been paid to verify that the insured property has been repaired and/or to upgrade the estimated value of the property (e.g., in the circumstance where the owner upgraded the property rather than applying a straight repair/replacement of the damaged property characteristics.

[0064] Additionally, in other implementations, certain computational stages may be performed in a different order. For example, cost estimates 128 may be calculated prior to risk estimates 122. Other modifications of the operational flow 100 are possible.

[0065] FIG. 3 is a block diagram of an example environment 300 for matching aerial image topographical features to corresponding property maintenance levels. The example environment 300, for example, can be used to implement the operational flow 100 described in relation to FIG. 1. The example environment 300 includes a property characteristic classification and condition analysis system 302 in communication with client computing system(s) 306, a number of cost data and/or risk data source computing system(s) 308, and a number of shape map, aerial imagery, and/or terrestrial imagery source computing system(s) 304. The communication connection may be wired or wireless, over a variety of network types. In a general overview, the system 302 obtains property identifier(s) 340 from client computing system(s) 306, accesses images of a property identified by the property identifier 340 from the imagery source computing system(s) 304, and analyzes the images to determine property characteristic(s) 342 and condition characteristic(s) 344. Using cost and/or risk data obtained from cost and risk data source computing system(s) 308, the system 302 may determine replacement cost estimate data 350 and/or disaster risk estimate data 352 based upon the property characteristics and their condition.

[0066] In some implementations, a user of a particular client computing system 306 submits a request to the system 302 through a graphical user interface supplied by a graphical user interface engine 334. The request, for example, may include at least one property identifier

340 as well as one or more property characteristics 342 and/or identification of at least one of a replacement or repair cost estimate, a disaster risk estimate, and a confirmation of repair assessment. The property identifier 340, in some examples, may include location information (e.g., address, geolocation coordinates, lot boundaries, etc.). The location information, for example, may conform with property location information 102b described in relation to FIG. 1. In other embodiments, the property identifier 340 may be a unique property identifier (e.g., number or string) used to look up property location information in a data store 310. In another embodiment, rather than submitting a property identifier, the user may submit a unique user identifier used to look up one or more properties associated with the user (e.g., properties insured by an insurance client, properties held by an investment client, etc.).

[0067] In one example, turning to FIG. 8A, a user may identify locations of one or more properties by selecting the properties within a graphical map interface 800. A number of properties are identified within the map view user interface 800 as indicated with an associated pin, such as pin 804. The pins, in some examples, may indicate properties insured by a particular insurance carrier, a type of property (e.g., commercial, industrial, residential, etc.), and/or properties of a value range (e.g., within a range, above a threshold, etc.). The pins, for example, may be displayed based upon filtering options supplied by the user or otherwise associated with a user profile (e.g., insurance carrier identification). In a particular example, a user may select three properties associated with three dialogue bubbles 802. As illustrated, each dialogue bubble identifies a replacement value associated with the property, and invites the user to review details regarding the selected property via a details control.

[0068] In some implementations, the user enters property characteristics associated with each selected property. In other implementations, the characteristics may be accessed upon identification of the property (e.g., selection of a pin identifying a property, as illustrated in FIG. 8A). For example, the property characteristics 342 may be obtained from the data store

310, as illustrated in FIG. 3. Turning to FIG. 8B, an example property characteristics user interface 820 presents building area characteristics 822 (e.g., building area 822a, stories 822b, and total building area 824c) and structure characteristics 824 (e.g., structure material 824a, construction class 824b). As described within, different or additional characteristics may vary per implementation. In some embodiments, the user may be provided the ability via the user interface 820 to edit the building area characteristics 822 and/or the structure characteristics 824, for example via an edit control 828a or 828b. For example, in the circumstance of recent development or renovation (e.g., construction of an addition), the user may modify previously stored characteristics values. The property characteristics user interface 820, for example, may be presented to a user upon selection of a details control of one of the dialogue bubbles 802 illustrated in the user interface of FIG. 8A.

[0069] The user interface 820 further presents, in some implementations, premium characteristics 826 such as a replacement value. The premium information, for example, may relate to an insurance policy purchased for the property or parameters for insuring the property (e.g., based upon upgraded or new characteristics). The user, in some embodiments, may be provided to update the premium information via an edit control 828c.

[0070] In some implementations, upon identification of property location information, the system 302 accesses imagery of the property from the imagery source computing system(s) 304 using an image acquisition engine 336. The images can include, in some examples, a shape map (e.g., such as the shape maps 102a described in relation to FIG. 1), two-dimensional aerial imagery (e.g., such as the aerial imagery 102c described in relation to FIG. 1), three-dimensional aerial imagery (e.g., such as the aerial imagery 102c described in relation to FIG. 1), and/or terrestrial imagery (e.g., such as the terrestrial imagery 102d described in relation to FIG. 1). The images obtained by the image acquisition engine 336, in some embodiments, depend upon the property characteristic(s) identified by the user. For

example, certain types of images are preferred for analyzing certain types of property characteristics. Housing siding, for example, is more easily perceived from a terrestrial image or three-dimensional aerial image than from a two-dimensional aerial image.

[0071] In some implementations, an image quality analysis and preparation engine 326 analyzes the acquired image(s) to confirm the acquired image(s) contains an adequately clear and detailed image of the property identified by the property identifier 340. In some embodiments, the image quality analysis and preparation engine 326 crops and/or resizes the acquired image(s). For example, the image quality analysis and preparation engine 326 may extract a portion of an acquired image based upon the property (e.g., building size). In some implementations, the image quality analysis and preparation engine 326 resizes each acquired image to a standard size. The standard size, in a particular example, may be 256 by 256 pixels per image. Resizing to a standard size, for example, may increase accuracy in later classification analysis. The image quality analysis and preparation engine 326, in some embodiments, may be configured to apply corrections to the acquired image(s). For example, the image quality analysis and preparation engine 326 may be configured to adjust an aerial image from a normal orthophoto angle, to a true orthophoto version as described above.

[0072] In some implementations, the image quality analysis and preparation engine 326 uses shape outlines as part of the analysis. For example, a composite image generation engine 318 may overlay an aerial image with a shape map image, as described in relation to FIG. 5C. Using the resultant composite image, the image quality analysis and preparation engine 326 may confirm the aerial image conforms with an urban planning map or other property placement guide (e.g., navigational map data, etc.). Further, the image quality analysis and preparation engine 326 may use the overlaid shape map as a guide in determining whether an aerial image requires correction to a true orthophoto angle and/or how closely to crop the

image to capture the property (and, optionally, its immediate surroundings such as its lot or a portion of the proximate neighborhood).

[0073] In some implementations, if the image quality analysis and preparation engine 326 determines that the acquired image is insufficient, the image quality analysis and preparation engine 326 may request a replacement image from the image acquisition engine 336. For example, the image acquisition engine 336 may obtain images based upon a variety of factors including, in some examples, recency of capture, resolution, cost, and/or applicability to a particular property characteristic analysis. Upon determination by the image quality analysis and preparation engine 326 that the first obtained image is insufficient, for example, the image acquisition engine 336 may determine a next best source for obtaining an image of the property.

[0074] In some implementations, once an image has been approved (and, optionally, prepared and/or corrected) by the image quality analysis and preparation engine 326, a feature identification engine 320 extracts features from the property image(s) related to the identified property characteristics 342. In the circumstance of a fence, for example, the feature identification engine 320 may identify a perimeter enclosure or partial perimeter enclosure abutting and extending from the property as indicative of a fence.

[0075] In some implementations, upon identification of features by the feature identification engine 320, a property characteristic classification engine 322 classifies the property characteristic. For example, the features may be classified using one or more machine learning techniques as described in relation to computational stage 106 (classify features of each image) of FIG. 1. The property characteristic classification engine 322, for example, may generate property characteristics 342 representing a grouping, type, or other characterization of a particular property feature. Continuing with the particular example of a fence, the extracted features may be analyzed and classified in relation to height and/or

material. Upon classifying the property characteristics, the property characteristic classifications may be stored in the data store 310 as property characteristics 342 (e.g., similar to property characteristics 110 of FIG. 1).

[0076] In some implementations, the property characteristic classification engine 322 uses characteristic profile(s) 360 in classifying property characteristics. The property characteristic classification engine 322, for example, may obtain, for each property characteristic being analyzed, a particular characteristic profile 360 from a profile data store 314. The characteristic profiles, for example, may be similar to the characteristic profiles 108 described in relation to FIG. 1.

[0077] In some implementations, the property characteristic profiles 360 are generated by a characteristic classification learning engine 328. The characteristic classification learning engine 328, for example, may generate characteristic profiles 360 through a sample data set and learning process as described, generally, in relation to FIG. 2A. In a particular example, the characteristic classification learning engine 328 may analyze JPG (lossy compression digital image standard developed by the Joint Photographic Experts Group) to recognize varying rooftop shapes.

[0078] While certain property characteristic classifications are done by analysis, in some implementations, one or more feature classifications may be obtained from previously stored property characteristics 342. For example, based upon tax records, real estate records, etc. some basic materials and structure information regarding a property may be readily available through local and/or remote database system(s). In other examples, the previously stored property characteristics 342 may also be obtained from previous condition assessments performed for a property location by the system 302.

[0079] In some implementations, once the property characteristic classification engine 322 has classified the property characteristic(s), a characteristic condition classification engine

324 classifies the condition of each property characteristic. For example, the property characteristics may be classified as described in relation to computational stage 112 (classify condition of each feature) of FIG. 1. The characteristic condition classification engine 324, for example, may generate condition characteristics 344 representing a rating, qualification, or ranking of the condition of the particular characteristic. In some examples, the characteristic condition classification engine 324 may qualify a characteristic as a) "good" or "bad", b) "like new", "acceptable", "needs repair", or "needs replacement", c) rated on a numeric scale such as a scale from 1 to 5 where 5 may correspond to "like new" and 1 may correspond to "needs replacement." In other implementations, particular problems may be identified by the characteristic condition classification engine 324 such as, in some examples, a fence feature is partially fallen, or a roof feature shows signs of structural damage.

[0080] In some implementations, the characteristic condition classification engine 324 uses condition profile(s) 362 in classifying property characteristic conditions. The characteristic condition classification engine 324, for example, may obtain, for each property characteristic being analyzed, a particular condition profile 362 from the profile data store 314. The condition profiles 362, for example, may be similar to the condition profiles 114 described in relation to FIG. 1.

[0081] In some implementations, the condition profiles 362 are generated by a condition classification learning engine 330. The condition classification learning engine 330, for example, may generate condition profiles 362 through a sample data set and learning process as described, generally, in relation to FIG. 2B. In a particular example, color histogram analysis may be used to identify peak pixel values of the images in gray scale. Using the group of calculated peak pixel values, the learning engine can classify property condition into certain categories.

[0082] In some implementations, based upon the output of the property characteristic classification engine 322 and/or the characteristic condition classification engine 324, a risk calculation engine 316 may estimate risk of damage based upon one or more types of disaster. For example, the disaster risk estimate data 352 may be calculated as described in relation to computational stage 120 (calculate damage risk) of FIG. 1. The disaster risk estimate data 350, in one example, can include a percentage likelihood of damage due to each particular type of risk based upon the particular property characteristics and/or property conditions, as described in relation to the risk estimates 122 of FIG. 1. Further, in some embodiments, the disaster risk estimate data 350 may include a set of risk estimates based upon, in some examples, a number of severities of disaster, a particular path of disaster, and/or hazard intensity of disaster. The disaster severities, in some examples, may correspond to the Richter scale of seismic activity magnitude or the Saffir-Simpson Hurricane Wind Scale category. The path of the disaster, in some examples, can include geographical direction such as northeasterly, etc. or angle of impact with respect to the property characteristic(s). The hazard intensity of disaster, in some examples, can relate to wind speed or rainfall amount. Repair costs, for example, may be more accurately estimated when the roof condition is known. Due to poor condition of a rooftop in one particular example, the roof may be more vulnerable to damage requiring replacement. In another particular example, due to a poor condition rooftop, the likelihood for interior property damage (e.g., water damage due to breach of the roof) may increase at a set level of severity of disaster and above.

[0083] In some embodiments, the risk calculation engine 316 accesses one or more risk profiles 364 from the data store 314 based upon property characteristics and/or condition characteristics. The risk profiles, for example, may be similar to the disaster risk profiles 118 described in relation to FIG. 1. The risk profiles 364, for example, may be obtained from one

or more risk data sources 306 by a cost and risk data acquisition engine 338. In other embodiments, the system 302 may generate risk profiles 364 (e.g., using risk data obtained from one or more cost and risk data sources 306 and a risk data analysis engine (not illustrated)).

[0084] The risk estimate data 352, in some embodiments, is shared with one or more clients 306. For example, an insurance carrier client 306 may use risk estimate data in making insurance assessments. In another example, a real estate investment broker or firm client 306 may apply risk estimate data 352 when selecting investment properties for an investment portfolio.

[0085] Turning to FIG. 8C, an example disaster risk user interface 840 presents risk assessment information based upon risk profiles 364 related to the selected property (e.g., one of the properties identified via the dialogue bubbles 802c of FIG. 8A). The user interface 840, for example, may be accessed by scrolling downward from the user interface 820. The user interface 840 illustrates a number of disaster risk factors 842 and associated risk estimate data 844 for the selected property. As illustrated, the disaster risk factors 842 include a fire factor 842a, a wind factor 842b, a flood factor 842c, an earthquake factor 842d, a tsunami factor 842e, and a landslide factor 842f. In some embodiments, only a subset of the risk estimate data is determined via risk assessment techniques described herein. For example, flood data 844c may be generated based upon governmental flood map evaluation rather than via aerial imaging assessment, while fire risk 844a may be determined at least in part based upon proximity to neighboring properties as derived via imaging analysis and/or construction properties derived via image analysis. Further, wind risk data 842b may be derived via rooftop analysis as described in greater detail herein.

[0086] In some implementations, based upon the output of the property characteristic classification engine 322 and/or the characteristic condition classification engine 324, a cost

calculation engine 336 calculates repair or replacement costs for improving problems identified by the characteristic condition classification engine 324 and generates replacement cost estimate data 350. For example, the replacement cost estimate data 352 may be calculated as described in relation to computational stage 126 (calculate repair or replacement costs) of FIG. 1. The replacement cost estimate data 350, for example, may be similar to the cost estimates 128 described in relation to FIG. 1.

[0087] In some implementations, the cost calculation engine 336 based calculations in part on one or more cost profiles 366 (e.g., similar to the cost profiles 120 of FIG. 1). In some embodiments, the cost calculation engine 336 accesses one or more cost profiles 366 from the data store 314 based upon property characteristics and/or condition characteristics. The cost profiles 366, in some embodiments, are obtained from one or more cost data sources 306 by the cost and risk data acquisition engine 338. In other embodiments, the system 302 may generate cost profiles 366 (e.g., by a cost data analysis engine (not illustrated) using cost data obtained from one or more cost and risk data sources 306).

[0088] The cost estimate data 350, in some embodiments, is shared with one or more clients 306. For example, an insurance carrier client 306 may use cost estimate data in determining adequacy of insurance coverage for a particular property. In another example, a real estate investment broker or real estate investment firm client 306 may apply cost estimate data 350 in determining cost of maintaining/upgrading a particular investment property.

[0089] In some implementations, the cost estimate data 350 and/or risk estimate data 352 is provided to a requesting client 306, responsive to receiving identification of one or more properties, in real-time or near real-time. For example, a client 306 accessing a dashboard interface, may format a request for a risk estimate or cost estimate related to an identified property within a dashboard interface and submit the request via a network to the system 302. Responsive to the request, the system 302 may conduct the analysis described generally

above and respond, in real time or near-real time to the client 306 with a risk analysis or cost analysis. For example, risk analysis information is presented in user interface 840 of FIG. 8C.

[0090] In some implementations, the system may identify, through updated meteorological data, one or more properties within a client real estate portfolio affected by a disaster. The system, further to identification of the affected properties, may proactively prepare a repair estimate to provide to the client corresponding to the real estate portfolio shortly after the disaster took effect. In one example, the Japan Meteorological Agency may update observation data via a web site interface within an hour or so of observation. In this example, the system may provide repair cost estimates to clients between one and two hours after a disaster has taken place.

[0091] Rather than sharing cost estimate data 350 and/or risk estimate data 352 directly with the clients 306, in other embodiments, the system 302 may include a report generation engine (not illustrated) that prepares reports regarding condition, damage, and risk assessments of one or more properties. Further, in some embodiments, the system 302 may compare a current condition characteristic 344 to a historic condition characteristic 344 to confirm whether a property owner made repairs to a property (e.g., based upon payment of an insurance claim). Other modifications of the system 302 are possible.

[0092] FIG. 4 is a flow chart of an example method 400 for classifying condition characteristics of a property based on aerial image analysis. The flow chart, for example, may represent computational stages 104 through 112 as described in relation to FIG. 1. The method 400 may be performed, for example, by the system 302 of FIG. 3.

[0093] In some implementations, the method 400 begins with accessing a two-dimensional shape map including the shape of a property (402). The shape map, for example, may be accessed by the image acquisition engine 336 from a shape map imagery source 304, as

described in relation to FIG. 3. The two-dimensional shape map, for example, may take a form of any of the shape maps 102a described in relation to FIG. 1. In a particular example, the shape map may be in a form similar to the shape map 500 described in relation to FIG. 5A.

[0094] In some implementations, two-dimensional and/or three-dimensional aerial imagery including an image of the property is accessed (404). The two-dimensional and/or three-dimensional aerial imagery, for example, may be accessed by the image acquisition engine 336 from an aerial imagery source 304, as described in relation to FIG. 3. The two-dimensional and/or three-dimensional aerial imagery, for example, may take a form of any of the aerial imagery 102c described in relation to FIG. 1. In a particular example, the two-dimensional aerial imagery may be in a form similar to the aerial image 510 described in relation to FIG. 5B.

[0095] In some implementations, the aerial imagery is overlaid with the shape map (406). The composite image generation engine 318 of FIG. 3, for example, may overlay the aerial imagery with the shape map to generate a composite image. The composite image, for example, may be in a form similar to the composite image 520 described in relation to FIG. 5C.

[0096] If a shape match is not identified (408), in some implementations, the method 400 accesses alternate two-dimensional or three-dimensional aerial imagery (410). In some embodiments, the image quality analysis and preparation engine 326 of FIG. 3 determines whether the composite image presents an adequate shape match of the property(s) of interest. Upon determining the image does not match, the image acquisition engine 336 of FIG. 3, for example, may obtain an alternative two-dimensional or three-dimensional aerial image from the aerial imagery source(s) 304. As described in relation to FIG. 3, for example, For the image acquisition engine 336 may determine a next best source for obtaining an image of the

property based upon one or more factors. Conversely, the method 400, in other implementations (not illustrated), could proceed without matching the shape map to the aerial imagery.

[0097] If a shape match is identified (408), in some implementations, the formatting of the aerial imagery is prepared (411). In some embodiments, the image is cropped to include the property of interest or the property of interest plus a portion of its surroundings (e.g., the lot containing the property and/or a portion of the proximate neighborhood in which the property resides). Cropping may be based, for example, on the correlation of the shape map to the property. In illustration, the image may be cropped to include the shape map outline of the property plus a border region. In some embodiments, cropping may include cropping to a set shape (e.g., X by X pixels square, X by Y pixels rectangle, etc.). In some embodiments, in addition to cropping the image, the image may be resized. For example, depending upon the resolution of the aerial imagery, the image resolution may be reduced, for example, to fit within an X by X pixels square or an X by Y pixels rectangle. Resizing to a standard image size, for example, can contribute to analysis consistency and improvement in classification accuracy. In further embodiments, the color depth and/or color mapping of the aerial imagery may be adjusted. For consistent color histogram analysis of the imagery, for example, the color depth and color mapping may be made consistent across analyzed images. In a particular example, color images may be converted to grayscale for grayscale image analysis. Adjustments to the imagery, for example, may be effected by the image quality analysis and preparation engine 326, described in relation to FIG. 3.

[0098] In some implementations, orthogonality of the aerial imagery is assessed (412). For example, the image quality analysis and preparation engine 326 may assess orthogonality of the aerial imagery. The image quality analysis and preparation engine 326, in one example, may determine that orthogonality correction is desired. In another example, if the image

represents a normal orthophoto rather than a true orthophoto, the image quality analysis and preparation engine 326 may notify further modules which may compensate for the angle of capture of the aerial image. In other implementations (not illustrated), orthogonality may be assessed without use of an overlaid shape map.

[0099] Returning to FIG. 4, in some implementations, if the aerial imagery is not orthogonal (414), an orthogonal version of the aerial imagery is generated (416). The image quality analysis and preparation engine 326 of FIG. 3, for example, may correct a normal orthophoto form to generate a true orthophoto form. The true orthophoto form, for example, may better match the shape map overly.

[0100] In some implementations, one or more property characteristics of the property are classified (418). The property, in some embodiments, is analyzed based on the portion of the aerial image substantially bounded by the shape map of the property. In other embodiments, the property analysis encompasses a surrounding of the property (e.g., features proximate the property upon the property lot, nearby properties, etc.). The property characteristic(s), for example, may be classified by the property characteristic classification engine 322, as described in relation to FIG. 3. In a particular example, a rooftop property feature may be classified as one of a variety of rooftop shapes, as illustrated in FIG. 2A.

[0101] In some implementations, if a property characteristic classification is identified (420), a condition of each of the property characteristics can be classified (422). The property characteristic condition(s), for example, may be classified by the characteristic condition classification engine 324, as described in relation to FIG. 3. In a particular example, a hipped classification of the rooftop feature may be classified as one of a good condition and a poor condition, as illustrated in FIG. 2B. In some implementations, the classifications of the condition of each of the property characteristics may be output to a computing device of a requester (424) via a dashboard interface screen. In some examples, in addition to providing

the condition classification for the property characteristics, the dashboard interface screen may include replacement costs for replacing the property characteristics, risk cost estimates due to damage from natural disasters, or confirmation of whether or not repairs have been made to the property characteristics.

[0102] If, instead, a classification match was not identified (420), in some implementations, alternate two-dimensional or three-dimensional aerial imagery is accessed (410) and the method 400 restarts with overlaying the replacement aerial imagery with the shape map (406). Alternatively, in some embodiments, even if a classification match is not identified, condition may be assessed based upon a default profile associated with the property feature (not illustrated). For example, if the rooftop shape does not match one of the shapes trained into the system, the condition of the rooftop may still be assessed based upon a general condition profile trained with a variety of rooftop shapes. In some examples, the condition of the rooftop may be assessed by comparing the current rooftop conditions to stored historic condition characteristics for the property from a previous condition assessment.

[0103] Although the method 400 is illustrated as a series of steps, in other implementations, more or fewer steps may be included. For example, in some implementations, terrestrial images are obtained and used to classify the same and/or different property characteristics, as described in relation to the operational flow 100 of FIG. 1.

[0104] Additionally, in other implementations, certain steps may be performed in a different order. For example, in some implementations, property characteristics and condition characteristics may be classified (418, 422) in parallel. Other modifications of the operational flow 100 are possible.

[0105] Aspects of the present disclosure may be directed to computing systems for categorizing a repair condition of a property characteristic in order to provide dynamic, real-time property condition assessments in response to requests received from users such as

insurance carriers or real estate investment brokers using aerial imagery. The implementations described herein improve upon conventional methodologies by applying deep learning analysis models to detected property characteristics of the obtained imagery in order to assess whether a condition of the property characteristics is degraded to a point of needing repair or replacement and determine an amount of risk exposure of the property due to the detected condition of the property characteristics. The implementations described herein improve processing efficiency of the system to reduce an amount of time it takes to perform the condition assessments and automate a condition assessment process.

[0106] Next, a hardware description of the computing device, mobile computing device, or server according to exemplary embodiments is described with reference to Figure 6. In Figure 6, the computing device, mobile computing device, or server includes a CPU 600 which performs the processes described above. The process data and instructions may be stored in memory 602. These processes and instructions may also be stored on a storage medium disk 604 such as a hard drive (HDD) or portable storage medium or may be stored remotely. Further, the claimed advancements are not limited by the form of the computer-readable media on which the instructions of the inventive process are stored. For example, the instructions may be stored on CDs, DVDs, in FLASH memory, RAM, ROM, PROM, EPROM, EEPROM, hard disk or any other information processing device with which the computing device, mobile computing device, or server communicates, such as a server or computer.

[0107] Further, a portion of the claimed advancements may be provided as a utility application, background daemon, or component of an operating system, or combination thereof, executing in conjunction with CPU 600 and an operating system such as Microsoft Windows 6, UNIX, Solaris, LINUX, Apple MAC-OS and other systems known to those skilled in the art.

[0108] CPU 600 may be a Xenon or Core processor from Intel of America or an Opteron processor from AMD of America, or may be other processor types that would be recognized by one of ordinary skill in the art. Alternatively, the CPU 600 may be implemented on an FPGA, ASIC, PLD or using discrete logic circuits, as one of ordinary skill in the art would recognize. Further, CPU 600 may be implemented as multiple processors cooperatively working in parallel to perform the instructions of the inventive processes described above.

[0109] The computing device, mobile computing device, or server in FIG. 6 also includes a network controller 606, such as an Intel Ethernet PRO network interface card from Intel Corporation of America, for interfacing with network 6X. As can be appreciated, the network 628 can be a public network, such as the Internet, or a private network such as an LAN or WAN network, or any combination thereof and can also include PSTN or ISDN sub-networks. The network 628 can also be wired, such as an Ethernet network, or can be wireless such as a cellular network including EDGE, 3G and 4G wireless cellular systems. The wireless network can also be Wi-Fi, Bluetooth, or any other wireless form of communication that is known.

[0110] The computing device, mobile computing device, or server further includes a display controller 608, such as a NVIDIA GeForce GTX or Quadro graphics adaptor from NVIDIA Corporation of America for interfacing with display 610, such as a Hewlett Packard HPL2445w LCD monitor. A general purpose I/O interface 612 interfaces with a keyboard and/or mouse 614 as well as a touch screen panel 616 on or separate from display 610. General purpose I/O interface also connects to a variety of peripherals 618 including printers and scanners, such as an OfficeJet or DeskJet from Hewlett Packard.

[0111] A sound controller 620 is also provided in the computing device, mobile computing device, or server, such as Sound Blaster X-Fi Titanium from Creative, to interface with speakers/microphone 622 thereby providing sounds and/or music.

[0112] The general purpose storage controller 624 connects the storage medium disk 604 with communication bus 626, which may be an ISA, EISA, VESA, PCI, or similar, for interconnecting all of the components of the computing device, mobile computing device, or server. A description of the general features and functionality of the display 610, keyboard and/or mouse 614, as well as the display controller 608, storage controller 624, network controller 606, sound controller 620, and general purpose I/O interface 612 is omitted herein for brevity as these features are known.

[0113] One or more processors can be utilized to implement various functions and/or algorithms described herein, unless explicitly stated otherwise. Additionally, any functions and/or algorithms described herein, unless explicitly stated otherwise, can be performed upon one or more virtual processors, for example on one or more physical computing systems such as a computer farm or a cloud drive.

[0114] Reference has been made to flowchart illustrations and block diagrams of methods, systems and computer program products according to implementations of this disclosure. Aspects thereof are implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0115] These computer program instructions may also be stored in a computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0116] The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0117] Moreover, the present disclosure is not limited to the specific circuit elements described herein, nor is the present disclosure limited to the specific sizing and classification of these elements. For example, the skilled artisan will appreciate that the circuitry described herein may be adapted based on changes on battery sizing and chemistry, or based on the requirements of the intended back-up load to be powered.

[0118] The functions and features described herein may also be executed by various distributed components of a system. For example, one or more processors may execute these system functions, where the processors are distributed across multiple components communicating in a network. The distributed components may include one or more client and server machines, which may share processing, as shown on Fig. 8, in addition to various human interface and communication devices (e.g., display monitors, smart phones, tablets, personal digital assistants (PDAs)). The network may be a private network, such as a LAN or WAN, or may be a public network, such as the Internet. Input to the system may be received via direct user input and received remotely either in real-time or as a batch process. Additionally, some implementations may be performed on modules or hardware not identical to those described. Accordingly, other implementations are within the scope that may be claimed.

[0119] In some implementations, as illustrated in FIG. 7, the innovations described herein may interface with a cloud computing environment 730, such as Google Cloud Platform™ to

perform at least portions of methods or algorithms detailed above. The processes associated with the methods described herein can be executed on a computation processor, such as the Google Compute Engine by data center 734. The data center 734, for example, can also include an application processor, such as the Google App Engine, that can be used as the interface with the systems described herein to receive data and output corresponding information. The cloud computing environment 730 may also include one or more databases 738 or other data storage, such as cloud storage and a query database. In some implementations, the cloud storage database 738, such as the Google Cloud Storage, may store processed and unprocessed data supplied by systems described herein.

[0120] The systems described herein may communicate with the cloud computing environment 730 through a secure gateway 732. In some implementations, the secure gateway 732 includes a database querying interface, such as the Google BigQuery platform.

[0121] The cloud computing environment 102 may include a provisioning tool 740 for resource management. The provisioning tool 740 may be connected to the computing devices of a data center 734 to facilitate the provision of computing resources of the data center 734. The provisioning tool 740 may receive a request for a computing resource via the secure gateway 732 or a cloud controller 736. The provisioning tool 740 may facilitate a connection to a particular computing device of the data center 734.

[0122] A network 702 represents one or more networks, such as the Internet, connecting the cloud environment 730 to a number of client devices such as, in some examples, a cellular telephone 710, a tablet computer 712, a mobile computing device 714, and a desktop computing device 716. The network 702 can also communicate via wireless networks using a variety of mobile network services 720 such as Wi-Fi, Bluetooth, cellular networks including EDGE, 3G and 4G wireless cellular systems, or any other wireless form of communication that is known. In some embodiments, the network 702 is agnostic to local interfaces and

networks associated with the client devices to allow for integration of the local interfaces and networks configured to perform the processes described herein.

[0123] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the present disclosures. Indeed, the novel methods, apparatuses and systems described herein can be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods, apparatuses and systems described herein can be made without departing from the spirit of the present disclosures. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the present disclosures.

CLAIMS

What is claimed is:

1. A method for automatically categorizing a repair condition of a property characteristic, comprising:
receiving, from a user at a remote computing device, a request for a property condition classification, wherein the property classification request includes identification of a property and at least one property characteristic;
obtaining, by processing circuitry of a computing system responsive to receiving the request, an aerial image of a geographic region including the property;
identifying, by the processing circuitry, a plurality of features of the aerial image corresponding to the property characteristic;
analyzing, by the processing circuitry, the plurality of features to determine a property characteristic classification;
analyzing, by the processing circuitry, a region of the aerial image including the property characteristic to determine a condition classification;
determining, by the processing circuitry using the property characteristic classification and the condition classification, a risk estimate of damage to the property due to one or more disasters; and
returning, to the user at the remote computing device via a graphical user interface responsive to receiving the request, a condition assessment of the property characteristic including the condition classification and the risk estimate of damage to the property due to the one or more disasters.
2. The method of claim 1, wherein the property characteristic classification is rooftop shape.

3. The method of claim 1, wherein analyzing the plurality of features to determine a property characteristic comprises applying a deep learning analysis model to the plurality of features.
4. The method of claim 1, wherein the deep learning analysis model is NIN.
5. The method of claim 1, wherein analyzing the region of the aerial image including the property characteristic to determine the condition classification comprises applying a machine learning analysis model to a plurality of image pixels within the region.
6. The method of claim 5, wherein the machine learning analysis model comprises a color histogram analysis model.
7. The method of claim 1, wherein determining the risk estimate comprises applying a disaster risk profile corresponding to a) a first disaster of the at least one disaster and b) the property characteristic.
8. A system for automatically categorizing a repair condition of a property characteristic, comprising:
processing circuitry; and
a non-transitory computer-readable medium having instructions stored thereon;
wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to

receive, from a user at a remote computing device, a property condition classification request, wherein the property classification request includes identification of a property and at least one property characteristic;

obtain, from a remote data source responsive to receiving the property classification request, an aerial image of a geographic region including the property;

identify a plurality of features of the aerial image corresponding to the property characteristic;

analyze the plurality of features to determine a property characteristic classification;

analyze a region of the aerial image including the property characteristic to determine a condition classification; and

determine, in real-time responsive to receiving the property classification request and using the property characteristic classification and the condition classification, a replacement cost for replacing the property characteristic.

9. The system of claim 8, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, prior to identifying the plurality of features:

obtain a shape map image including the property;

overlay the aerial image with the shape map image; and

determine whether a boundary of the property as identified by the shape map matches a boundary of the property as illustrated in the aerial image.

10. The system of claim 9, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, upon determining that the shape map

does not match the boundary of the corresponding property, obtain an alternate aerial image of the property.

11. The system of claim 8, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to compare a current condition classification of the property characteristic to a stored historic condition classification of the property characteristic.
12. The system of claim 11, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, in real-time responsive to receiving the property condition classification request, determine whether repairs have been made to the property based on the comparison of the current condition classification to the historic condition classification of the property characteristic.
13. The system of claim 8, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, prior to identifying the plurality of features, assess orthogonality of the aerial imagery.
14. The system of claim 13, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, responsive to assessing that the orthogonality of the aerial imagery does not correspond to a true orthophoto form, cause correction of the aerial imagery to the true orthophoto form.

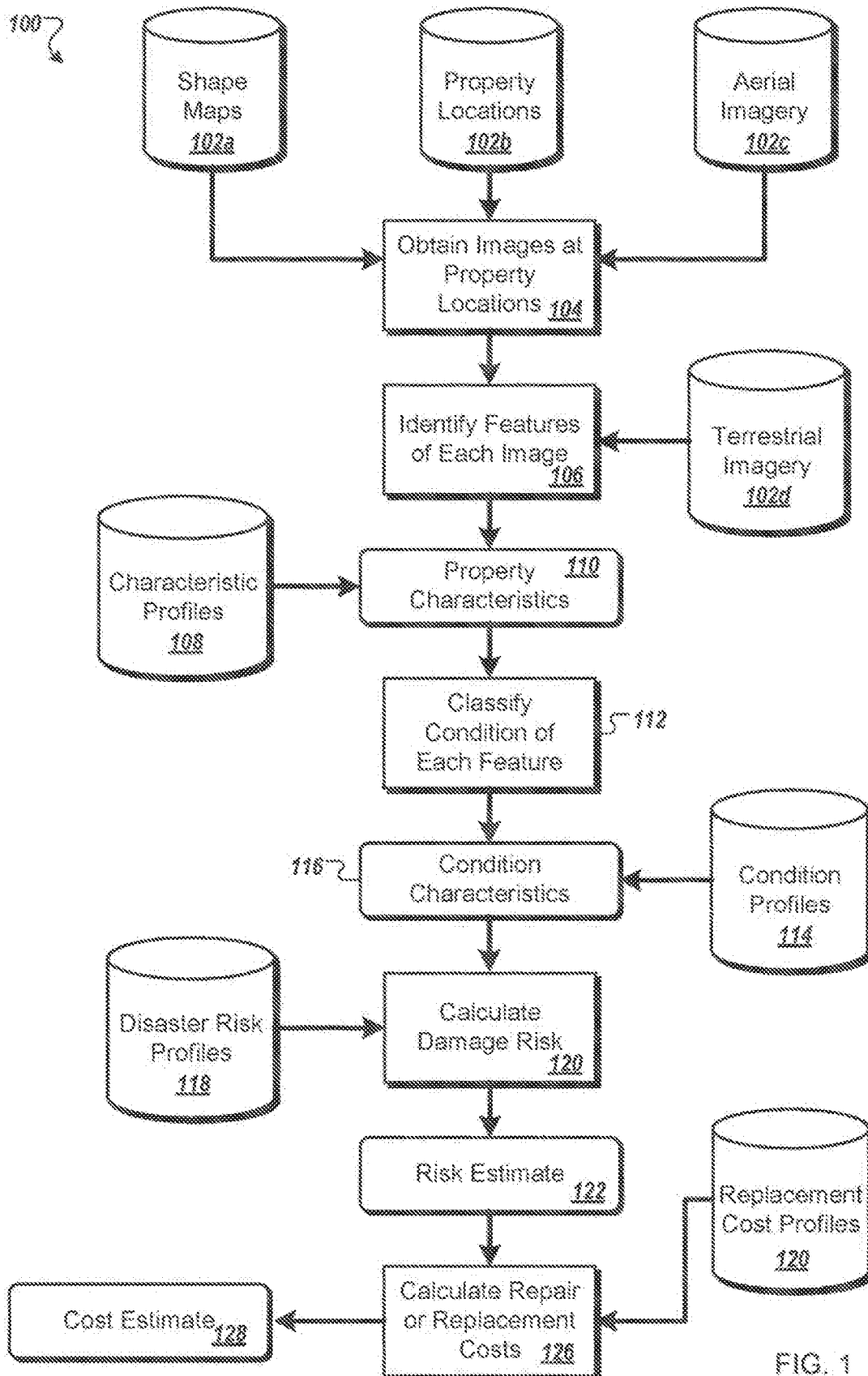
15. A non-transitory computer readable medium having instructions stored thereon, wherein the instructions, when executed by processing circuitry, cause the processing circuitry to:
- receive, from a user at a remote computing device, a property condition classification request, wherein the property classification request includes identification of a property and at least one property characteristic;
 - obtain, from a remote data source responsive to receiving the property classification request, an aerial image of a geographic region including the property;
 - identify a respective plurality of features of the aerial image corresponding to each property characteristic of the at least one property characteristic;
 - for each of the at least one property characteristic,
 - analyze the corresponding plurality of features to determine a respective property characteristic classification, and
 - analyze a region of the aerial image including the respective property characteristic to determine a respective condition classification; and
 - determine, in real-time responsive to receiving the property classification request and using the property characteristic classification of each property characteristic and the condition classification of each property characteristic, at least one risk estimate representing risk of damage due to disaster.
16. The non-transitory computer readable medium of claim 15, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to, prior to obtaining the aerial image of the geographic region, determine, based upon the at least one property characteristic, a preferred image type

corresponding to each property characteristic of the at least one property characteristic.

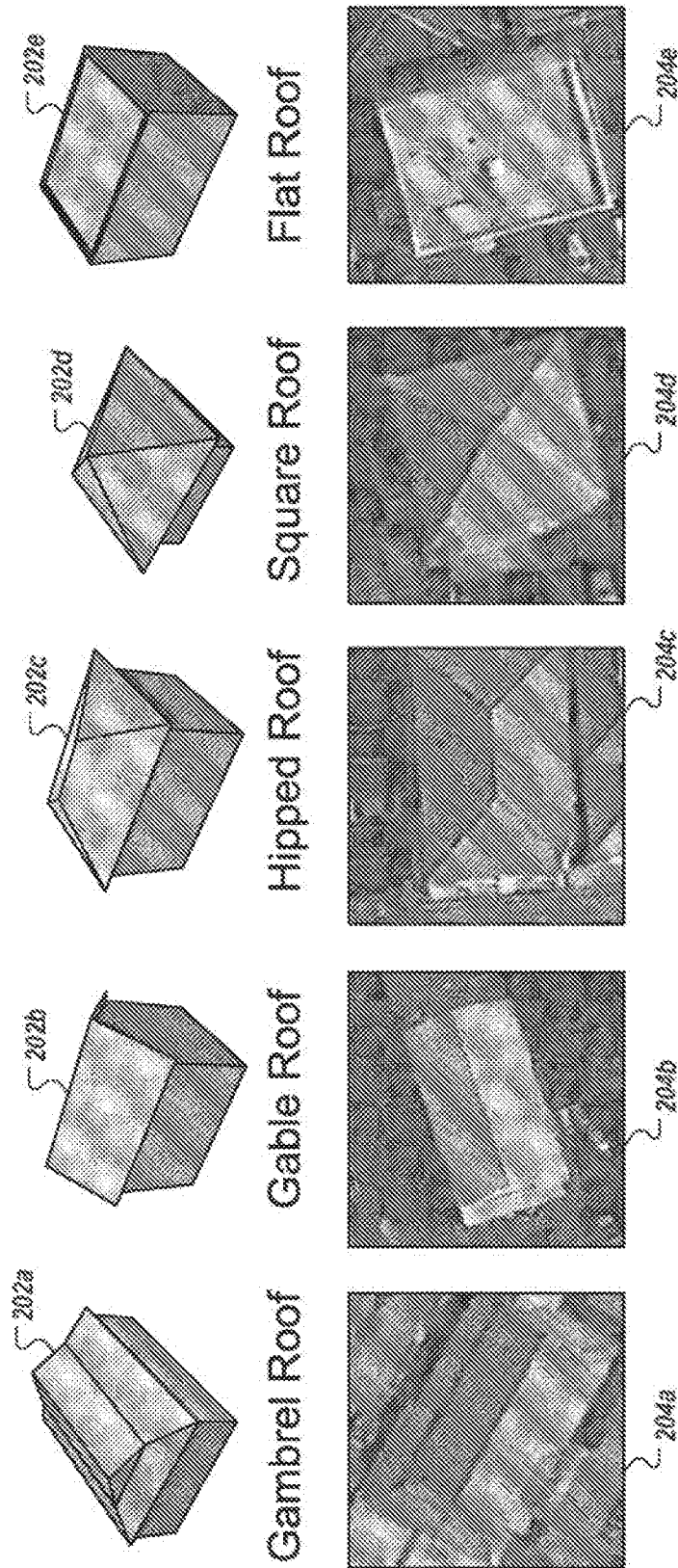
17. The non-transitory computer readable medium of claim 16, wherein:
the at least one property characteristic comprises two or more property characteristics;
and
the instructions, when executed by the processing circuitry, cause the processing circuitry to, responsive to determining the preferred image type corresponding to a first property characteristic of the at least one property characteristic is a terrestrial image, obtain a terrestrial image of the geographic region including the property.
18. The non-transitory computer readable medium of claim 15, wherein the instructions, when executed by the processing circuitry, cause the processing circuitry to access one or more known property characteristics, wherein determining the at least one risk estimate comprises determining the at least one risk estimate further based on the one or more known property characteristics.
19. The non-transitory computer readable medium of claim 18, wherein the one or more known property characteristics comprise at least one of a property age, a property elevation, a property slope, a year built, a year renovated, and a building height.
20. The non-transitory computer readable medium of claim 15, wherein:

receiving identification of the property and the at least one property characteristic comprises receiving, via a network from a remote computing device, the identification of the property; and

the instructions, when executed by the processing circuitry, cause the processing circuitry to provide, via the network to a graphical user interface at the remote computing device in real-time responsive to receiving the at least one property characteristic, the at least one risk estimate.



Example Characteristic Classifications: Roof Type



More Vulnerable to Strong Wind

Example Risk Profile based on Roof Type

FIG. 2A

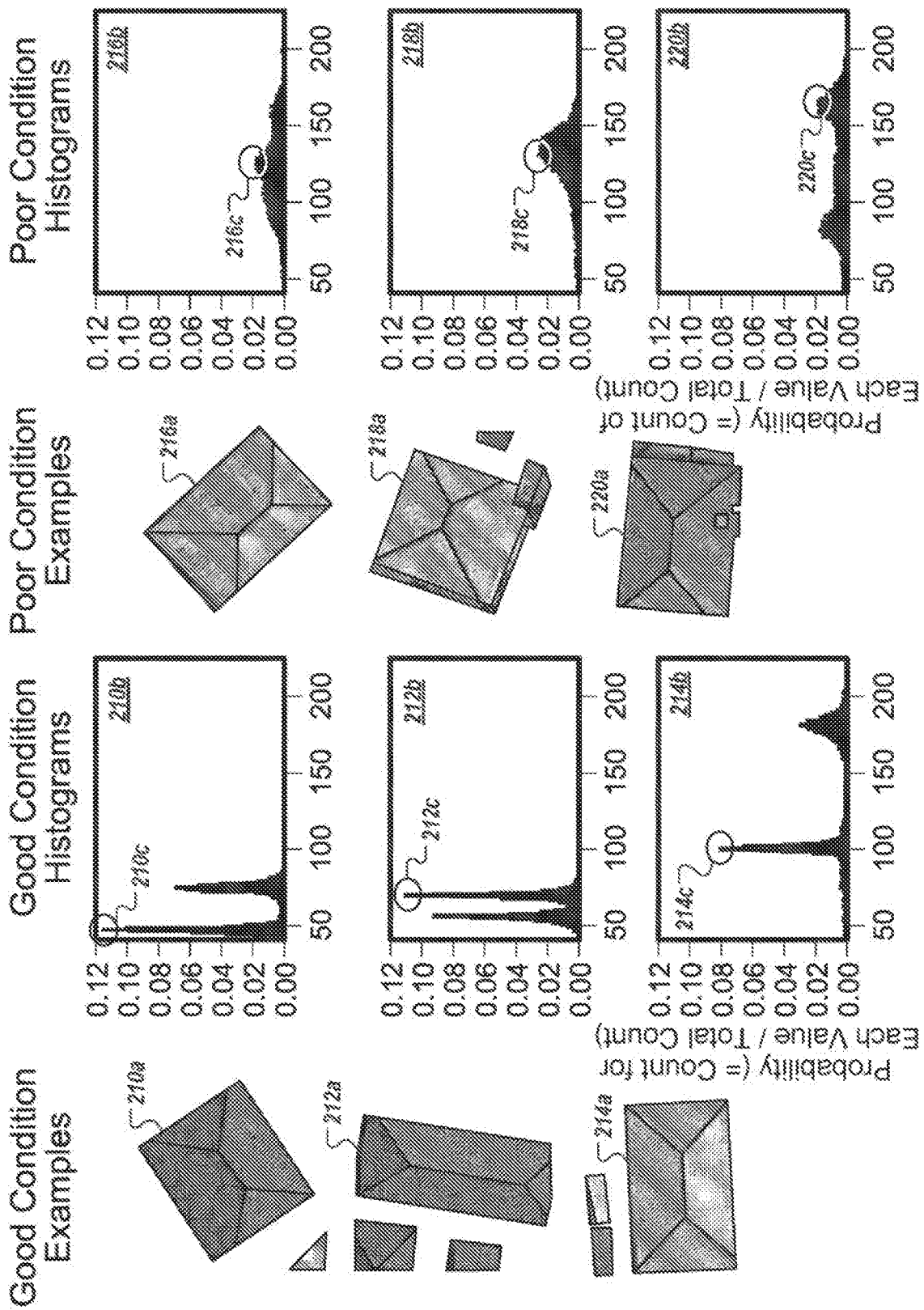


FIG. 2B

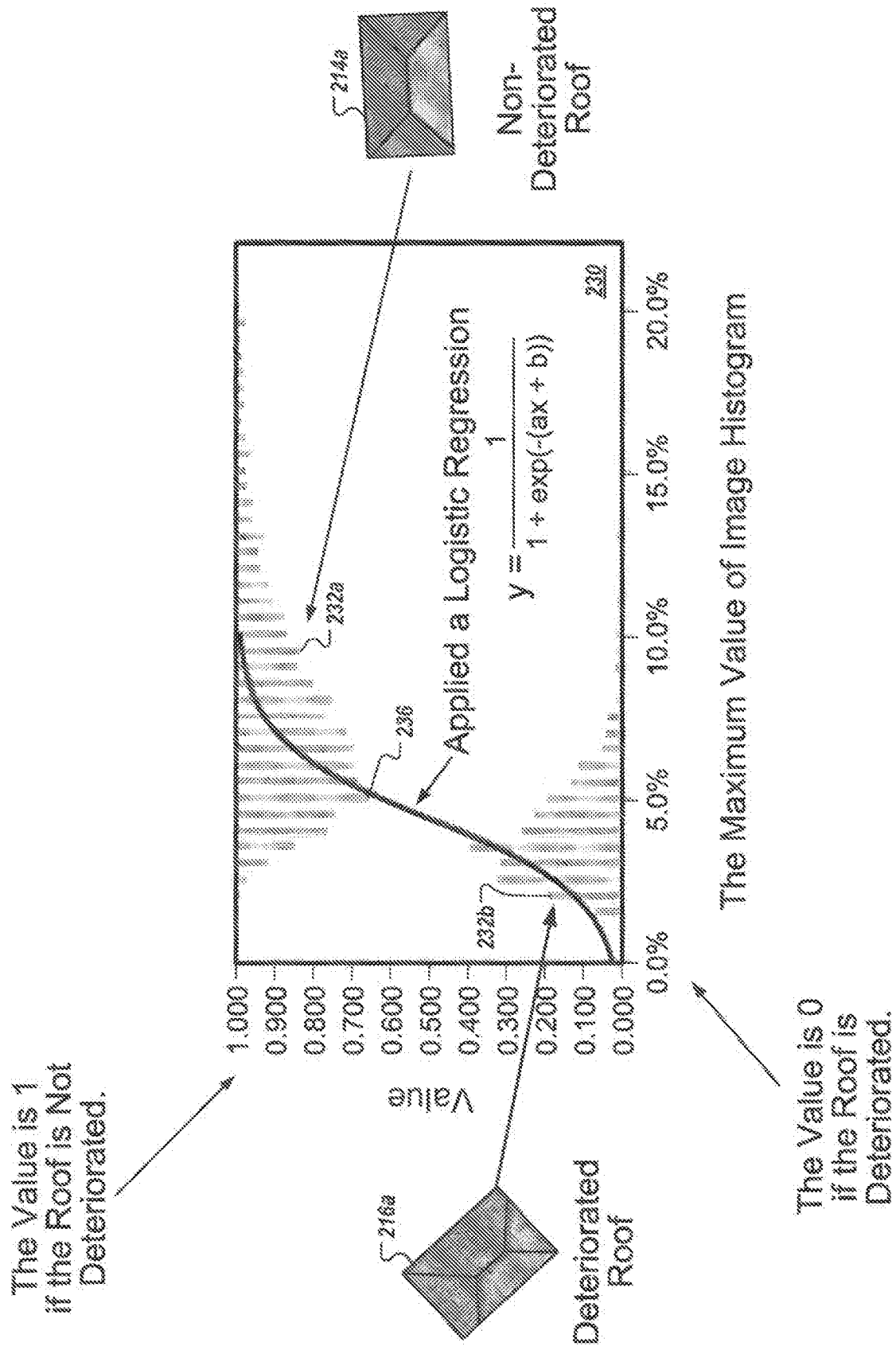


FIG. 2C

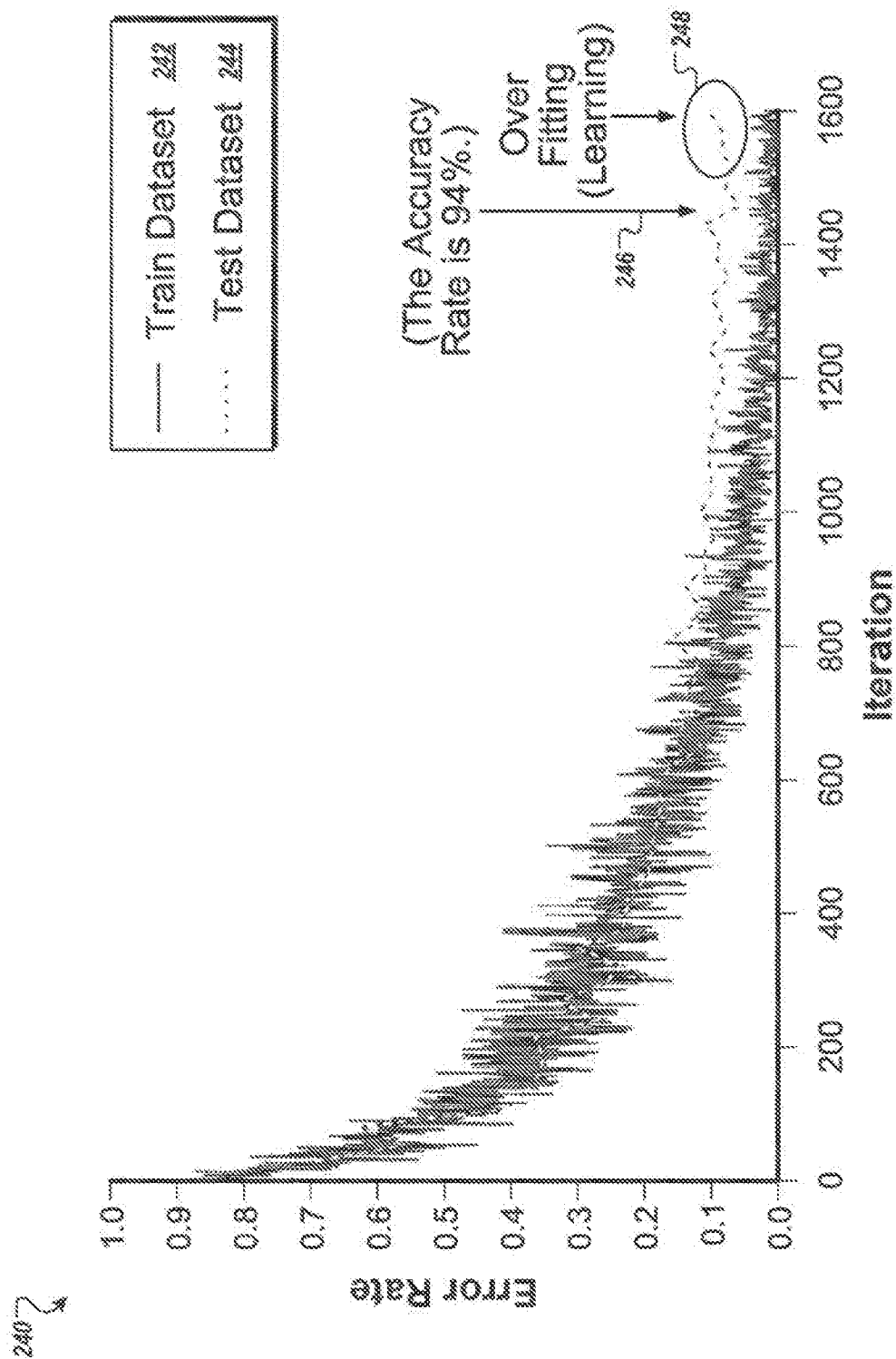


FIG. 2D

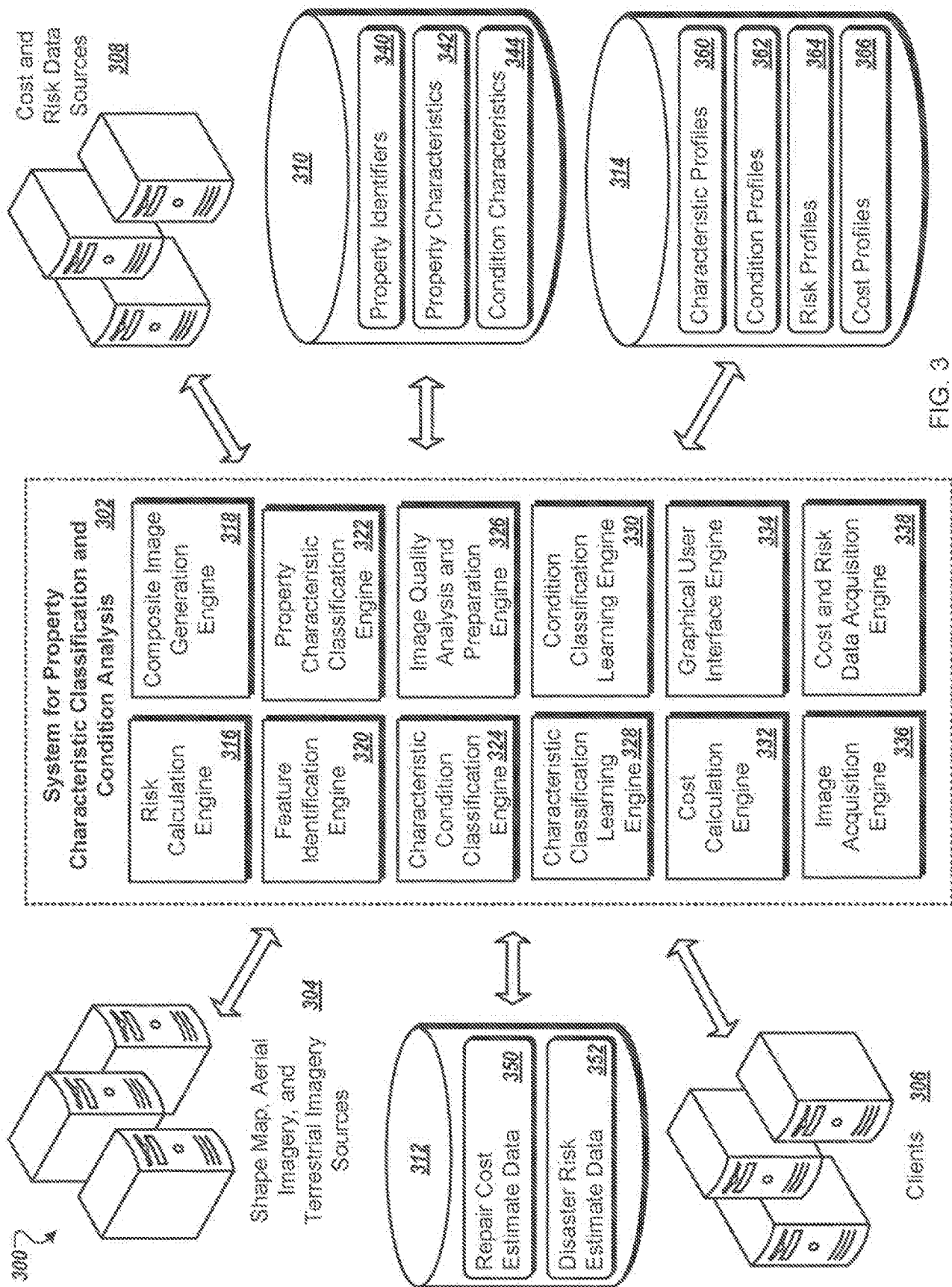


FIG. 3

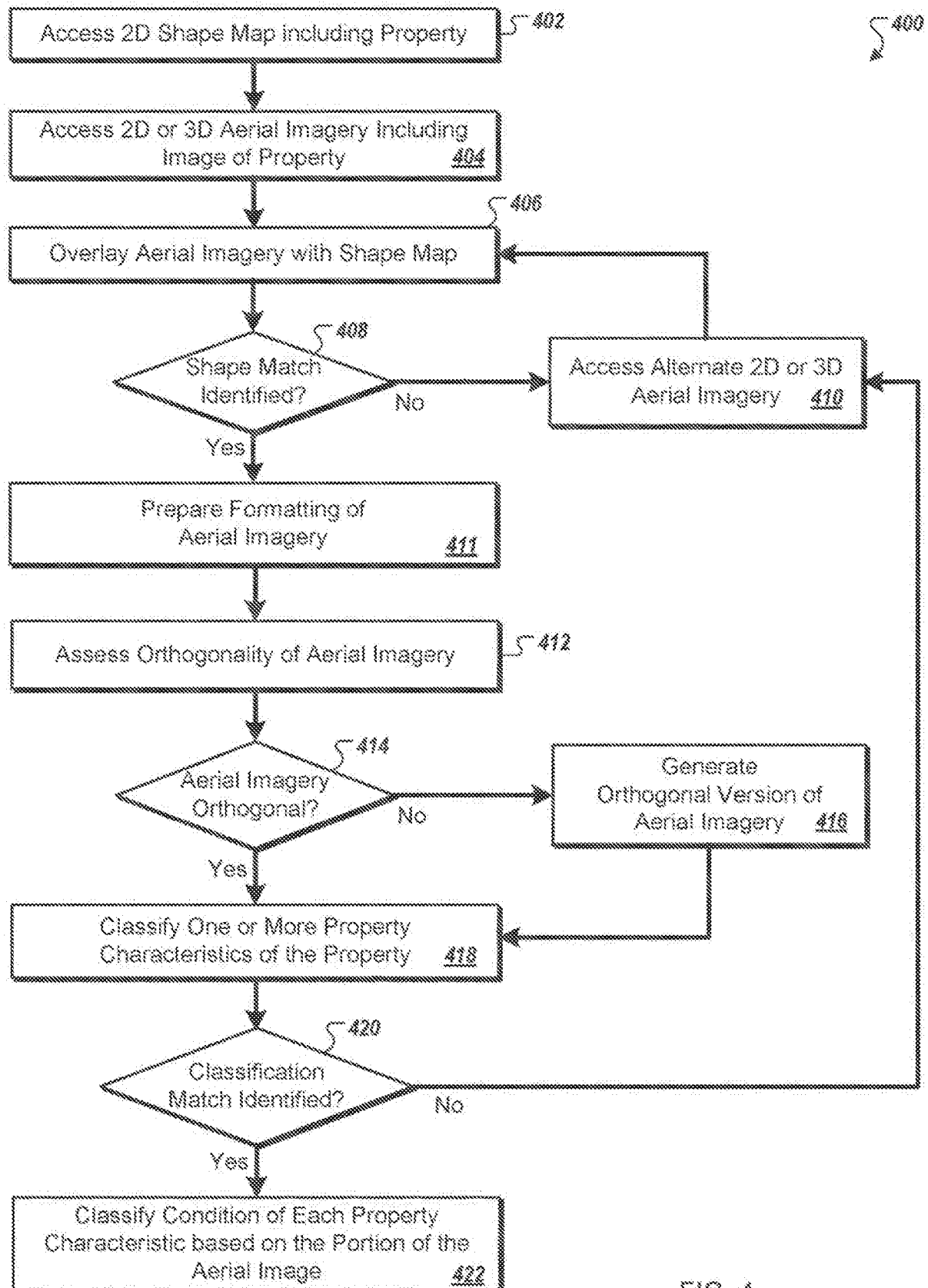


FIG. 4

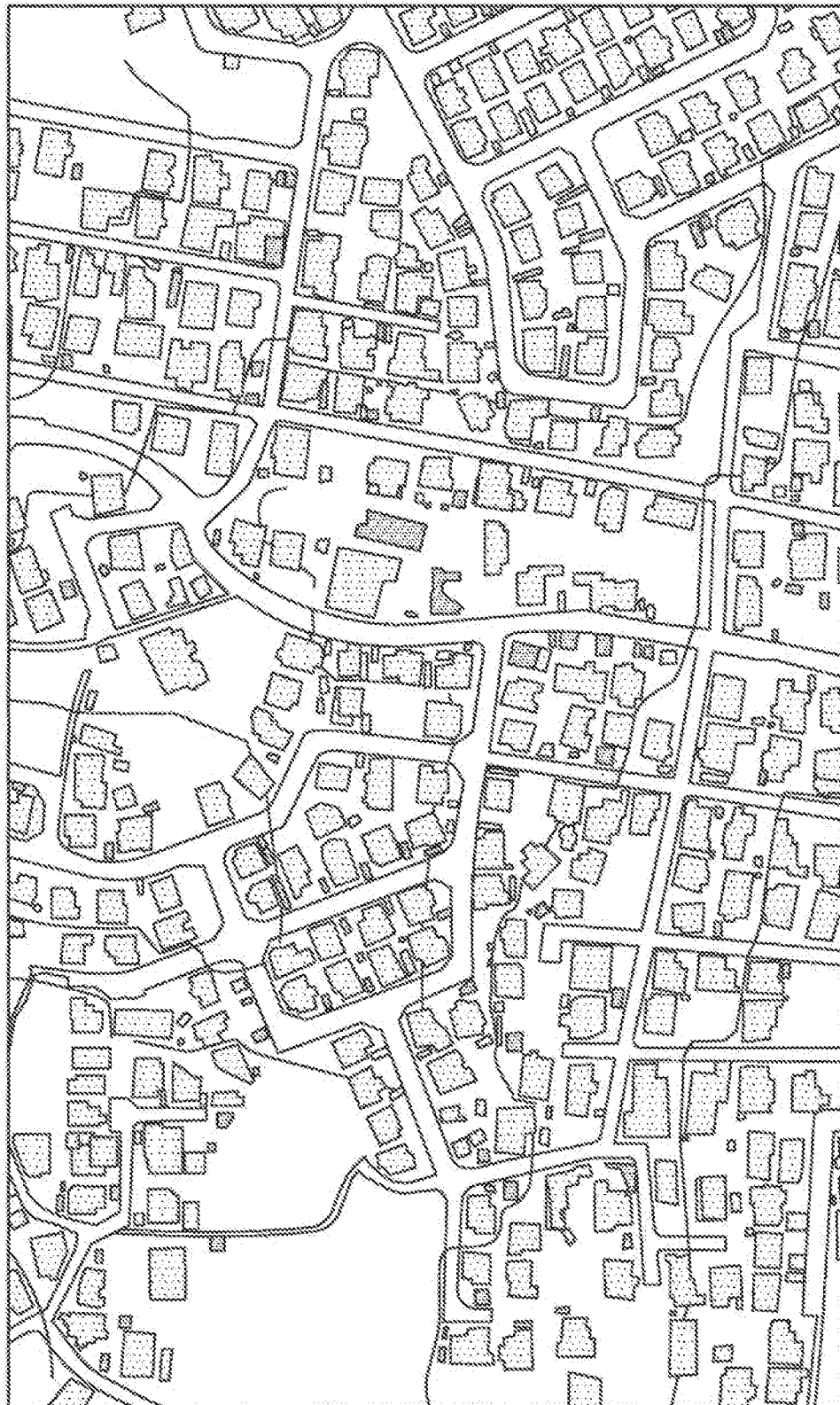


FIG. 5A

5000

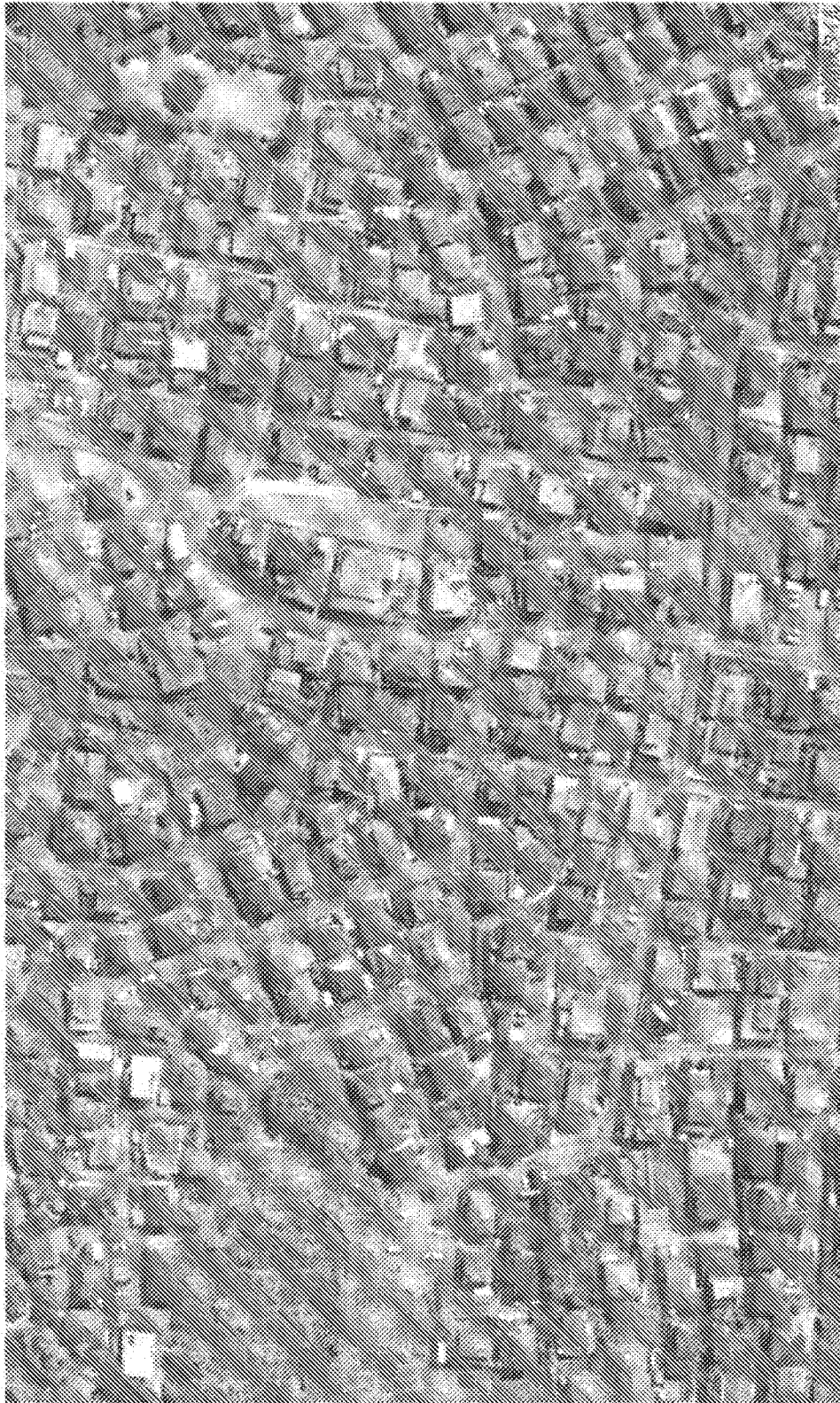


FIG. 5B

5102

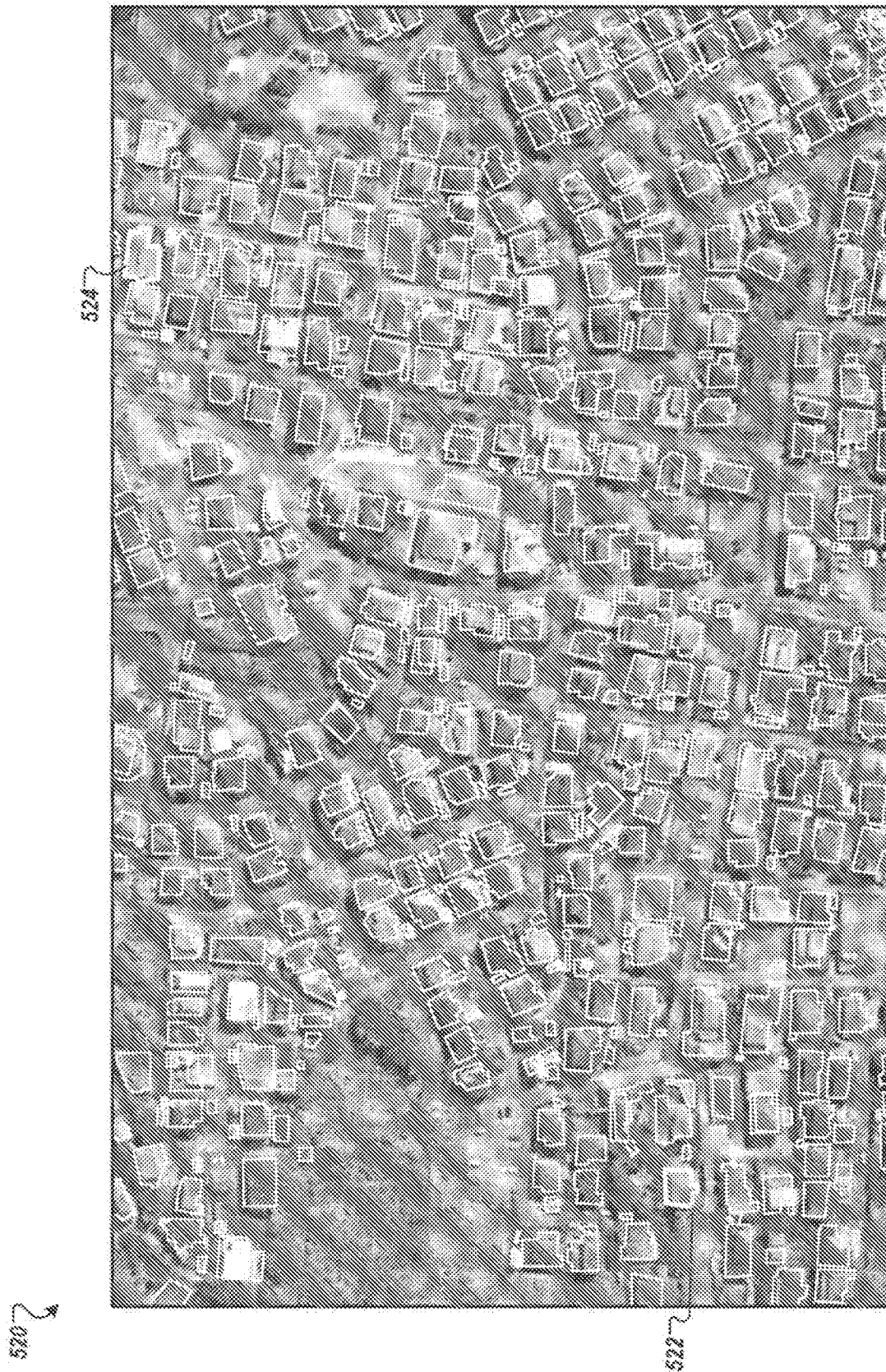


FIG. 5C

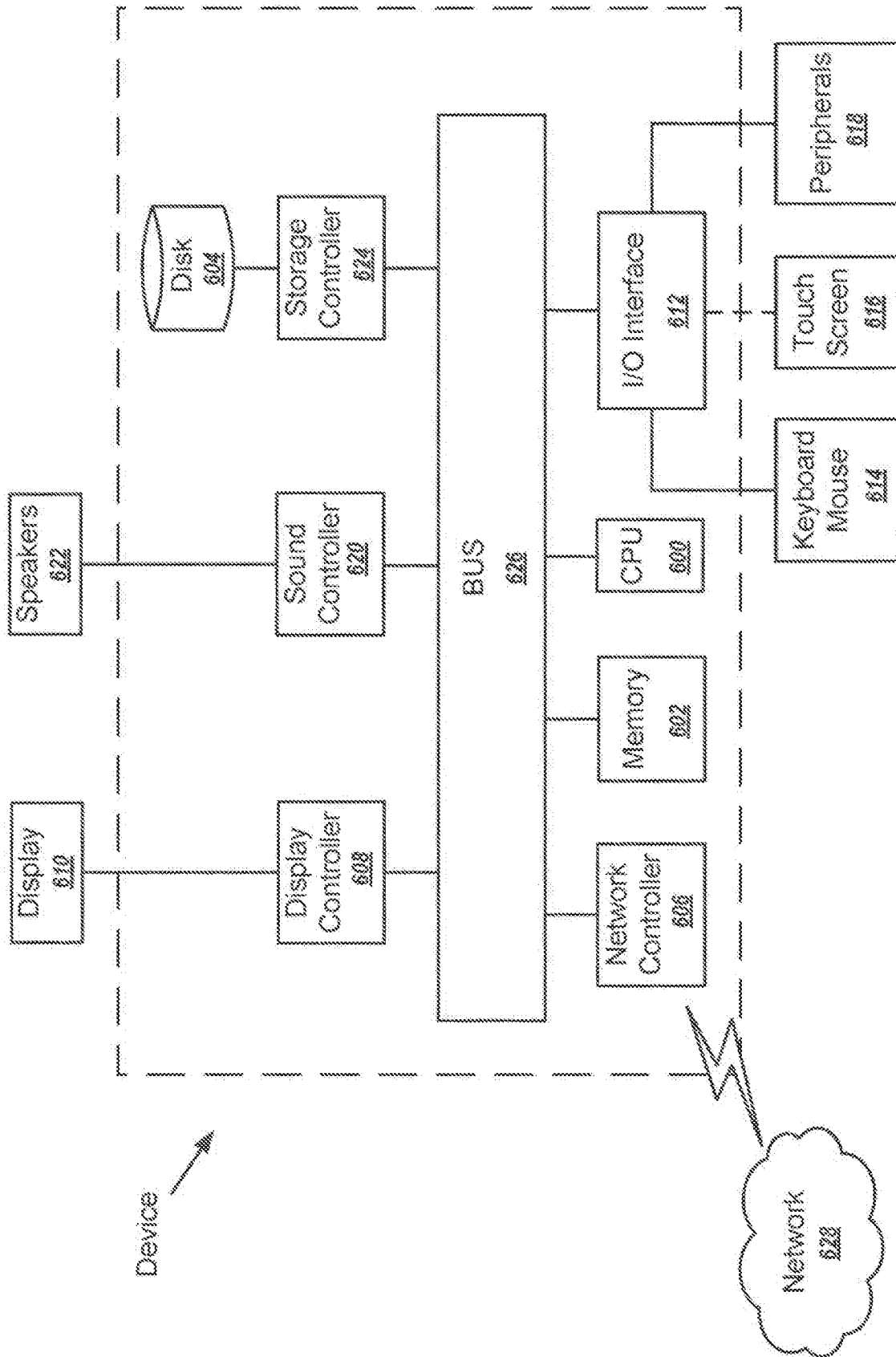


FIG. 6

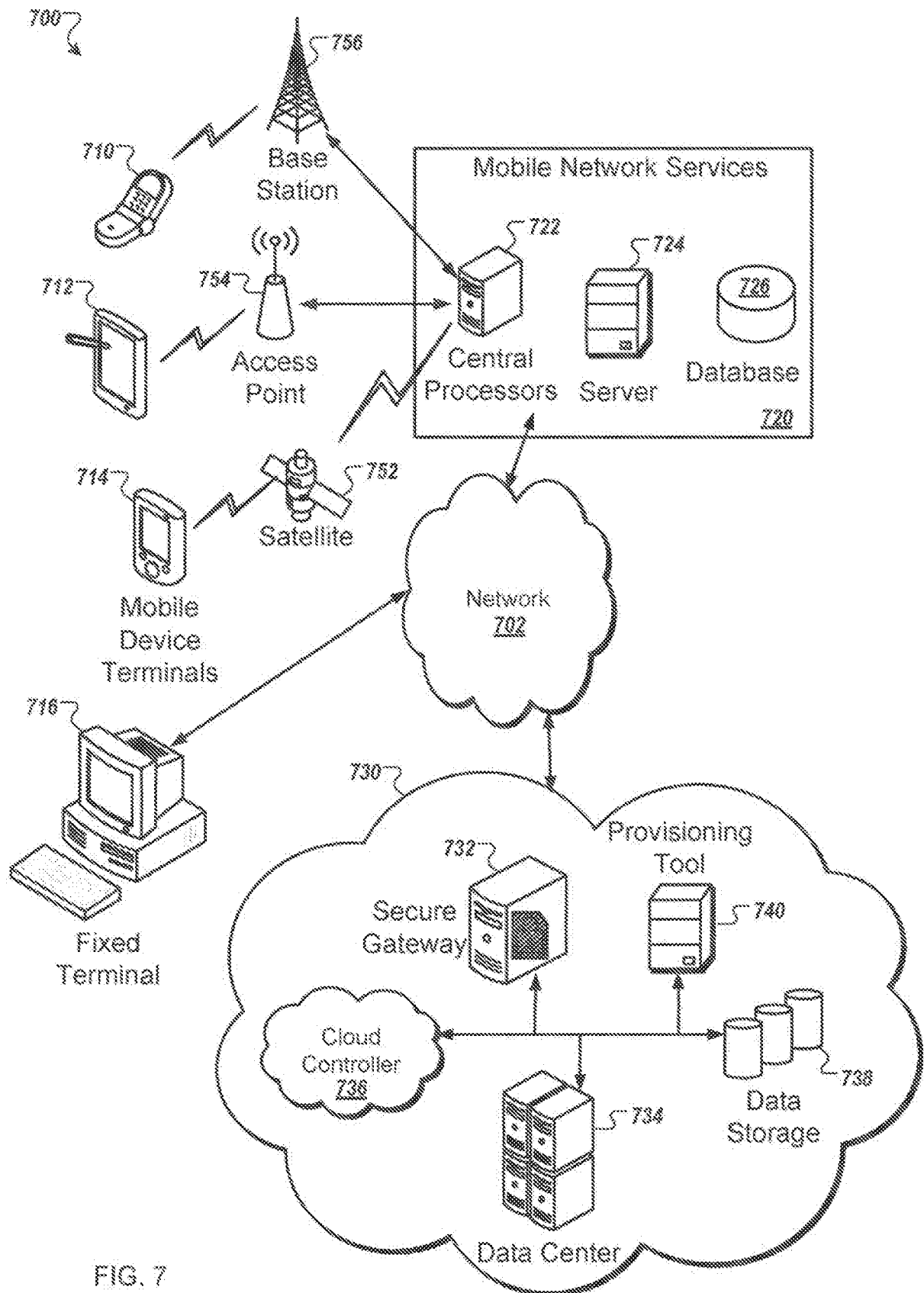


FIG. 7

800

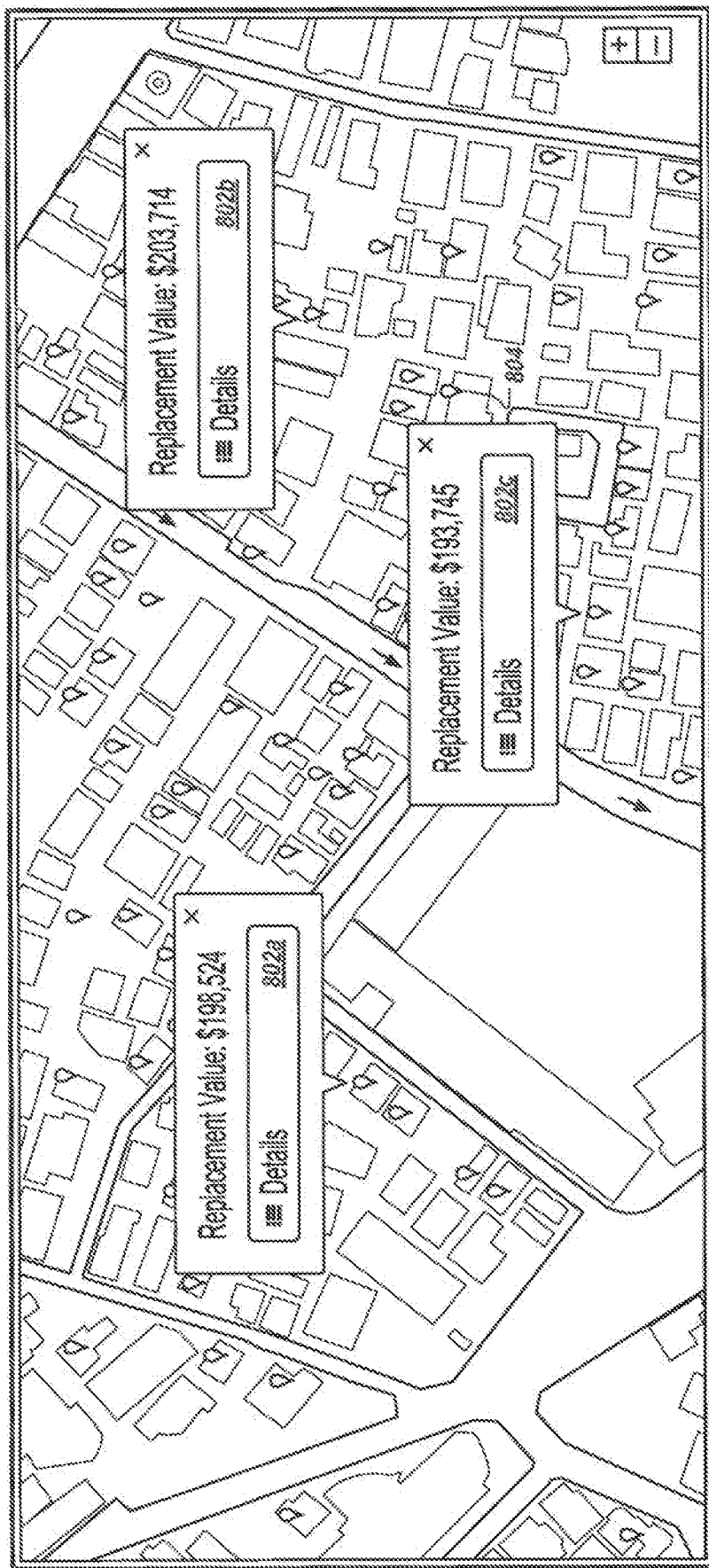


FIG. 8A

820

Bld Area / Edit		828a
Bld Area	63m ²	822a
Stories	2	822b
Total Bld Area	127m ²	822c
Structure / Edit		828b
Structure	Wooden	824a
Construction Class	Grade H	824b
Premium / Edit		828c
Replacement Value, USD	\$203,714	826

FIG. 8B

840

Disaster Risk		
842a	 Fire	Level: 4~5 844a
842b	 Wind	Wind speed: 34m/s 844b
842c	 Flood	None 844c
842d	 Earthquake	6.1 844d
842e	 Tsunami	None 844e
842f	 Landslide	None 844f

FIG. 8C

INTERNATIONAL SEARCH REPORT

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PCT/US 17/53265

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G06K 9/00 (2017.01)

CPC - G06T 2201/0051, H04N 2201/327, G06T 2201/0052, H04N 2201/3233, G06T 1/0028

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)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014/0019186 A1 (Swanson et al.) 16 January 2014 (16.01.2014) entire document (especially para [0008]-[0010], para [0012], para [0025]-[0026])	1-20
Y	US 2016/0259994 A1 (Accenture Global Service Limited) 08 September 2016 (08.09.2016) entire document (especially para [0010]-[0013], para [0017], para [0024], para [0034], para [0043])	1-20
Y	US 9,070,018 B1 (Eagle View Technologies, Inc.) 30 June 2015 (30.06.2015) (col. 7, ln 55-62; col. 11, ln 5-15)	6

☐ 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

14 November 2017 (14.11.2017)

Date of mailing of the international search report

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G06K 9/00 (2006.01) G06T 17/05 (2011.01)

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[Continued on next page]

(54) Title: AUTOMATED SYSTEM AND METHODOLOGY FOR FEATURE EXTRACTION

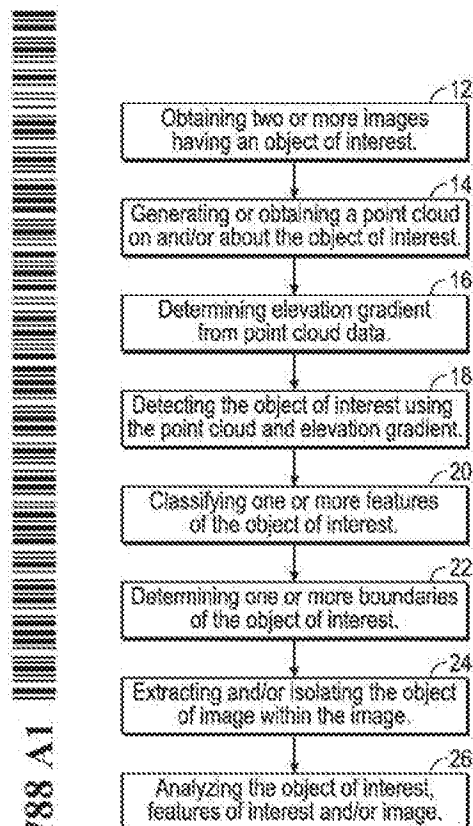


FIG. 1

(57) Abstract: An automated method performed by at least one processor running computer executable instructions stored on at least one non-transitory computer readable medium, comprising: classifying first data points identifying at least one man-made roof structure within a point cloud and classifying second data points associated with at least one of natural structures and ground surface to form a modified point cloud; identifying at least one feature of the man-made roof structure in the modified point cloud; and generating a roof report including the at least one feature.



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AUTOMATED SYSTEM AND METHODOLOGY FOR FEATURE EXTRACTION

Incorporation by Reference

[0001] The present patent application claims priority to the provisional patent application identified by U.S. Serial No. 62/295,336, filed on February 15, 2016, entitled "Automated System and Methodology for Feature Extraction", and to the provisional patent application identified by U.S. Serial No. 62/411,284, filed on October 21, 2016, entitled "Automated System and Methodology for Feature Extraction," the entire contents of all of which are hereby incorporated herein by reference.

Background

[0002] Feature extraction within images holds a multitude of uses over multiple industries. The identification of elements or features within an image, or even absent from an image, provides valuable information. Prior art uses of human identification, however, wastes time and energy, in addition to variances between human extractors.

[0003] For example, residential and/or commercial property owners approaching a major roofing project may be unsure of the amount of material needed and/or the next step in completing the project. Generally, such owners contact one or more contractors for a site visit. Each contractor must physically be present at the site of the structure in order to make a determination on material needs and/or time. The time and energy for providing such an estimate becomes laborious and may be affected by contractor timing, weather, contractor education, and the like. Estimates may be varied even between contractors in determination of estimated square footage causing variance in supply ordering as well. Additionally, measuring an actual roof may be costly and potentially hazardous – especially with steeply pitched roofs. Completion of a proposed roofing project may depend on ease in obtaining a simplified roofing estimate and/or obtaining reputable contractors for the roofing project.

[0004] Remote sensing technology has the ability to be more cost effective than manual inspection while providing pertinent information for assessment of

roofing projects. Images are currently being used to measure objects and structures within the images, as well as to be able to determine geographic locations of points within the image when preparing estimates for a variety of construction projects, such as roadwork, concrete work, and roofing. See for example U.S. Patent No. 7,424,133 that describes techniques for measuring within oblique images. Also see for example US Patent No. 8,145,578 that describe techniques for allowing the remote measurements of the size, geometry, pitch and orientation of the roof sections of the building and then uses the information to provide an estimate to repair or replace the roof, or to install equipment thereon. Estimating construction projects using software increases the speed at which an estimate is prepared, and reduces labor and fuel costs associated with on-site visits.

[0005] Further, feature extraction, or cataloguing feature extraction, can go beyond features represented within an image and provide useful information on features missing from an image. For example, tree density within a forest, or changes to the tree density over time, may be determined using lack of trees, a feature within a known area of an image. Thus, the location of missing feature may be determined relevant in feature extraction of the image.

Brief Description of Several Views of the Drawings

To assist those of ordinary skill in the relevant art in making and using the subject matter hereof, reference is made to the appended drawings, which are not intended to be drawn to scale, and in which like reference numerals are intended to refer to similar elements for consistency. For purposes of clarity, not every component may be labeled in every drawing.

[0006] FIG. 1 illustrates a block diagram for automatic feature extraction of one or more natural and/or man-made structures within an image, in accordance with the present disclosure.

[0007] FIG. 2 illustrates a schematic diagram of hardware forming an exemplary embodiment of a system for automatic feature extraction of one or more natural and/or man-made structures within an image. The system includes an image capturing system and a computer system.

[0008] FIG. 3 illustrates a diagrammatic view of an example of the image-capturing system of FIG. 2.

[0009] FIG. 4 illustrates a block diagram of the image-capturing computer system of FIG. 3 communicating via a network with multiple processors.

[0010] FIG. 5 illustrates a screen shot of an image of a region having multiple objects of interest in accordance with the present disclosure.

[0011] FIG. 6 illustrates a screen shot of a point cloud of the region illustrated in FIG. 5.

[0012] FIG. 7 illustrates a screen shot of a modified point cloud having data points at an elevation of interest.

[0013] FIG. 8 illustrates a screen shot of buildings identified using data points of a point cloud in accordance with the present disclosure.

[0014] FIG. 9 illustrates a screen shot of an image showing boundaries on a building identified using the modified point cloud of FIG. 7.

[0015] FIGS. 10-12 illustrate an exemplary method for automated object detection in accordance with the present disclosure.

[0016] FIG. 13 illustrates the building of FIG. 9 extracted from the image.

[0017] FIG. 14 illustrates a screen shot of roof features identified in accordance with the present disclosure.

[0018] FIG. 15 illustrates an exemplary roof report generated in accordance with the present disclosure.

Detailed Description

[0019] Before explaining at least one embodiment of the disclosure in detail, it is to be understood that the disclosure is not limited in its application to the details of construction, experiments, exemplary data, and/or the arrangement of the components set forth in the following description or illustrated in the drawings unless otherwise noted.

[0020] The disclosure is capable of other embodiments or of being practiced or carried out in various ways. For example, although the roofing industry may be used as an example, feature extraction in one or more images in any industry is contemplated. Additionally, identification of features absent within one or more images is also contemplated. Also, it is to be understood that the phraseology and terminology employed herein is for purposes of description, and should not be regarded as limiting.

[00021] The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

[00022] As used in the description herein, the terms "comprises," "comprising," "includes," "including," "has," "having," or any other variations thereof, are intended to cover a non-exclusive inclusion. For example, unless otherwise noted, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements, but may also include other elements not expressly listed or inherent to such process, method, article, or apparatus.

[00023] Further, unless expressly stated to the contrary, "or" refers to an inclusive and not to an exclusive "or". For example, a condition A or B is satisfied by one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

[00024] In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the inventive concept. This description should be read to include one or more, and the singular also includes the plural unless it is obvious that it is meant otherwise. Further, use of the term "plurality" is meant to convey "more than one" unless expressly stated to the contrary.

[00025] As used herein, any reference to "one embodiment," "an embodiment," "some embodiments," "one example," "for example," or "an example" means that a particular element, feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment. The appearance of the phrase "in some embodiments" or "one example" in various places in the specification is not necessarily all referring to the same embodiment, for example.

[00026] Circuitry, as used herein, may be analog and/or digital components, or one or more suitably programmed processors (e.g., microprocessors) and associated hardware and software, or hardwired logic. Also, "components" may perform one or more functions. The term "component," may include hardware, such as a processor (e.g., microprocessor), an application specific integrated circuit (ASIC), field programmable gate array (FPGA), a combination of hardware and software, and/or the like. The term "processor" as used herein means a single processor or multiple processors working independently or together to collectively perform a task.

[00027] Software may include one or more computer readable instructions that when executed by one or more components cause the component to perform a specified function. It should be understood that the algorithms described herein may be stored on one or more non-transitory computer readable medium. Exemplary non-transitory computer readable mediums may include random access memory, read only memory, flash memory, and/or the like. Such non-transitory computer readable mediums may be electrically based, optically based, and/or the like.

[00028] It is to be further understood that, as used herein, the term user is not limited to a human being, and may comprise, a computer, a server, a website, a processor, a network interface, a human, a user terminal, a virtual computer, combinations thereof, and the like, for example.

[00029] Referring now to the Figures, and in particular to FIG. 1, shown therein is a flow chart 10 of an exemplary method for automatically extracting features of one or more natural and/or man-made structures within an image. Using a combination of point cloud data and spectral analysis, features within one or more images may be extracted. Alternatively, using a combination of point cloud data and spectral analysis, missing features within an image may be determined. Further, in some embodiments, features within images and/or missing features within images may be catalogued (e.g., spatial cataloguing) within one or more databases for retrieval and/or analysis. For example, measurements of features (e.g., size of building(s), height of tree(s), footprint(s) of man-made or non-man made features) may be obtained. In some embodiments, such features may be stored in one or more database with measurements of features associated therewith, in addition to other metadata associated with the feature and/or image (e.g., date, algorithms used).

[00030] Generally, one or more images having raster data depicting an object of interest (e.g., a building) may be obtained and stored in a geospatial database to be available for use in creating and/or interpreting a point cloud that overlaps with the one or more images, as shown in step 12. The raster data depicting the object of interest may depict colors of visible light in mostly three bands (red, green, and blue) or one or more other modalities. For example, the raster data may include information for hyperspectral imaging which collects and processes information from across the electromagnetic spectrum. In some embodiments, the raster data may include near infrared data or thermal data. Each image may be geo-referenced such

that geographical coordinates are provided for each point in the images. Geo-referencing may include associating each image, e.g., raster data, with camera pose parameters indicative of internal orientation information of the camera, and external orientation information of the camera. Internal orientation information includes, but is not limited to, known or determinable characteristics including focal length, sensor size and aspect ratio, radial and other distortion terms, principal point offset, pixel pitch, and alignment. External orientation information includes, but is not limited to, altitude, orientation in terms of roll, pitch and yaw, and the location of the camera relative to the Earth's surface. The internal and external orientation information can be obtained in a manner described, for example, in U.S. Patent No. 7,424,133. Alternatively, or in addition, the internal and external orientation information can be obtained from analyzing overlapping images using any suitable technique, such as bundle – adjustment. Techniques for bundle adjustment are described, for example, in U.S. Patent Nos. 6,996,254 and 8,497,905. The internal and external orientation information can be stored within metadata of the image, or can be stored separately from the image and associated with the image utilizing any suitable technique, such as a unique code for each image stored within a look-up field within the geospatial database.

[00031] In step 14, a point cloud may be generated or obtained on and/or about the object of interest. The point cloud may be generated using a 3D scanner, a detection system that works on the principle of radar, but uses light from a laser (these systems are known in the art and identified by the acronym “Lidar”), or from the images stored in the geospatial database using the internal and external orientation information for the images. Techniques for generating a point cloud using internal and external information for the images as well as feature matching techniques are known to those skilled in the art. For example, suitable computer programs for the photogrammetric creation of point clouds include Agisoft Photoscan by Agisoft; Metigo 3D by fokus GmbH Leipzig; 123D Catch by Autodesk; Pix4Dmapper by Pix4D; and DroneMapper by DroneMapper. Point clouds include a series of points in which each point may be identified with a three-dimensional (e.g., X, Y, and Z) position. The three – dimensional position of points representing man-made or natural objects can be classified as such using the relative position of the points relative to other points, as well as the shape of a grouping of the points. Further analysis can be conducted on these points as well as images correlated with

the points to extract features of the objects represented in the point cloud. In some embodiments, the point cloud may be formed such that all features having known locations within three dimensions are represented. The point cloud(s) can be saved in any suitable format, such as point data, DSM/DTM, CAD, Tiff, Autodesk cloud, GeoTiff, and KMZ, for example.

[00032] Because the three-dimensional position on the Earth of each point in the point cloud is known, in a step 16, the Z values of the points can be analyzed to determine whether the points represent the ground, or a man-made or natural object located above the ground. In some embodiments, an elevation value or an elevation gradient may be used to analyze the point cloud data to determine whether particular points represent the ground, a man-made object, or a natural object above the ground. In some embodiments, classification of ground surface and non-ground surface may be determined for each data point. Identification of features on the ground surface versus features on a non-ground surface may aid in differentiation between features within the image. For example, a shadow created by a roof may have similar characteristics to the roof and be difficult for detection within an image using spectral analysis. Identification that the shadow is on the ground surface, however, would differentiate the shadow of the roof from the actual roof.

[00033] Data points can be transformed with information classifying the type of object that the data point represents. For example, data points indicative of the ground surface may be classified within the point cloud as being part of the ground surface. In some embodiments, data points of certain type(s) of objects can be removed from the point cloud to enhance processing of the remaining type(s) of objects within a modified point cloud. For example, all of the data points classified as being part of the ground surface may be removed from the point cloud to enhance the analysis of the points representing man-made objects or natural objects.

[00034] Certain objects of interest (e.g., man-made objects or natural objects) may be identified, and in a step 18, the object of interest may be detected using the point cloud and elevation gradient. In some embodiments, man-made structures, natural structures, and ground structures may also be determined. Natural structures and ground structures may be classified, and/or removed from the point cloud forming a modified point cloud. For example, assuming that buildings are the object of interest, points in the point cloud representing the building will have a higher elevation (e.g., Z value) than points in the point cloud representing the ground

surface. In this case, the points having a lower elevation Z-value than adjacent points can be classified as the ground surface, and the other points in the point cloud can be initially classified as either a man-made structure, or a natural structure. The classification can be accomplished by storing additional data within the point cloud. Even further, an elevation of interest may be determined and all data points below the elevation of interest may be classified as the ground structure, or all data points above the elevation of interest may be classified as a natural object or a man-made object.

[00035] It should be noted that a point cloud is not needed for identification of features within an image or missing features within an image as described herein. The point cloud may aid in identification of ground surface versus non-ground surface, but is not a mandatory step in determination of features within an image or features missing within an image.

[00036] In a step 20, the points within the point cloud that are initially classified as not being part of the ground structure, are further analyzed to determine whether the points represent a man-made object (e.g., a building), or a natural object, (e.g., a tree). This can be accomplished by analyzing the shape of a grouping of the points. Groupings of points having planar surfaces (e.g., roof section(s)) detectable within the point cloud can be classified as a man-made object, and groupings of points devoid of planar surfaces (e.g., tree(s)) detectable within the point cloud can be classified as a natural object. This can be accomplished by analyzing a variation of surface normal direction between each point of a group of points and the other points within the group.

[00037] Once this analysis has been accomplished, the points are classified as either representing a man-made object or a natural object. Then, points within the point cloud that represent the man-made object, for example, can be further analyzed to determine one or more features (e.g., roof) of the object of interest (e.g., building). In some embodiments, the features may be classified using the modified point cloud in which the points have been classified, and/or certain points have been removed from the point cloud. In a step 22, one or more first information, (e.g., initial boundary) of the object of interest may be determined by looking for an outer boundary of a group of points, as well as analyzing the Z value of the points and looking for differences above a threshold between the Z values of adjacent points. In some embodiments, the boundaries of the object of interest may be further

determined and/or refined using a first location (e.g., latitude and longitude) of the points within the point cloud that are determined to be part of the object of interest and querying the geospatial database to obtain images having raster data depicting the object of interest. Then, standard edge detection methods and/or spectral analysis can be used to precisely determine second information, e.g., the boundary of the object of interest having second location coordinates. The second location coordinates can be X, Y pixel coordinates, or latitude/longitude and elevation. In some embodiments, the first information (e.g., initial boundary) may be initially determined using the point cloud or modified point cloud, and then refined to generate second information by registering the point cloud data or modified point cloud data with the raster data within one or more images, and then analyzing the raster data with one or more suitable image processing technique. Examples of suitable image processing techniques include, but are not limited to standard edge detection methods or spectral analysis methods.

[00038] Spectral analysis may be used to group data points of an object of interest. For example, data points of a feature within an image may have similar spectral signatures such that reflected and/or absorbed electromagnetic radiation may be similar and able to be differentiated from data points of other features within the image. For example, data points of a building may have spectral signatures different from data points of grass surrounding the building. Data points within the image having similar spectral signatures may thus be grouped to identify one or more features within the image. Exemplary spectral analysis methods are described in U.S. Patent No. 9,070,018, the entire content of which is incorporated herein by reference.

[00039] In some embodiments, thermal analysis of the object of interest may be used to group data points of objects of interest having similar or different thermal signatures. For example, a thermographic camera may be used to obtain an image using infrared radiation. Data points may be grouped based on temperature measurements of each feature within the image. Thermal analysis may be in addition to, or in lieu of a typical image (e.g., RGB image).

[00040] In a step 24, the object of interest may be extracted, classified, and/or isolated within the image. Additionally, the object of interest may be cataloged within one or more database. Cataloging may be via address, size of feature(s) and/or object of interest, color(s) of features and/or object of interest,

feature type, spatial relations (e.g., address, coordinates), and/or the like. For example, in some embodiments, the object of interest may be spatially cataloged within one or more database. To that end, one or more features of the object of interest may be isolated and/or extracted. One or more outlines of the one or more features may also be determined e.g., polygon outline of one facet of a roof. Each line of the outline may be spatially stored within a database such that retrieval may be via coordinates, address, and/or the like.

[00041] In a step 26, further analysis of the object of interest and/or the image may be performed. For example, when the present disclosure is used for analyzing a roof of a building and the data points include the three-dimensional position of the part of the object represented by the data points, data points representing the outer boundaries can be used to calculate the perimeter of the roof; data points representing a ridge and a valley bordering a roof section can be used to calculate a pitch of the roof section. These techniques can be used to calculate a variety of roof features, roof dimensions, and/or roof pitch of sections of the roof. The roof outline can be saved as a data file using any suitable format, such as a vector format, or a raster format. The calculated data and the data file of the roof outline can be saved in the geospatial database or a separate database that may or may not be correlated with the geospatial database. Further, the latitude and longitude of the data points can be used to determine a physical address of a particular object of interest (e.g., building) and such address can be stored with the calculated data. The calculated data, the image data and the address can be correlated together, and automatically used to populate a template thereby preparing a predetermined report about the object of interest including one or more images of the object of interest and calculated data about the object of interest. This methodology can be automatically executed by one or more processors as discussed herein to identify and obtain information about objects of interest for a variety of purposes. For example, the methodology can be automatically executed by one or more processors to generate reports for a plurality of objects of interest, without manual or human intervention. Thus, the presently described methodology provides a performance increase over conventional methods for generating object reports, as well as an enhancement to the operation of the processor when generating reports for one or more objects of interest.

[00042] Examples of the hardware/software for obtaining the images and performing the steps described above will now be described.

[00043] Referring to FIGS. 1 and 2, in some embodiments, an image capturing system 28 may be used to obtain the one or more images. The image capturing system 28 may include a platform 30 carrying the image capturing system 28. The platform 30 may be an airplane, unmanned aerial system, space shuttle, rocket, satellite, and/or any other suitable vehicle capable of carrying the image capturing system 28. For example, in some embodiments, the platform 30 may be a fixed wing aircraft.

[00044] The platform 30 may carry the image capturing system 28 at one or more altitudes above a ground surface 32. For example, the platform 30 may carry the image capturing system 28 over a predefined area and at one or more predefined altitudes above the Earth's surface and/or any other surface of interest. In FIG. 2, the platform 30 is illustrated carrying the image capturing system 28 at a plane P above the ground surface 32.

[00045] The platform 30 may be capable of controlled movement and/or flight. As such, the platform 30 may be manned or unmanned. In some embodiments, the platform 30 may be capable of controlled movement and/or flight along a pre-defined flight path and/or course. For example, the platform 30 may be capable of controlled movement and/or flight along the Earth's atmosphere and/or outer space.

[00046] The platform 30 may include one or more systems for generating and/or regulating power. For example, the platform 30 may include one or more generators, fuel cells, solar panels, and/or batteries for powering the image capturing system 28.

[00047] Referring to FIGS. 2 and 3, the image capturing system 28 may include one or more image capturing devices 34 configured to obtain an image from which a point cloud may be generated. In some embodiments, the image capturing system 28 may optionally include one or more LIDAR scanners 36 to generate data that can be used to create a point cloud. Additionally, in some embodiments, the image capturing system 28 may include one or more global positioning system (GPS) receivers 38, one or more inertial navigation units (INU) 40, one or more clocks 42, one or more gyroscopes 44, one or more compasses 46, and one or more altimeters 48. In some embodiments, the image capturing system 28 may include one or more thermographic cameras configured to capture one or more

thermographic images. One or more of these elements of the image capturing system 28 may be interconnected with an image capturing and processing computer system 50. In some embodiments, the internal and external orientation information for the images can be determined during post processing using an image processing technique, such as bundle adjustment. In these embodiments, the image capturing system 28 may not include the one or more INU 40.

[00048] In some embodiments, the one or more image capturing devices 34 may be capable of capturing images photographically and/or electronically. The one or more image capturing devices 34 may be capable and/or configured to provide oblique and/or vertical images, and may include, but are not limited to, conventional cameras, digital cameras, digital sensors, charge-coupled devices, thermographic cameras and/or the like. In some embodiments, the one or more image capturing devices 34 may be one or more ultra-high resolution cameras. For example, in some embodiments, the one or more image capturing devices 34 may be ultra-high resolution capture systems, such as may be found in the Pictometry PentaView Capture System, manufactured and used by Pictometry International based in Henrietta, New York.

[00049] The one or more image capturing devices 34 may include known or determinable characteristics including, but not limited to, focal length, sensor size, aspect ratio, radial and other distortion terms, principal point offset, pixel pitch, alignment, and/or the like.

[00050] The one or more image capturing devices 34 may acquire one or more images and issue one or more image data signals 52 corresponding to one or more particular images taken. Such images may be stored in the image capturing and processing computer system 50.

[00051] The LIDAR scanner 36 may determine a distance between the platform 30 and objects on or about the ground surface 32 by illuminating a laser and analyzing the reflected light to provide data points. In some embodiments, software associated with the LIDAR scanner 36 may generate a depth map or point cloud based on the measured distance between the platform 30 on and/or about the object of interest. To that end, the LIDAR scanner 36 may issue one or more data signals 54 to the image capturing and processing computer system 50 of such data points providing a point cloud wherein each data point may represent a particular coordinate. An exemplary LIDAR scanner 36 may be the Riegl LMS-Q680i,

manufactured and distributed by Riegl Laser Measurement Systems located in Horn, Austria. It should be noted that distance between the platform 30 and objects on or about the ground surface 32 may be determined via other methods including, but not limited to, stereographic methods.

[00052] In some embodiments, the LIDAR scanner 36 may be a downward projecting high pulse rate LIDAR scanning system. It should be noted that other three-dimensional optical distancing systems or intensity-based scanning techniques may be used. In some embodiments, the LIDAR scanner 36 may be optional as a point cloud may be generated using one or more images and photogrammetric image processing techniques, e.g., the images may be geo-referenced using position and orientation of the image capturing devices 34 and matched together to form the point cloud.

[00053] The GPS receiver 38 may receive global positioning system (GPS) signals 56 that may be transmitted by one or more global positioning system satellites 58. The GPS signals 56 may enable the location of the platform 30 relative to the ground surface 32 and/or an object of interest to be determined. The GPS receiver 38 may decode the GPS signals 56 and/or issue location signals 60. The location signals 60 may be dependent, at least in part, on the GPS signals 56 and may be indicative of the location of the platform 30 relative to the ground surface 32 and/or an object of interest. The location signals 60 corresponding to each image captured by the image capturing devices 34 may be received and/or stored by the image capturing and processing computer system 50 in a manner in which the location signals are associated with the corresponding image.

[00054] The INU 40 may be a conventional inertial navigation unit. The INU 40 may be coupled to and detect changes in the velocity (e.g., translational velocity, rotational velocity) of the one or more image capturing devices 34, the LIDAR scanner 36, and/or the platform 30. The INU 40 may issue velocity signals and/or data signals 62 indicative of such velocities and/or changes therein to the image capturing and processing computer system 50. The image capturing and processing computer system 50 may then store the velocity signals and/or data 62 corresponding to each image captured by the one or more image capturing devices 34 and/or data points collected by the LIDAR scanner 36.

[00055] The clock 42 may keep a precise time measurement. For example, the clock 42 may keep a precise time measurement used to synchronize events.

The clock 42 may include a time data/clock signal 64. In some embodiments, the time data/clock signal 64 may include a precise time that an image is taken by the one or more image capturing devices 34 and/or the precise time that points are collected by the LIDAR scanner 36. The time data 64 may be received by and/or stored by the image capturing and processing computer system 50. In some embodiments, the clock 42 may be integral with the image capturing and processing computer system 50, such as, for example, a clock software program.

[00056] The gyroscope 44 may be conventional gyroscope commonly found on airplanes and/or within navigation systems (e.g., commercial navigation systems for airplanes). The gyroscope 44 may submit signals including a yaw signal 66, a roll signal 68, and/or a pitch signal 70. In some embodiments, the yaw signal 66, the roll signal 68, and/or the pitch signal 70 may be indicative of the yaw, roll and picture of the platform 30. The yaw signal 66, the roll signal 68, and/or the pitch signal 70 may be received and/or stored by the image capturing and processing computer system 50.

[00057] The compass 46 may be any conventional compass (e.g., conventional electronic compass) capable of indicating the heading of the platform 30. The compass 46 may issue a heading signal and/or data 72. The heading signal and/or data 72 may be indicative of the heading of the platform 30. The image capturing and processing computer system 50 may receive, store and/or provide the heading signal and/or data 72 corresponding to each image captured by the one or more image capturing devices 34.

[00058] The altimeter 48 may indicate the altitude of the platform 30. The altimeter 48 may issue an altimeter signal and/or data 74. The image capturing and processing computer system 50 may receive, store and/or provide the altimeter signal and/or data 74 corresponding to each image captured by the one or more image capturing devices 34.

[00059] Referring to FIGS. 3 and 4, the image capturing and processing computer system 50 may be a system or systems that are able to embody and/or execute the logic of the processes described herein. Logic embodied in the form of software instructions and/or firmware may be executed on any appropriate hardware. For example, logic embodied in the form of software instructions or firmware may be executed on a dedicated system or systems, or on a personal computer system, or on a distributed processing computer system, and/or the like. In some

embodiments, logic may be implemented in a stand-alone environment operating on a single computer system and/or logic may be implemented in a networked environment, such as a distributed system using multiple computers and/or processors. For example, a subsystem of the image capturing and processing computer system 50 can be located on the platform 30, and another subsystem of the image capturing and processing computer system 50 can be located in a data center having multiple computers and/or processor networked together.

[00060] In some embodiments, the image capturing and processing computer system 50 may include one or more processors 76 communicating with one or more image capturing input devices 78, image capturing output devices 80, and/or I/O ports 82 enabling the input and/or output of data to and from the image capturing and processing computer system 50.

[00061] FIG. 4 illustrates the image capturing and processing computer system 50 having a single processor 76. It should be noted, however, that the image capturing and processing computer system 50 may include multiple processors 76. In some embodiments, the processor 76 may be partially or completely network-based or cloud-based. The processor 76 may or may not be located in a single physical location. Additionally, multiple processors 76 may or may not necessarily be located in a single physical location.

[00062] The one or more image capturing input devices 78 may be capable of receiving information input from a user and/or processor(s), and transmitting such information to the processor 76. The one or more image capturing input devices 78 may include, but are not limited to, implementation as a keyboard, touchscreen, mouse, trackball, microphone, fingerprint reader, infrared port, slide-out keyboard, flip-out keyboard, cell phone, PDA, video game controller, remote control, fax machine, network interface, speech recognition, gesture recognition, eye tracking, brain-computer interface, combinations thereof, and/or the like.

[00063] The one or more image capturing output devices 80 may be capable of outputting information in a form perceivable by a user and/or processor(s). For example, the one or more image capturing output devices 80 may include, but are not limited to, implementations as a computer monitor, a screen, a touchscreen, a speaker, a website, a television set, a smart phone, a PDA, a cell phone, a fax machine, a printer, a laptop computer, an optical head-mounted display (OHMD), combinations thereof, and/or the like. It is to be understood that in some exemplary

embodiments, the one or more image capturing input devices 78 and the one or more image capturing output devices 80 may be implemented as a single device, such as, for example, a touchscreen or a tablet.

[00064] Each of the data signals 52, 54, 60, 62, 64, 66, 68, 70, 72, and/or 74 may be provided to the image capturing and processing computer system 50. For example, each of the data signals 52, 54, 60, 62, 64, 66, 68, 70, 72, and/or 74 may be received by the image capturing and processing computer system 50 via the I/O port 82. The I/O port 82 may comprise one or more physical and/or virtual ports.

[00065] In some embodiments, the image capturing and processing computer system 50 may be in communication with one or more additional processors 84 as illustrated in FIG. 4. In this example, the image capturing and processing computer system 50 may communicate with the one or more additional processors 84 via a network 86. As used herein, the terms "network-based", "cloud-based", and any variations thereof, may include the provision of configurable computational resources on demand via interfacing with a computer and/or computer network, with software and/or data at least partially located on the computer and/or computer network, by pooling processing power of two or more networked processors.

[00066] In some embodiments, the network 86 may be the Internet and/or other network. For example, if the network 86 is the Internet, a primary user interface of the image capturing software and/or image manipulation software may be delivered through a series of web pages. It should be noted that the primary user interface of the image capturing software and/or image manipulation software may be replaced by another type of interface, such as, for example, a Windows-based application.

[00067] The network 86 may be almost any type of network. For example, the network 86 may interface by optical and/or electronic interfaces, and/or may use a plurality of network topographies and/or protocols including, but not limited to, Ethernet, TCP/IP, circuit switched paths, and/or combinations thereof. For example, in some embodiments, the network 86 may be implemented as the World Wide Web (or Internet), a local area network (LAN), a wide area network (WAN), a metropolitan network, a wireless network, a cellular network, a Global System for Mobile Communications (GSM) network, a code division multiple access (CDMA) network, a 3G network, a 4G network, a satellite network, a radio network, an optical network, a cable network, a public switched telephone network, an Ethernet network,

combinations thereof, and/or the like. Additionally, the network 86 may use a variety of network protocols to permit bi-directional interface and/or communication of data and/or information. It is conceivable that in the near future, embodiments of the present disclosure may use more advanced networking topologies.

[00068] The image capturing and processing computer system 50 may be capable of interfacing and/or communicating with the one or more computer systems including processors 84 via the network 86. Additionally, the one or more processors 84 may be capable of communicating with each other via the network 86.

[00069] The processors 84 may include, but are not limited to implementation as a variety of different types of computer systems, such as a server system having multiple servers in a configuration suitable to provide a commercial computer based business system (such as a commercial web-site and/or data center), a personal computer, a smart phone, a network-capable television set, a television set-top box, a tablet, an e-book reader, a laptop computer, a desktop computer, a network-capable handheld device, a video game console, a server, a digital video recorder, a DVD player, a Blu-Ray player, a wearable computer, a ubiquitous computer, combinations thereof, and/or the like. In some embodiments, the computer systems comprising the processors 84 may include one or more input devices 88, one or more output devices 90, processor executable code, and/or a web browser capable of accessing a website and/or communicating information and/or data over a network, such as network 86. The computer systems comprising the one or more processors 84 may include one or more non-transient memory comprising processor executable code and/or software applications, for example. The image capturing and processing computer system 50 may be modified to communicate with any of these processors 84 and/or future developed devices capable of communicating with the image capturing and processing computer system 50 via the network 86.

[00070] The one or more input devices 88 may be capable of receiving information input from a user, processors, and/or environment, and transmit such information to the processor 84 and/or the network 86. The one or more input devices 88 may include, but are not limited to, implementation as a keyboard, touchscreen, mouse, trackball, microphone, fingerprint reader, infrared port, slide-out keyboard, flip-out keyboard, cell phone, PDA, video game controller, remote control, fax machine, network interface, speech recognition, gesture recognition, eye tracking, brain-computer interface, combinations thereof, and/or the like.

[00071] The one or more output devices 90 may be capable of outputting information in a form perceivable by a user and/or processor(s). For example, the one or more output devices 90 may include, but are not limited to, implementations as a computer monitor, a screen, a touchscreen, a speaker, a website, a television set, a smart phone, a PDA, a cell phone, a fax machine, a printer, a laptop computer, an optical head-mounted display (OHMD), combinations thereof, and/or the like. It is to be understood that in some exemplary embodiments, the one or more input devices 88 and the one or more output devices 90 may be implemented as a single device, such as, for example, a touchscreen or a tablet.

[00072] Referring to FIG. 4, in some embodiments, the image capturing and processing computer system 50 may include one or more processors 76 working together, or independently to execute processor executable code, and one or more memories 92 capable of storing processor executable code. In some embodiments, each element of the image capturing and processing computer system 50 may be partially or completely network-based or cloud-based, and may or may not be located in a single physical location.

[00073] The one or more processors 76 may be implemented as a single or plurality of processors working together, or independently, to execute the logic as described herein. Exemplary embodiments of the one or more processors 76 may include, but are not limited to, a digital signal processor (DSP), a central processing unit (CPU), a field programmable gate array (FPGA), a microprocessor, a multi-core processor, and/or combination thereof, for example. The one or more processors 76 may be capable of communicating via the network 86, illustrated in FIG. 4, by exchanging signals (e.g., analog, digital, optical, and/or the like) via one or more ports (e.g., physical or virtual ports) using a network protocol. It is to be understood, that in certain embodiments, using more than one processor 76, the processors 76 may be located remotely from one another, in the same location, or comprising a unitary multi-core processor. The one or more processors 76 may be capable of reading and/or executing processor executable code and/or capable of creating, manipulating, retrieving, altering, and/or storing data structures into one or more memories 92.

[00074] The one or more memories 92 may be capable of storing processor executable code. Additionally, the one or more memories 92 may be implemented as a conventional non-transitory memory, such as, for example, random access

memory (RAM), a CD-ROM, a hard drive, a solid state drive, a flash drive, a memory card, a DVD-ROM, a floppy disk, an optical drive, combinations thereof, and/or the like, for example.

[00075] In some embodiments, the one or more memories 92 may be located in the same physical location as the image capturing and processing computer system 50. Alternatively, one or more memories 92 may be located in a different physical location as the image capturing and processing computer system 50, with the image capturing and processing computer system 50 communicating with one or more memories 92 via a network such as the network 86, for example. Additionally, one or more of the memories 92 may be implemented as a "cloud memory" (i.e., one or more memories 92 may be partially or completely based on or accessed using a network, such as network 86, for example).

[00076] Referring to FIG. 4, the one or more memories 92 may store processor executable code and/or information comprising one or more databases 94 and program logic 96 (i.e., computer executable logic). In some embodiments, the processor executable code may be stored as a data structure, such as a database and/or data table, for example. For example, one of the databases 94 can be a geospatial database storing aerial images, another one of the database 94 can store point clouds, and another one of the database 94 can store the internal and external orientation information for geo-referencing the images within the geospatial database.

[00077] In use, the image capturing and processing computer system 50 may execute the program logic 96 which may control the reading, manipulation, and/or storing of data signals 52, 54, 60, 62, 64, 66, 68, 70, 72, and/or 74. For example, the program logic may read data signals 52 and 54, and may store them within the one or more memories 92. Each of the signals 60, 62, 64, 66, 68, 70, 72 and 74, may represent the conditions existing at the instance that an oblique image and/or nadir image is acquired and/or captured by the one or more image capturing devices 34.

[00078] In some embodiments, the image capturing and processing computer system 50 may issue an image capturing signal to the one or more image capturing devices 34 to thereby cause those devices to acquire and/or capture an oblique image and/or a nadir image at a predetermined location and/or at a predetermined interval. In some embodiments, the image capturing and processing computer system 50 may issue the image capturing signal dependent on at least in part on the

velocity of the platform 30. Additionally, the image capturing and processing computer system 50 may issue a point collection signal to the LIDAR scanner 36 to thereby cause the LIDAR scanner to collect points at a predetermined location and/or at a predetermined interval.

[00079] Program logic 96 of the image capturing and processing computer system 50 may decode, as necessary, and/or store the aforementioned signals within the memory 92, and/or associate the data signals with the image data signals 52 corresponding thereto, or the LIDAR scanner signal 54 corresponding thereto. Thus, for example, the altitude, orientation, roll, pitch, yaw, and the location of each image capturing device 34 relative to the ground surface 32 and/or object of interest for images captured may be known. More particularly, the [X, Y, Z] location (e.g., latitude, longitude, and altitude) of an object or location seen within the images or location seen in each image may be determined. Similarly, the altitude, orientation, roll, pitch, yaw, and the location of the LIDAR scanner 36 relative to the ground surface 32 and/or object of interest for collection of data points may be known. More particularly, the [X, Y, Z] location (e.g., latitude, longitude, and altitude) of a targeted object or location may be determined. In some embodiments, location data for the targeted object or location may be catalogued within one or more database for retrieval.

[00080] The platform 30 may be piloted and/or guided through an image capturing path that may pass over a particular area of the ground surface 32. The number of times the platform 30 and/or the one or more image capturing devices 34 and LIDAR scanner 36 pass over the area of interest may be dependent at least in part upon the size of the area and the amount of detail desired in the captured images.

[00081] As the platform 30 passes over an area of interest, a number of images (e.g., oblique images, nadir images) may be captured by the one or more image capturing devices 34 and data points may be captured by the LIDAR scanner 36 (optional). In some embodiments, the images may be captured and/or acquired by the one or more image capturing devices 34 at predetermined image capture intervals that may be dependent, at least in part, upon the velocity of the platform 30. For example, the safe flying height for a fixed wing aircraft may be a minimum clearance of 2,000' above the ground surface 32, and may have a general forward flying speed of 120 knots. In this example, oblique image-capturing devices may

capture 1 cm to 2 cm ground sample distance imagery, and vertical image-capturing devices may be capable of capturing 2 cm to 4 cm ground sample distance imagery.

[00082] The image data signals 52 corresponding to each image acquired and the data point via the LIDAR scanner 36 may be received by and/or stored within the one or more memories 92 of the image capturing and processing computer system 50 via the I/O port 82. Similarly, the signals 60, 62, 64, 66, 68, 70, 72 and 74 corresponding to each captured image may be received and stored within the one or more memories 92 of the image capturing and processing computer system 50 via the I/O port 82. The LIDAR scanner signals 54 may be received and stored as LIDAR 3D point clouds.

[00083] Thus, the location of the one or more image capturing devices 34 relative to the ground surface 32 at the precise moment each image is captured is recorded within the one or more memories 92 and associated with the corresponding captured oblique and/or nadir image. Additionally, location data associated with one or more object of interest may be catalogued and stored within one or more database.

[00084] The processor 76 may create and/or store in the one or more memories 92, one or more output image and data files. For example, the processor 76 may convert image data signals 52, signals 60, 62, 64, 66, 68, 70, 72 and 74, and LIDAR scanner signals 54 into computer-readable output image, data files, and LIDAR 3D point cloud files. The output image, data files, and LIDAR 3D point cloud files may include a plurality of captured image files corresponding to captured oblique and/or nadir images, positional data, and/or LIDAR 3D point clouds corresponding thereto. Additionally, data associated with the one or more object of interest and/or images may be catalogued and saved within one or more database. For example, location information and/or metadata may be catalogued and saved within one or more database.

[00085] Output image, data files, and LIDAR 3D point cloud files may then be further provided, displayed and/or used for obtaining measurements of and between objects depicted within the captured images, including measurements of variable distribution. In some embodiments, the image capturing and processing computer system 50 may be used to provide, display and/or obtain measurements of and between objects depicted within the captured images. Alternatively, the image capturing and processing computer system 50 may deliver the output image, data

files, and/or LIDAR 3D point clouds to one or more processors, such as, for example, the processors 84 illustrated in FIG. 4 for processors 84 to provide, display and/or obtain measurement.

[00086] In some embodiments, delivery of the output image, data files, and/or LIDAR 3D point cloud files may also be by physical removal of the files from the image capturing and processing computer system 50. For example, the output image, data files, and/or LIDAR 3D point cloud files may be stored on a removable storage device and transported to one or more processors 84. In some embodiments, the image capturing and processing computer system 50 may provide at least a portion of the display and/or determine at least a portion of the measurements further described herein.

[00087] For simplicity, the following description for measurement of objects of interest as described herein includes reference to residential housing wherein the roof is the object of interest; however, it should be understood by one skilled in the art that the methods described herein may be applied to any structure and/or object of interest. For example, the methods may be applied to any man made and/or natural object (e.g., commercial building structure, tree, driveway, road, bridge, concrete, water, turf and/or the like).

[00088] FIGS. 5-9 illustrate exemplary images that are annotated to explain how embodiments of the present disclosure automatically locate objects of interest and automatically generate building outlines reports about the objects of interest that can be used for a variety of purposes including automated building reports, change detection by comparing building outlines generated from imagery of the same building but captured at different times, and steering of mosaic outlines through portions of the imagery that do not contain a building outline.

[00089] Referring to FIG. 5, illustrated therein is a screen shot 100 of an image 102 of a region 104 having multiple buildings 106. In this example, the region 104 includes one or more objects of interest with each building 106 being an object of interest. Roofs 108 of each building are features of the objects of interest. It should be noted that the object(s) of interest and/or feature(s) of the object(s) of interest may be any natural and/or man-made objects within the image. For simplicity of description, buildings 106, as the objects of interest, and roofs 108, as the features of the objects of interest, will be used in the following description. It should be noted, however, that any object of interest within an image may be used

including man-made or non-man made objects (e.g., natural objects). Further, objects of interest absent within an image may also be determined using systems and methods described herein. For example, alterations in a footprint of trees may be determined (i.e., loss of trees) using systems and methods described herein.

[00090] Generally, the output image file and data files may be used to geo-reference the collected images. Exemplary methods for geo-referencing the imagery may be found in at least U.S. Patent Nos. 7,424,133 and 5,247,356, which are hereby incorporated by reference in their entirety. Geo-referencing each image results in information that can be used with predetermined algorithms, such as a single – ray projection algorithm, to determine three dimensional geographical coordinates for points in each image. Using the internal and external orientation information also permits the real-world three-dimensional position of pixels to be determined using multiple images and stereophotogrammetry techniques. Referring to FIGS. 1, 5 and 6, a point cloud may be generated as discussed above using geo-referenced images and/or LIDAR data points.

[00091] FIG. 6 illustrates a screen shot 110 of a point cloud 112 of the region 104 having the building 106. In some embodiments, the point cloud 112 may be generated by extracting points with determined geographical coordinates using two or more images and geo-referenced data obtained from the image capturing and processing computer system 50. Using a known or calculated distance between capture locations of the one or more image capturing devices 34 and stereo photogrammetry using multiple images, three dimensional points having three dimensional distances from the one or more image capturing devices 34 may be determined. In some embodiments, stereo analysis using standard stereo pair photogrammetry techniques may be automated. In each image, a geographical coordinate, such as (x, y, z) may correspond to a data point in the point cloud 112. As such, each data point has a three-dimensional coordinate.

[00092] In some embodiments, the LIDAR 3D data point files may be processed and geo-referenced providing the point cloud 112. For example, the LIDAR 3D data point files may be processed and geo-referenced using software such as Reigl's RiProcess application, distributed by Reigl located in Horn, Austria. In some embodiments, images and georeferenced data, in addition to LIDAR data point files, may be used to generate the point cloud. In some embodiments, images

and georeferenced data, in lieu of LIDAR data point files, may be used to generate the point cloud 112.

[00093] Referring to FIGS. 1, 6 and 7, in three-dimensional space, natural and man-made structures may be above ground (i.e., ground surface 32 illustrated in FIG. 2). The point cloud 112 may be analyzed to identify data points within the point cloud 112 at particular elevations above ground and/or classify data points within the point cloud at particular elevations. In one example, the point cloud 112 may be analyzed to identify and classify ground structures 114 and/or non-ground structures (i.e., those structures above the ground including man-made objects and natural objects). In some embodiments, areas within the point cloud 112 indicative of the ground structures 114 may be classified as the ground structure 114 and/or removed such that further analysis can be directed to natural and/or man-made structures depicted in the point cloud 112 above the ground structure 114.

[00094] Even further, data points at particular elevations may be isolated, classified and/or removed from the point cloud 112. For example, data points within the point cloud 112 not associated with structures at an elevation of interest 116 may be removed such that only data points of structures at the elevation of interest 116 remain within a modified point cloud 118. For example, FIG. 7 illustrates a screen shot 120 of the modified point cloud 118 wherein data points at the elevation of interest 116 (i.e., height h) were identified from the point cloud 112. Even further, data points not associated with structures at the elevation of interest 116 shown in FIG. 6 were classified as not being associated with structures, and then optionally removed from the point cloud 112 to obtain the modified point cloud 118 shown in FIG. 7.

[00095] In some embodiments, the elevation of interest 116 may be an average or estimated elevation. For example, FIG. 7 illustrates a screen shot 120 of a modified point cloud 118 showing data points at the elevation of interest 116 of an estimated height h of a roof from ground level shown in FIG. 6. In some embodiments, the elevation of interest 116 may be determined by analysis of the elevation gradient of the data points.

[00096] Referring to FIGS. 1, 6 and 7, an object of interest may be detected using the point cloud and the elevation gradient. For example, the object of interest may be the building 106. In one example, the remaining data points at the elevation of interest 116 may be used to classify structures in the modified point cloud 118 as

man-made structures 122 or natural structures 124 with each data point having a unique three dimensional point (x, y, z) within the modified point cloud 118. In particular, spatial relationships between each data point may be analyzed to classify such structures as man-made structures 122 (i.e., caused by humankind) or natural structures 124 (i.e., not made or caused by humankind). In one example, the variation of surface normal direction between each point of a group of points and the other points may be analyzed to differentiate man-made structures 122 and natural structures 124. This analysis can be implemented by analyzing a group of points within a local area surrounding particular points within the modified point cloud 118 to determine an orientation of a plane fitting the group of points and assigning this value(s) to the particular point. This process can be repeated for either all of the points in the modified point cloud 118 that have been classified as either a man-made structure or a natural structure or a subset of the points. The local area can be a matrix of pixels that is a subset of the modified point cloud. The size of the matrix can be varied. The matrix has a number of pixels that can be within a range of .1% to about 10% of the number of pixels within the modified point cloud 118. For example, the local area can be a 25x25 pixel matrix or the like. Once the orientations have been calculated, then the adjacent orientations are compared to determine a local variation of the surface normal direction. If the data points represent a man-made structure, then the local variation of surface normal direction should be smaller than if the data points represent a natural structure, such as a tree or bush. In some embodiments, data points in which local variation exceeds a pre-determined amount (e.g., 10-20 degrees, and more particularly 15 degrees) may be classified as the natural structure 124. Data points having variation that is below the pre-determined amount may be classified as a man-made structure 122. Each of the data points within the modified point cloud may be analyzed and data points positioned at or above the elevation of interest 116 may be classified as natural structures 124 or man-made structures 122 rather than the ground structure 114.

[00097] Referring to FIGS. 7 and 8, each of the data points at the elevation of interest 116 and classified as a part of a man-made structure 122 may be further identified as part of an identifiable structure within an image. For example, groupings of data points within Region A classified as part of man-made structures 122 may be further classified as building 106a; groupings of data points within Region B classified as part of man-made structures 122 may be further classified as

building 106b; groupings of data points within Region C classified as part of man-made structures 122 may be further classified as buildings 106c and 106e; and, groupings of data points within Region D classified as part of man-made structures 122 may be further classified as buildings 106d and 106f. Groupings of data points can be classified as particular buildings by detecting building outlines. Once the building outlines are detected, data points within the building outline are classified as part of the building.

[00098] Once groupings within the point cloud 112 or the modified point cloud 118 have been identified, then the outer most boundaries are identified to determine a rough outline of the object. The rough outline of the object can be refined by correlating the locations of the data points in the point cloud 112 or the modified point cloud 118 with images from one or more of the databases 94, and then analyzing the raster content within one or more images showing the object to more precisely locate the outline of the object. For example, FIG. 9 illustrates a screen shot 136 of building 106d. In some embodiments, edges of the building 106d may be detected within the images using any standard edge detection algorithm. Standard edge detection algorithms may include, but are not limited to, a Laplacian filter, and/or the like.

[00099] In some embodiments, spectral analysis of the raster content can be used to identify whether data points within the modified point cloud 118 are likely identifying an object of interest (e.g., buildings 106). For example, the automated roof detection system described in U.S. Patent No. 9,070,018, which is hereby incorporated by reference in its entirety, may be used to identify the objects of interest within images. Although the automated roof detection system is described in relation to detection of roofs, it should be noted that such system may apply to identification of any object of interest (e.g., man-made or natural structures). Generally, the automated object detection system may use statistical analysis to analyze sections of the images that depict the object of interest, as previously determined within the modified point cloud 118. The automated object detection system may further refine the boundary of the buildings 106 and/or roof 130. Statistical measures may be computed for sections of each image.

[000100] FIGS. 10-12 illustrate an exemplary process for determining group descriptor patterns used to identify objects of interest within an image for automated object classification. The rough outline of the object can be refined by correlating the

locations of the data points in the point cloud 112 or the modified point cloud 118 with images from one or more of the databases 94, and then analyzing the raster content within one or more images showing the object to more precisely locate the outline of the object.

[000101] Referring to FIG. 10, the value of each pixel within the image is part of a vector comprising the values determined for each of the measures calculated for that pixel within an n-dimensional feature space as shown in FIG. 10.

[000102] Referring to FIG. 11, a feature transformation may be performed, wherein image measures are statistically analyzed using clustering techniques to group data into separable descriptor groups (i.e., clusters). Image measures may include, for example, localized measures and neighborhood measures. Localized measures describe data points at a particular processing point. Example localized measures may include, but are not limited to, surface fractal analysis, topological contour complexity variation, and/or the like. Neighborhood measures may include ranging related neighborhood measures that describe the organization of structure surrounding a particular processing point. Exemplary neighborhood measures may include, but are not limited to, radial complexity, radial organization variation, and/or the like. It should be noted that the number of descriptor groups may not necessarily be the same as the number of measures.

[000103] Descriptor groups (i.e., clusters) may form a new feature vector that includes any error and/or uncertainty (e.g., integrity of the point cloud) of the measurements folded into a space describing the average statistical value of a structure or feature of a structure (e.g., building 106, roof).

[000104] Referring to FIG. 12, each descriptor group may be compared to one or more descriptor groups using a statistical model to create a descriptor pattern of inter-relational characteristics. For example, each descriptor group (i.e., cluster) may be compared to other descriptor groups using a statistical model such as an associative neural network. The group descriptor patterns may serve as the basis for identifying and/or classifying objects of interest and/or features of interest within the modified point cloud 118.

[000105] An average group descriptor pattern may be generated and cross correlated using an associated neural network, creating a single pattern template (e.g., a homogenous pattern) that may be used to determine which regions of the image are likely building 106 and/or roof 130. The trained neural networks may then

use the pattern template to discriminate between the building 106 and/or roof 130 and other surrounding environment. For example, the trained neural networks may use the homogenous pattern template to discriminate between roof 130 and non-roof areas. Based on these indications, second information, e.g., a boundary 138 (e.g., outline) may be determined for the building 106 (or roof 130) as shown in FIG. 9.

[000106] Once the boundary 138 is determined, locations within the raster content may be converted to vector form. In one example, the trained neural networks may distinguish between roof 130 and non-roof areas giving an estimated boundary for the roof 130. Such boundary may be defined in raster format. To convert the raster format into vector format, building corners 137 may be identified in the raster format and used to convert each line segment of the boundary 138 into vector form. Once in vector form, the boundary 138 may be stored in one of the databases 94 (shown in FIG. 4) and/or further analyzed. In some embodiments, the raster content may further be geo-referenced to real-world locations. For example, the building 106 may be identified by Latitude/Longitude. In some embodiments, using the boundary 138, the building 106 may be extracted from the image as shown in FIG. 13. Such information may be stored as individual files for each building (e.g., .shp file) in the database 94, or may be stored as multiple files within the database 94.

[000107] Referring to FIGS. 7, 8 and 14, once an object of interest is identified within the modified point cloud 118, features of interest (e.g., roofs 130a-130d, roof elements) within an image may be identified on the objects of interest (e.g., building 106a-106d) via the modified point cloud 118, the point cloud 112, or the original image(s). In some embodiments, identification of features of interest (e.g., roofs 130) may be through the automated object detection system as described herein and in U.S. Patent No. 9,070,018. In some embodiments, identification of features of interest may be identified via the original image subsequent to the automated classification of the object of interest via methods and systems as described, for example, U.S. Patent No. 8,977,520 and U.S. Patent No. 7,424,133, which are both hereby incorporated by reference in their entirety.

[000108] In some embodiments, elements within the feature of interest (e.g., roof 130) may be further classified. For example, FIG. 14 illustrates a screen shot 132 of roofs 130a-130d. Line segments 134 forming the roof may be further

classified using predefined roof elements including, but not limited to, a rake, a hip, a valley, an eave, a ridge, and/or the like.

[000109] In some embodiments, one or more features of interest may be further analyzed and/or measurements determined. For example, features of the roof 130, dimensions of the roof 130, and/or roof pitch may be determined using data points within the point cloud 112, the modified point cloud 118 and/or the one or more images. For example, roof pitch may be calculated using data points of the point cloud 112 as each data point coordinates with a geographical reference (x, y, z). Using data points of the point cloud 112 located at an elevation at the top of a peak and data points located at an elevation at the bottom of a peak, roof pitch may be calculated. Roof feature calculations may include, but are not limited to, dimensions of eaves, edges, ridge, angles, and/or the like. Characteristics of the roof 130 such as features of the roof 130, dimensions of the roof 130, roof pitch, condition and/or composition of the roof 130 may be determined by analyzing the one or more images. For example, if the one or more images were obtained from a manned aerial vehicle and included multi-spectral or hyper spectral information, then condition or composition of the roof 130 may also be determined. The capture platform may also be a drone, and in this instance the resolution of the one or more images may be sufficient to determine the condition (e.g., moss, excessive moisture, hail damage, etc.) or composition (tile, composition, wood, slate, etc.) of the roof 130.

[000110] In one example, boundaries may be used to identify changes to man-made and/or natural objects within an image. For example, boundaries 138 (as shown in FIG. 9) may be used to identify changes to buildings 106 and/or roof 130 over time. In some embodiments, boundaries and/or extraction techniques may be used in forming one or more mosaic models of the object of interest. For example, boundaries 138 and/or extraction techniques as described herein may be used in forming a mosaic model of the building 106. Images illustrating each side of the building 106 may be extracted using the methods as described herein. Such images may be composed into a three-dimensional mosaic model illustrating the building 106. In another example, boundaries and/or analysis of the features within the boundaries may be analyzed and/or described within a report.

[000111] Referring to FIG. 1, 4 and 15, a customer and/or contractor may receive a report regarding evaluation of object(s) of interest and/or feature(s) of

interest. For example, the customer and/or contractor may receive a report regarding evaluation of the building 106 and/or roof 130. FIG. 15 illustrates an exemplary embodiment of a roof report 140. The program logic 96 may provide for one or more of the processors 84 interfacing with the image capturing and processing computer system 50 over the network 86 to provide one or more roof reports 140.

[000112] Generally, the roof report 140 may include, but is not limited to, one or more data sets 142 regarding roof pitch, total area, eave length, hip ridge length, valley length, number of box vents, and/or the like. Additionally, the roof report 140 may include one or more images 144 of the building 106 and/or roof 130. Such images 144 may be automatically provided to the roof report 140 via extraction of the building 106 and/or roof 130 as described herein. Additionally, the roof report 140 may include a customer information data set 146 (e.g., customer name and contact information), estimated area detail, contractor data set 148 (e.g., contractor name and contract information), and/or the like.

[000113] In some embodiments, determination, analysis and measurements of data associated with the object of interest and/or features of interest may be catalogued and stored in one or more database for retrieval. Data catalogued and stored associated with the object of interest and/or feature of interest may include, but is not limited to, location data (e.g., object of interest, each point of the object of interest), date and/or time of image creation, algorithms used, measurements, metadata, footprint, and/or the like. For example, boundaries associated with the object of interest and/or feature of interest may be spatially catalogued using location (e.g., coordinate data, address).

[000114] From the above description, it is clear that the inventive concepts disclosed and claimed herein are well adapted to carry out the objects and to attain the advantages mentioned herein, as well as those inherent in the invention. While exemplary embodiments of the inventive concepts have been described for purposes of this disclosure, it will be understood that numerous changes may be made which will readily suggest themselves to those skilled in the art and which are accomplished within the spirit of the inventive concepts disclosed and claimed herein.

What is claimed is:

1. One or more non-transitory computer readable medium storing a set of computer executable instructions for running on one or more computer systems that when executed cause the one or more computer systems to:

classify at least one feature within an image as a man-made structure, wherein classification of the feature as a man-made structure includes:

analyzing data points within a point cloud indicative of a man-made structure, a natural structure and a ground structure to automatically classify certain of the data points within the point cloud representing the man-made structure as the man-made structure;

determining first information about the man-made structure by analyzing the data points classified as the man-made structure;

correlating the data points within the point cloud classified as the man-made structure with one or more images; and

spectrally analyze image raster content of at least one section of the one or more images correlated with the data points within the point cloud that are classified as the man-made structure to generate second information in which the second information is an update of the first information.

2. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 1, wherein the man-made structure is a building having a roof.

3. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 2, wherein the first information is a boundary of the building.

4. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 2, wherein the second information is a boundary of the building.

5. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of

claim 2, further comprising determining an estimated roof pitch by analyzing data points within the point cloud.

6. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 2, further comprising determining an estimated roof pitch by analyzing the one or more image.

7. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 2, further comprising generating a roof report including one image showing the roof and an estimated roof pitch.

8. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 1, wherein classification of man-made structures includes determination of shape of a grouping of data points.

9. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 8, wherein determination of shape of the grouping of data points includes analyzing the grouping of data points to determine a variation of surface normal direction between data points.

10. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 1, wherein the data points having a Z value above a first elevation are classified as at least one of the man-made structure and the natural structure.

11. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 10, wherein the first information includes an outline of the man-made structure.

12. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer systems of claim 11, wherein the outline is a first outline, and wherein the second information is a second outline of the man-made structure based upon the first outline.

13. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer system of claim 1, wherein spectral analysis of image raster content of at least one section of the one or more images correlated with the data points within the point cloud that are classified as the man-made structure includes grouping of data points based on one or more similar characteristics.

14. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer system of claim 13, wherein similar characteristics include similar spectral signatures.

15. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer system of claim 13, wherein similar characteristics include similar thermal signatures.

16. The one or more transitory computer readable medium storing the set of computer executable instructions for running on one or more computer system of claim 1, further comprising spatially cataloguing location of data points associated with the image.

17. An automated method performed by at least one processor running computer executable instructions stored on at least one non-transitory computer readable medium, comprising:

- classifying first data points identifying at least one man-made roof structure within a point cloud and classifying second data points associated with at least one of a natural structure and a ground surface to form a modified point cloud;

- identifying at least one feature of the man-made roof structure in the modified point cloud; and

- generating a roof report including the at least one feature.

18. The automated method of claim 17, wherein the at least one feature of the man-made roof structure is roof pitch.
19. The automated method of claim 17, further comprising creating an outline of the man-made roof structure and extracting the man-made roof structure from the at least one image.
20. The automated method of claim 17, further comprising calculating roof dimensions of the man-made roof structure using data points of the modified point cloud.
21. The automated method of claim 17, further comprising calculating roof pitch using data points of the point cloud.
22. The automated method claim 17, further comprising calculating roof features using data points of the point cloud.
23. The automated method of claim 22, wherein the roof features comprise one or more of the following: an eave, an edge, a ridge, and an angle.
24. An automated computerized system, comprising:
- a computer system executing image display and analysis software reading:
 - at least one image having corresponding location data indicative of position and orientation of an image capturing device used to capture the image, the image depicting an object of interest; and,
 - at least one database storing data points of a point cloud of the object of interest; and
 - wherein the image display and analysis software executed by the computer system determines and isolates the object of interest within the point cloud forming a modified point cloud having one or more data points with first location coordinates of the object of interest, and generates a boundary outline having second location coordinates of the object of interest using spectral analysis of at least one section of the at least one image identified with the first location coordinates.

25. The automated computer system of claim 24, wherein the image display and analysis software determines and classifies the object of interest as a man-made structure.

26. The automated computer system of claim 24, wherein the image display and analysis software determines and classifies the object of interest as a non man-made structure.

27. The automated computer system of claim 24, wherein the image display and analysis software spatially catalogues and stores the object of interest within the at least one database.

28. The automated computer system of claim 24, wherein the image display and analysis software identifies, catalogues, and stores characteristics of the object of interest within the at least one database.

29. The automated computer system of claim 28, wherein at least one characteristic is color.

30. The automated computer system of claim 28, further comprising generating an inventory report compiling stored characteristics of the object of interest.

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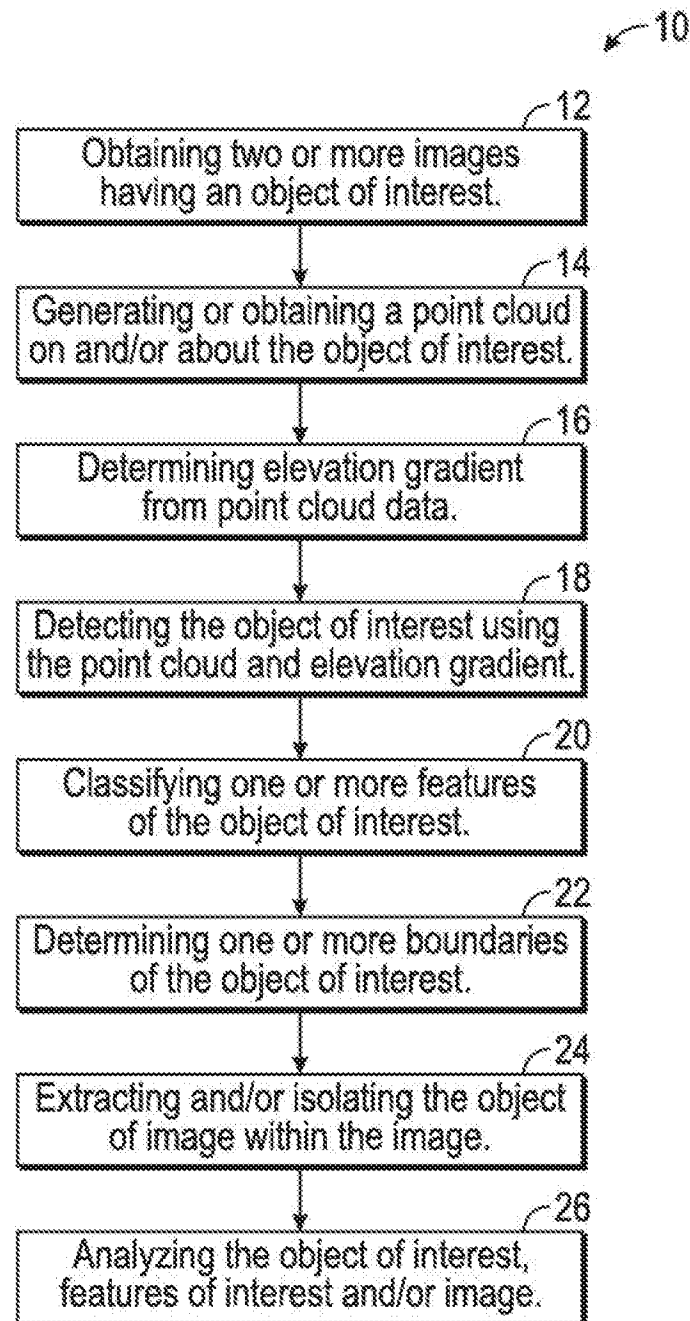


FIG. 1

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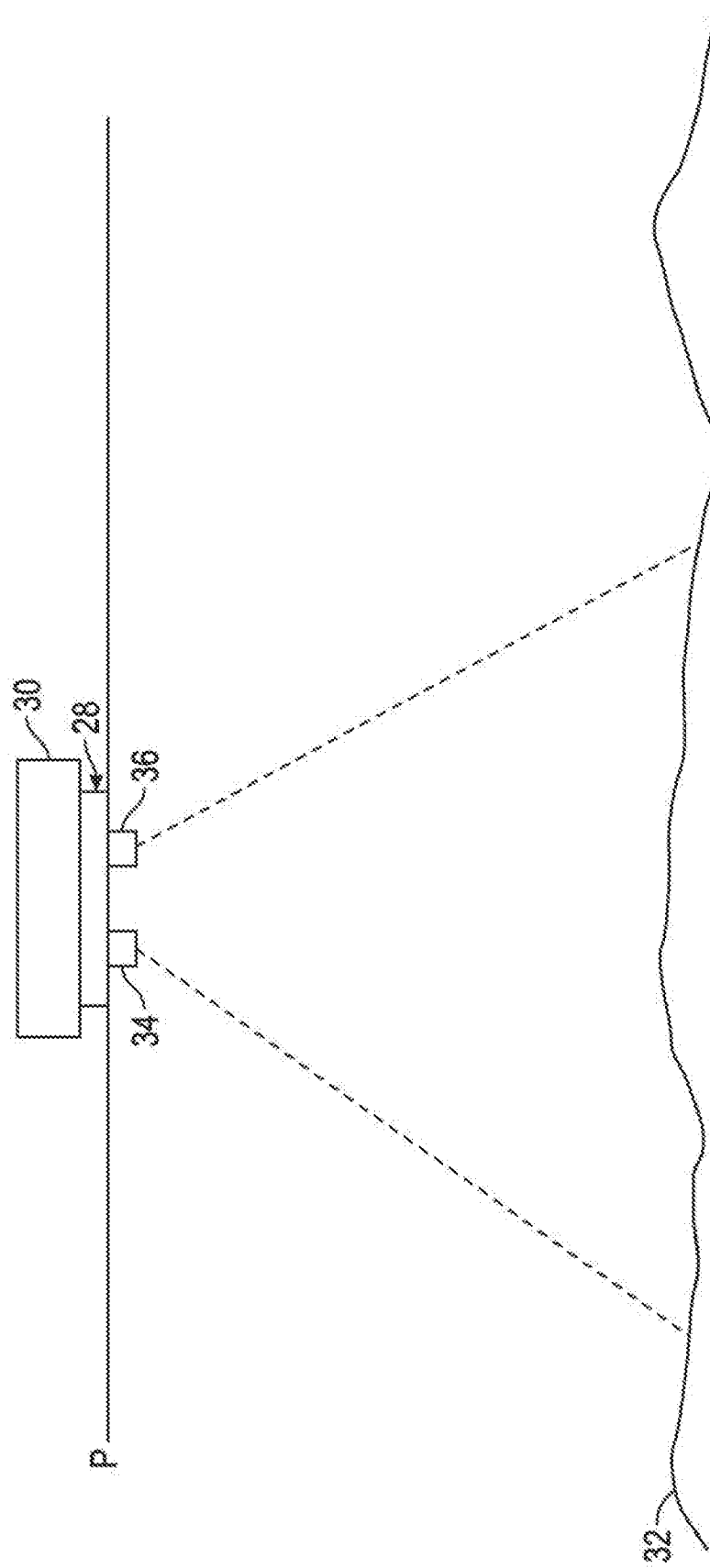


FIG. 2

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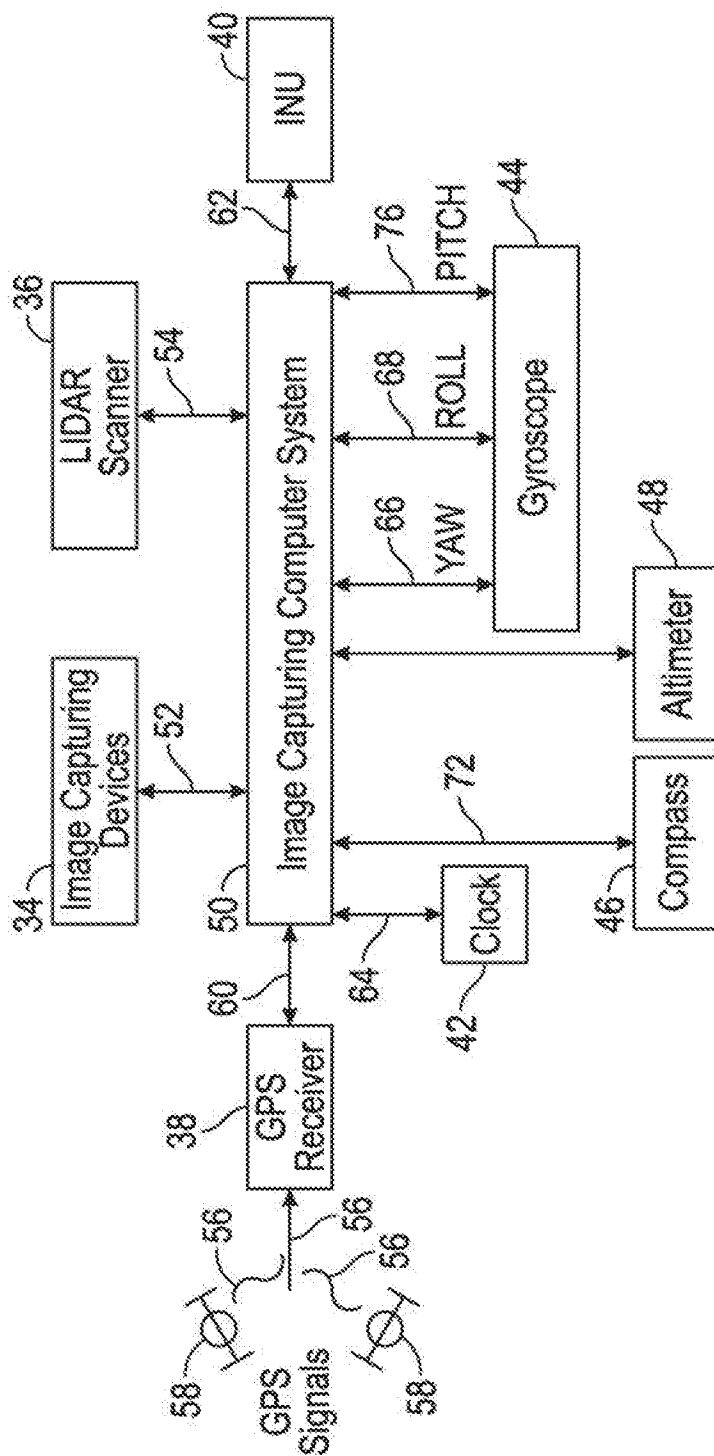


FIG. 3

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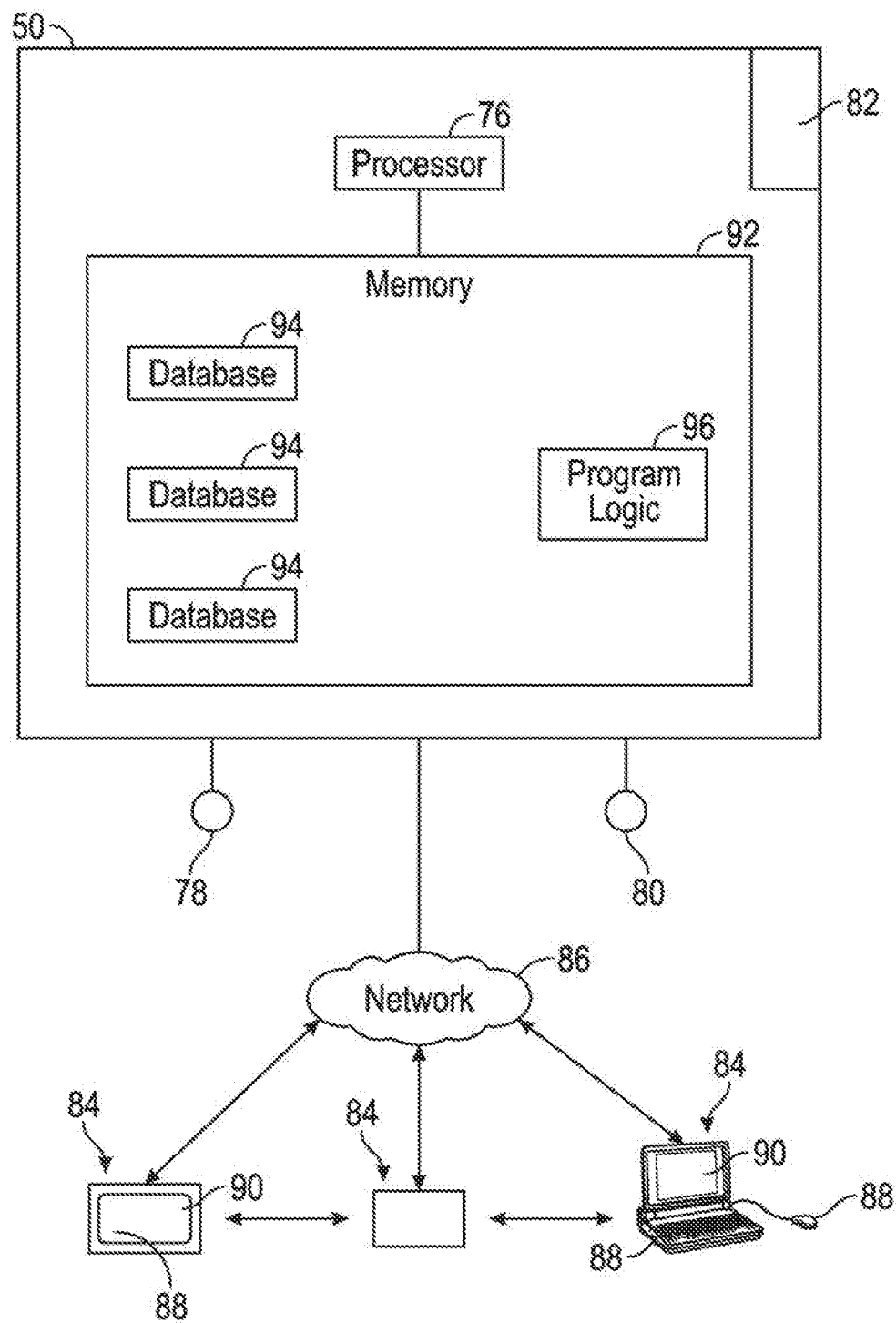


FIG. 4

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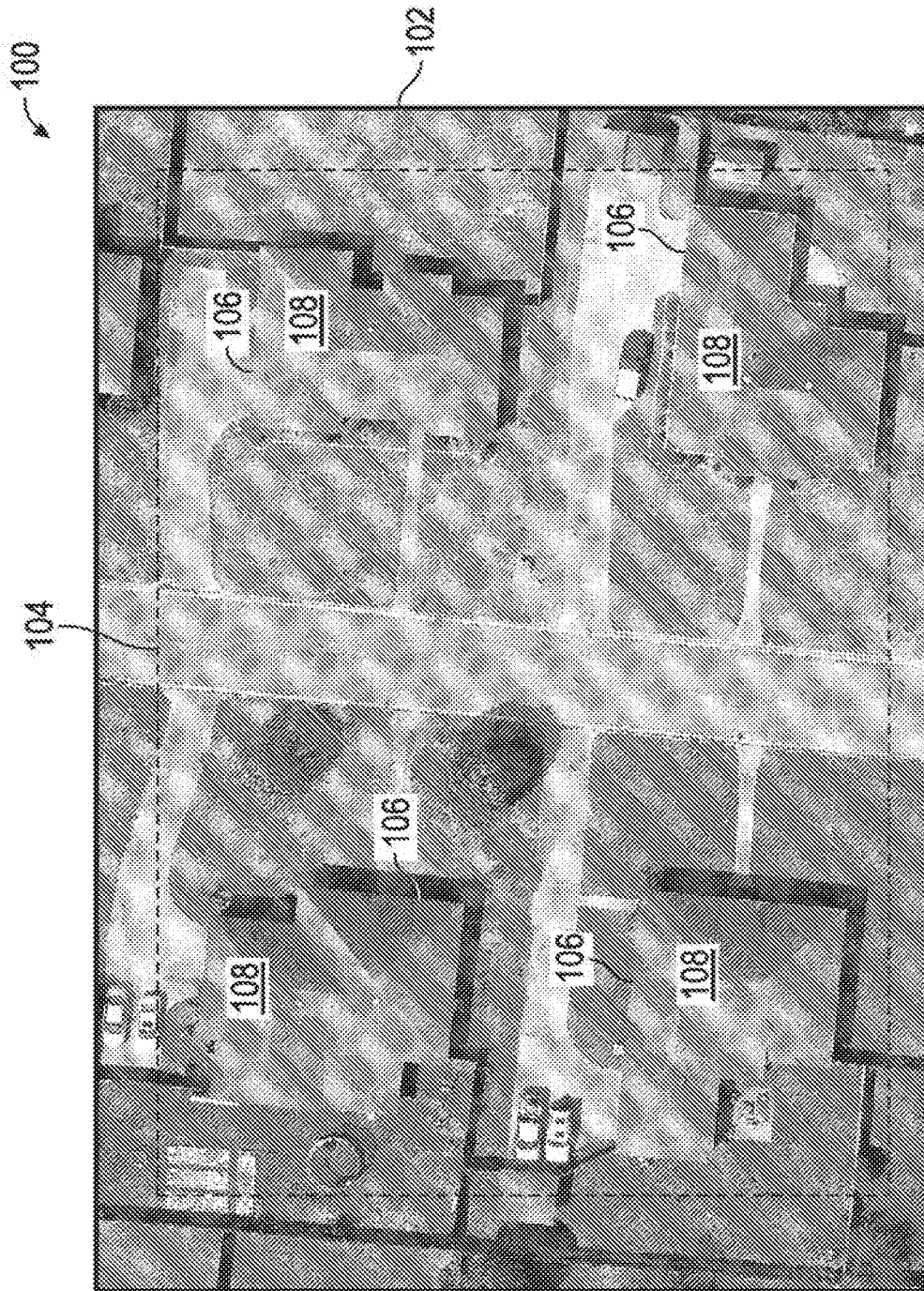


FIG. 5

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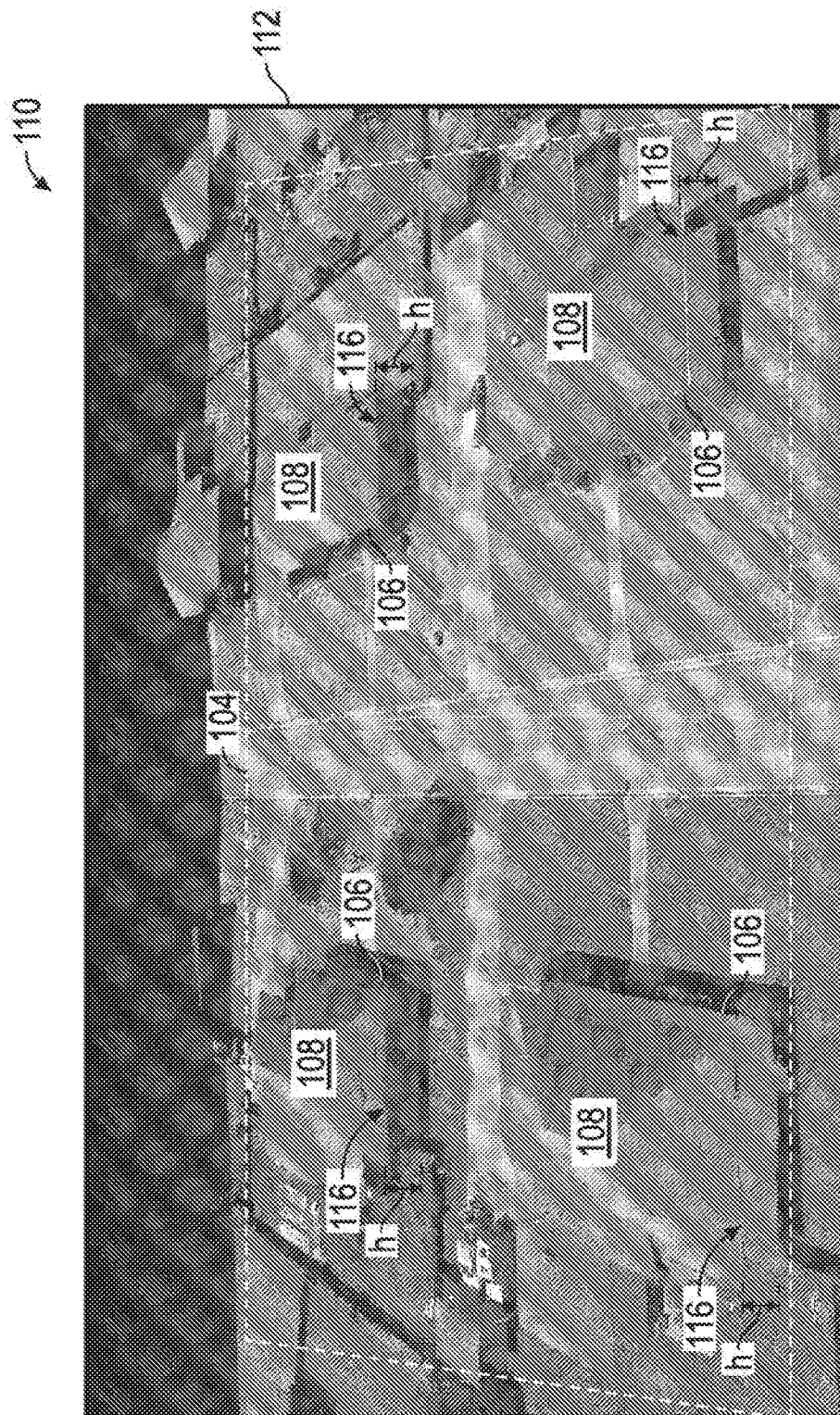


FIG. 6

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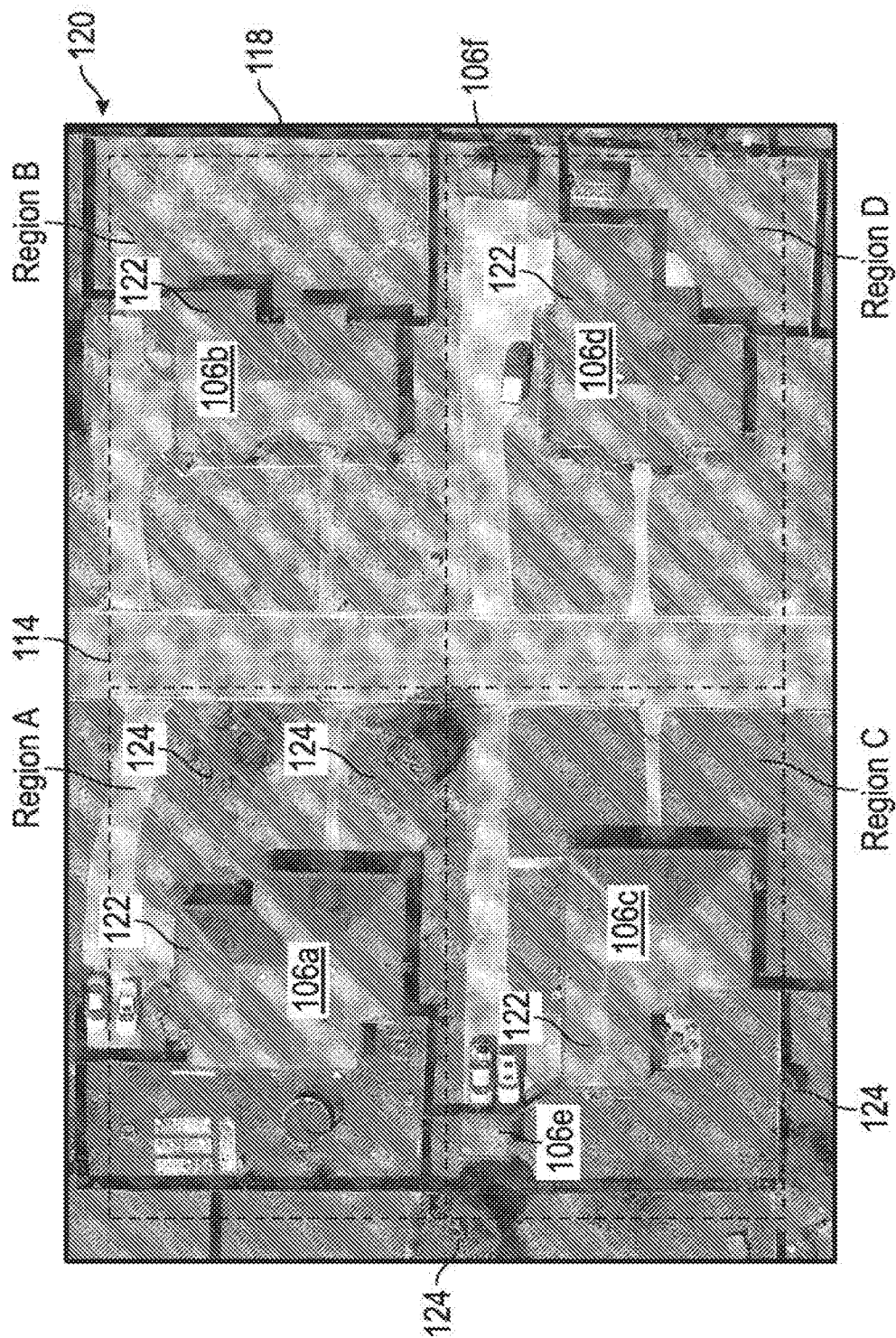


FIG. 7

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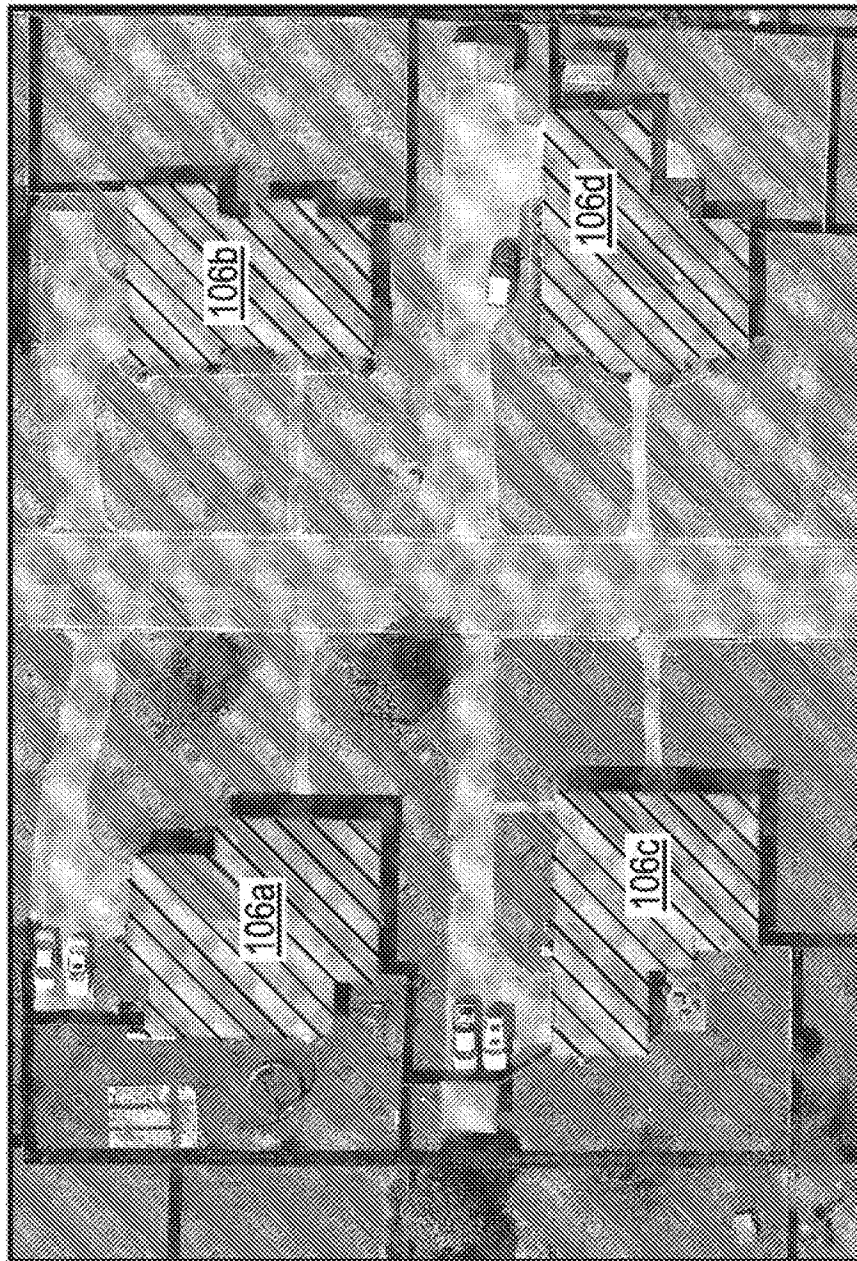


FIG. 8

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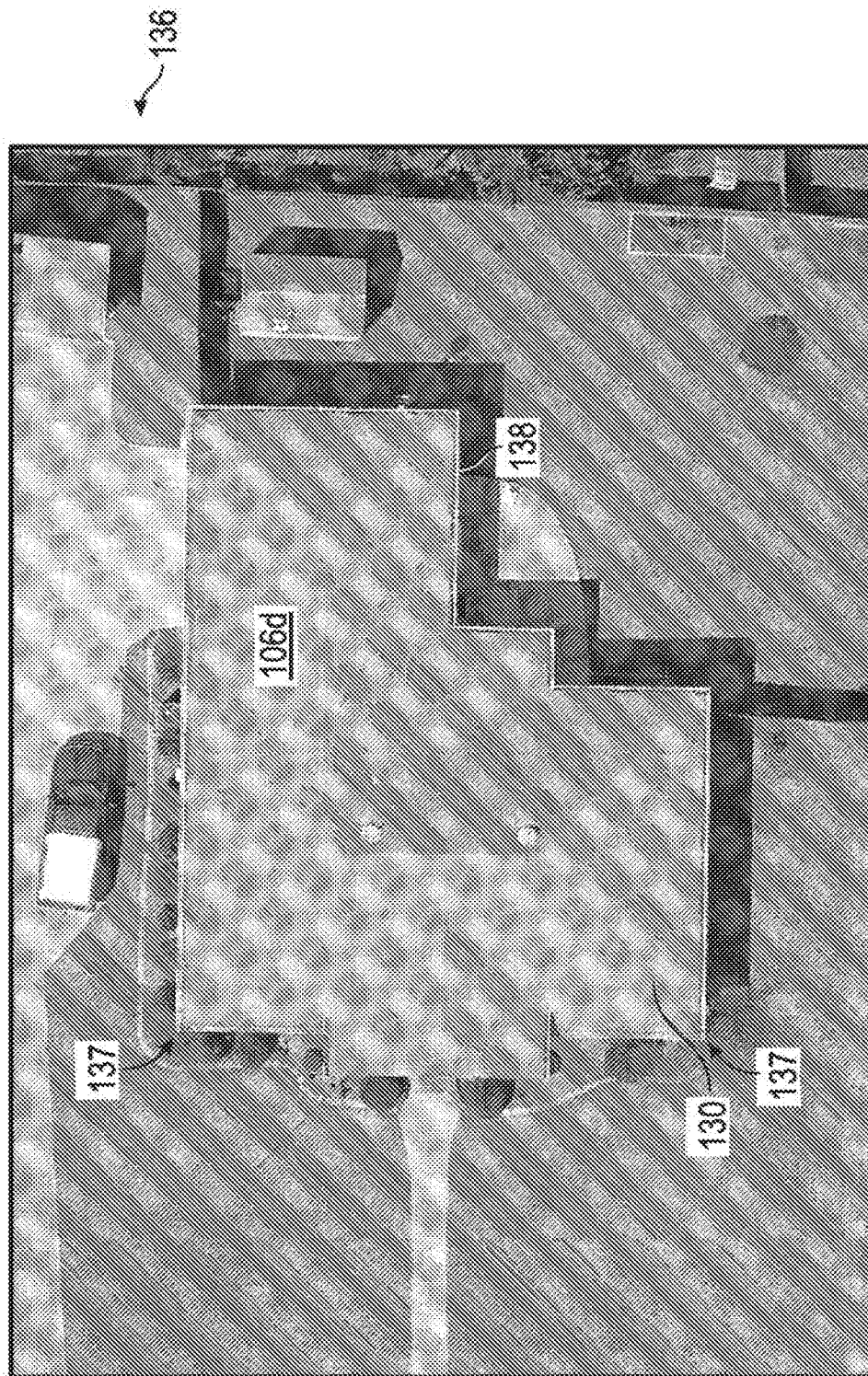


FIG. 9

10/15

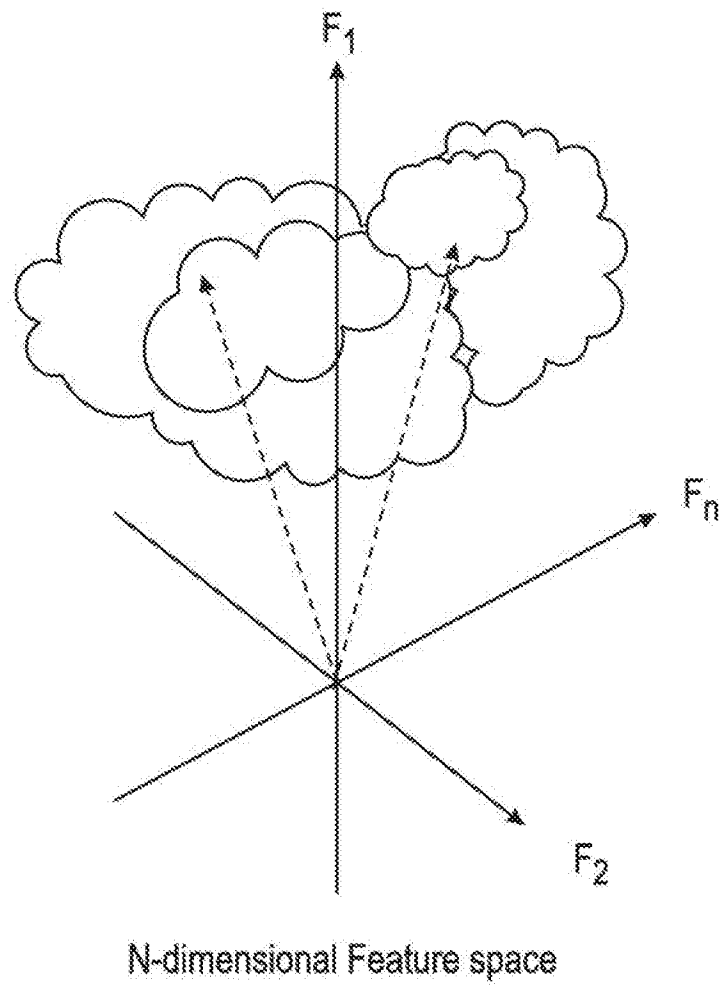


FIG. 10

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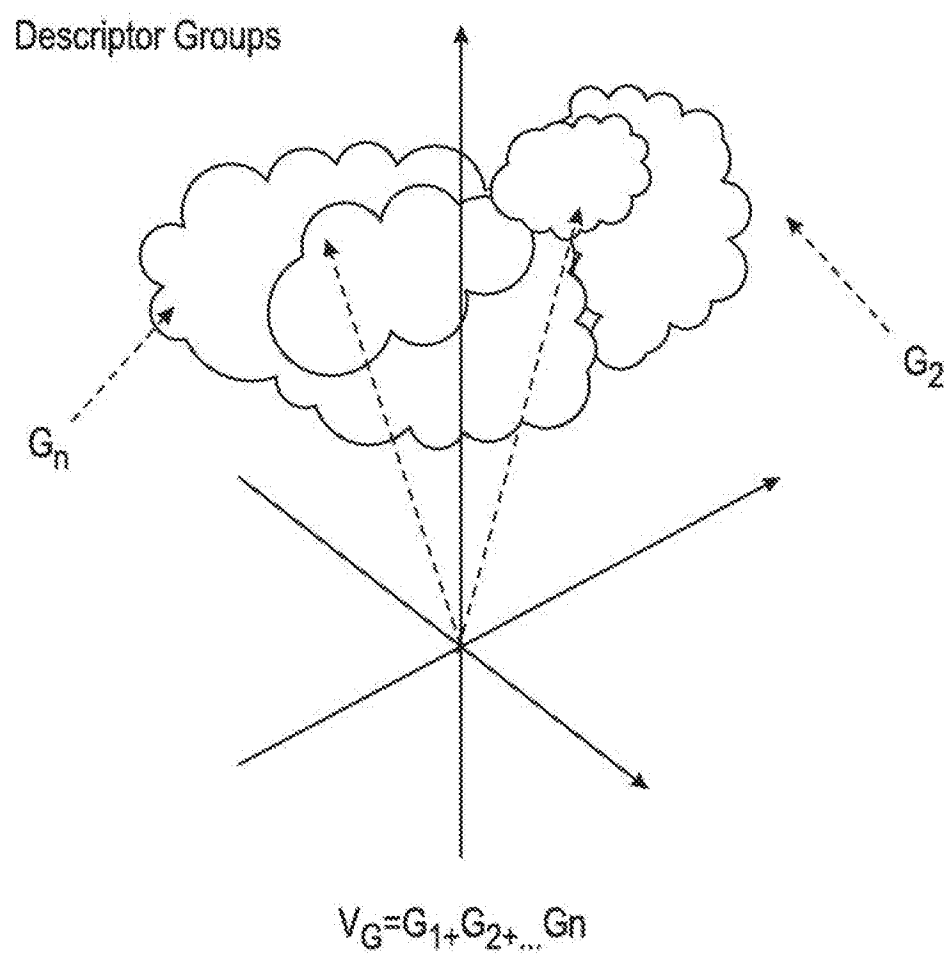


FIG. 11

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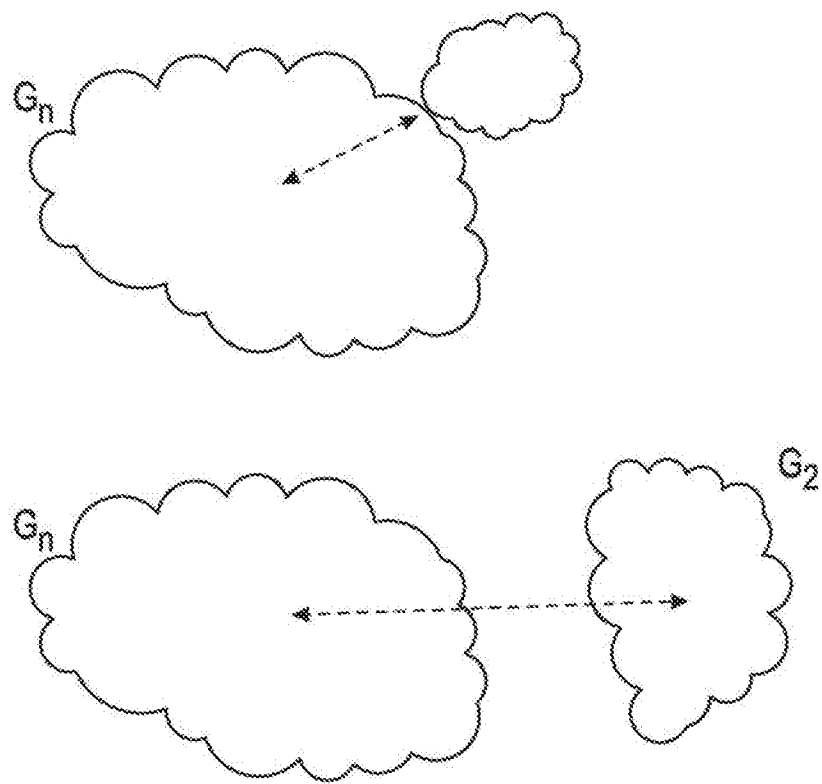


FIG. 12

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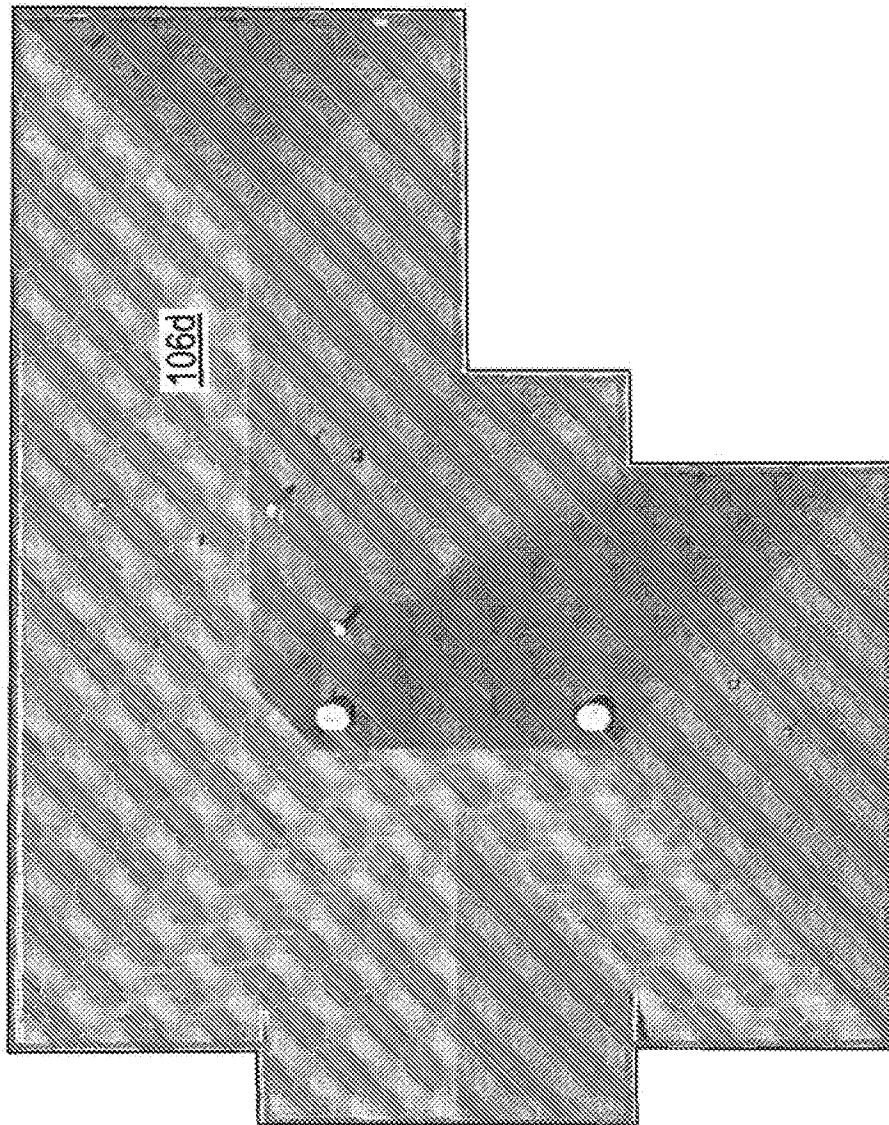


FIG. 13

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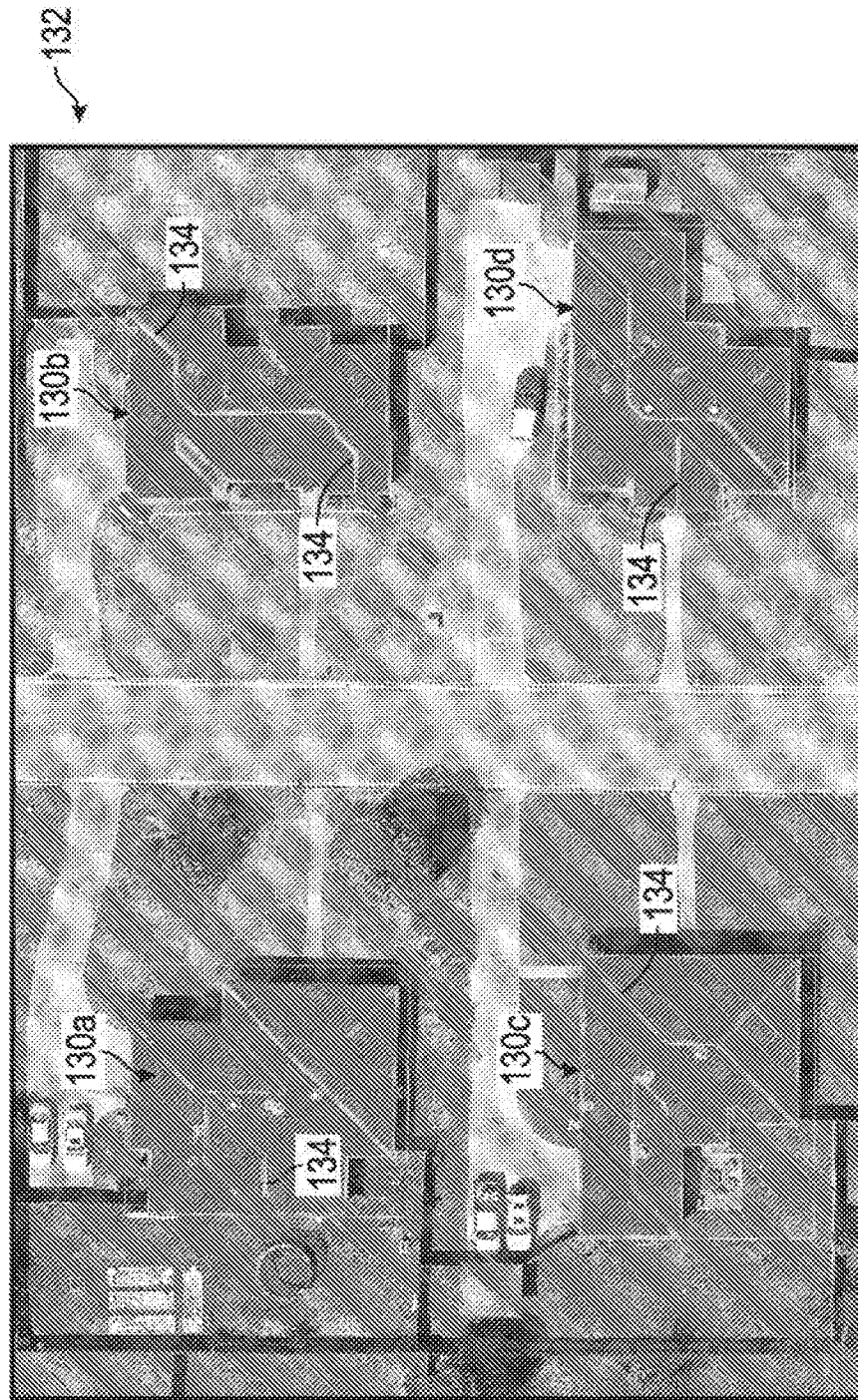
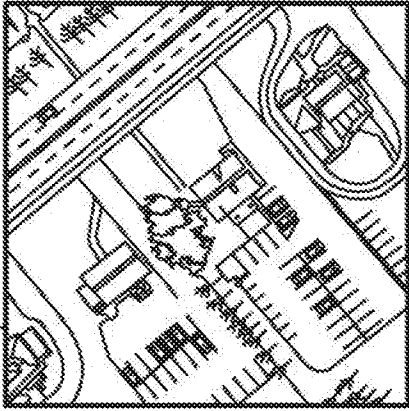


FIG. 14

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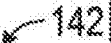


144

204



144



142

Square Feet	4006 sqft
Ridge	283.5 ft
Valley	106.93 ft
Eave Length	474 ft
Number of Box Vents	1
Pitch	26 degrees

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A copy of your report is being sent to the following GAF Master Elite Contractors who will be able to provide a quotation for installation services.

Contractor 1

123 Main Street

Anywhere, MY 11735

800Contractor1

Contractor 2

456 Main Street

Anywhere, MY 107470

800Contractor2

*DISCLAIMER: The in information contained in this report is for estimating purposes, and should be verified by a roofing professional.

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REPORT DETAILS: INTRODUCTION

HOMEOWNER	
John Homeowner	Order # : PIC-000012840
1440 Monroe Ave	Phone : 123-456-7890
Rochester NY, 14618	Email : homeowner@gaf.com

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Page. 1

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/017196

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01B 13/20; G01C 11/02; G06K 9/00; G06K 9/46; G06K 9/56; G06T 17/05 (2017.01)
 CPC - G01C 11/02; G01C 11/04; G03B 15/006; G03B 37/02; G06K 9/00624; G06K 9/0063; G06K 9/00637; G06K 9/44; G06K 9/4604; G06K 9/6203; G06K 9/6271; G06K 9/66; G06Q 10/00; G06Q 30/0206; G06Q 30/0283; G06Q 40/08; G06Q 50/16; G06T 3/4038; G06T 7/60; G06T 11/203; G06T 17/05; G06T 2207/10032; G06T 2207/30204 (2017.02)

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)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 358/141.500; 382/106; 702/156 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0208981 A1 (MINEAR et al) 19 August 2010 (19.08.2010), entire document	1, 8, 10-13, 16
Y		2-7, 9, 14, 15, 17-30
Y	SAMPATH et al. "Segmentation and reconstruction of polyhedral building roofs from aerial lidar point clouds." in: IEEE Transactions on geoscience and remote sensing. 03 November 2009 (03.11.2009) Retrieved from < https://www.researchgate.net/profile/Ajit_Sampath/publication/272818635_IEEE_Roof_Reconstruction/links/54ef7ac70c12495330a27871.pdf >, entire document	2-7, 9, 19
Y	US 2014/0200861 A1 (CYBERCITY 3D, INC.) 17 July 2014 (17.07.2014), entire document	5-7, 17-30
Y	US 2013/0173632 A1 (UNIVERSITY OF TENNESSEE RESEARCH FOUNDATION) 04 July 2013 (04.07.2013), entire document	14, 15
A	US 9,070,018 B1 (CIARCIA et al) 30 June 2015 (30.06.2015), entire document	1-30
A	US 7,046,841 B1 (DOW et al) 18 May 2006 (18.05.2006), entire document	1-30
A	US 2008/0262789 A1 (PERSHING et al) 23 October 2008 (23.10.2008), entire document	1-30
A	US 2004/0105090 A1 (SCHULTZ et al) 03 June 2004 (03.06.2004), entire document	1-30

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

01 April 2017

Date of mailing of the international search report

25 APR 2017

Name and mailing address of the ISA/US

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 Facsimile No. 571-273-8330

Authorized officer

Blaine R. Copenhagen

PCT Helpdesk: 571-272-4300

PCT OSP: 571-273-7775

Electronic Patent Application Fee Transmittal				
Application Number:		15714376		
Filing Date:		25-Sep-2017		
Title of Invention:		Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis		
First Named Inventor/Applicant Name:		Takeshi Okazaki		
Filer:		Natalie J. Grace/Kristin Sims		
Attorney Docket Number:		474139US01		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
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:				
RCE- 1ST REQUEST	1801	1	1300	1300
Total in USD (\$)				1300

Electronic Acknowledgement Receipt

EFS ID:	37658244
Application Number:	15714376
International Application Number:	
Confirmation Number:	8275
Title of Invention:	Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis
First Named Inventor/Applicant Name:	Takeshi Okazaki
Customer Number:	146018
Filer:	Natalie J. Grace/Kristin Sims
Filer Authorized By:	Natalie J. Grace
Attorney Docket Number:	474139US01
Receipt Date:	05-NOV-2019
Filing Date:	25-SEP-2017
Time Stamp:	14:40:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 1300
RAM confirmation Number	E2019A5E42461416
Deposit Account	601484
Authorized User	Kristin Sims

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37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
37 CFR 1.20 (Post Issuance fees)
37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	474139US01_RCE.pdf	1349941	no	3
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Warnings:					
Information:					
2	Transmittal Letter	474139US01_IDStransmittal.pdf	99827	no	1
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Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	474139US01_IDSform1.pdf	1037038	no	12
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Information:					
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Information:					
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6	Non Patent Literature	NPL_Lin.pdf	289738	no	10
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Information:					

7	Other Reference-Patent/App/Search documents	PCTUS2017053265_IPRP.pdf	1907920	no	8
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Information:					
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Warnings:					
Information:					
Total Files Size (in bytes):			148112465		
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146018 7590 11/20/2019
Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003

EXAMINER

NGUYEN, TIEN C

ART UNIT

PAPER NUMBER

3694

DATE MAILED: 11/20/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/714,376	09/25/2017	Takeshi Okazaki	474139US01	8275

TITLE OF INVENTION: Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	02/20/2020

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 ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

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: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (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)

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.

146018 7590 11/20/2019
Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

	(Typed or printed name)
	(Signature)
	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/714,376	09/25/2017	Takeshi Okazaki	474139US01	8275

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nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	02/20/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, TIEN C	3694	705-004000

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 03-09 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,

1 _____

(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.

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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(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. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

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

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

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.

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

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____



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.
15/714,376	09/25/2017	Takeshi Okazaki	474139US01	8275
146018	7590	11/20/2019	EXAMINER	
Gardella Grace P.A. 80 M Street SE, 1st Floor Washington, DC 20003			NGUYEN, TIEN C	
			ART UNIT	PAPER NUMBER
			3694	
DATE MAILED: 11/20/2019				

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

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

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.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B 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 30 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.

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) 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. 15/714,376	Applicant(s) Okazaki, Takeshi	
	Examiner TIEN C NGUYEN	Art Unit 3694	AIA (FITF) Status Yes

-- 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 RCE 11/5/2019.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

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 1-2,4 and 7-23. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

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. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ 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).

6. ☐ 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. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____. 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____. 4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.	5. ☐ Examiner's Amendment/Comment 6. ☒ Examiner's Statement of Reasons for Allowance 7. ☐ Other _____.
--	--

/TIEN C NGUYEN/
Primary Examiner, Art Unit 3694

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Examiner's Statement of Reasons for Allowance

1. The following is an Allowance in response RCE filed on 11/5/2019.
2. IDS filed on 11/5/2019 have been acknowledged and considered by the Office.
3. Claims 1-2, 4 and 7-23 were previously presented.
4. Therefore, claims 1-2, 4 and 7-23 are pending and allowed below.

Reasons for Allowance

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

Regarding the 35 USC 101 in view of Alice rejections, Applicant's claims recite the additional limitations of "obtaining, by processing circuitry of a computing system responsive to receiving the request, an aerial image of a geographic region including the property; extracting, by the processing circuitry, one or more of a plurality of features from the aerial image corresponding to the property characteristic, wherein the extracted features include pixel groupings representing the property characteristic; determining, by the processing circuitry from the extracted features, the a property characteristic classification for the property characteristic, wherein determining the property characteristic classification includes applying the pixel groupings for the property characteristic to a first machine learning classifier trained to identify property characteristics from a set of pixel groupings; determining, by the processing circuitry based on the identified property characteristic and the extracted features, a condition classification for the property characteristic, wherein identifying the condition classification includes applying the pixel groupings for the property characteristic to a second machine learning classifier trained to identify property characteristic conditions from a set of pixel groupings; determining, by the processing circuitry based in part on the property characteristic classification and the condition classification, a risk estimate of damage to the property due to

one or more disasters; and returning, to the user at the remote computing device via a graphical user interface responsive to receiving the request, a condition assessment of the property characteristic including the condition classification and the risk estimate of damage to the property due to the one or more disasters”, when viewed as an ordered combination, these additional limitations of the claims are applying or using the judicial exception in some other meaningful way beyond generally linking the use of the judicial exception to a particular technological environment. Thus, the claims are patent eligible.

Regarding the 35 USC 103 rejections, Swanson et al. (8,775,219) teaches a method and a system relates to using remote sensing capabilities like hyperspectral imaging to identify roof characteristics for insurance purposes. Downey et al. (2015/0325064) teaches methods, systems, and apparatus, including computer programs encoded on computer storage media, for unmanned aerial vehicle authorization and geofence envelope determination. Swanson and Downey does not teach a method and a system for automatically categorizing a repair condition of a property characteristic, comprising: receiving, from a user at a remote computing device, a request for a property condition classification, wherein the property classification request includes identification of a property and at least one property characteristic; obtaining, by processing circuitry of a computing system responsive to receiving the request, an aerial image of a geographic region including the property; extracting, by the processing circuitry, one or more of a plurality of features from the aerial image corresponding to the property characteristic, wherein the extracted features include pixel groupings representing the property characteristic: determining, by the processing circuitry from the extracted features, the a property characteristic classification for the property characteristic, wherein determining the property characteristic classification includes applying the pixel groupings for the property characteristic to a first machine learning classifier trained to identify property characteristics from a set of pixel groupings; determining, by the processing circuitry based on the identified property characteristic and the extracted features, a condition classification for the

property characteristic, wherein identifying the condition classification includes applying the pixel groupings for the property characteristic to a second machine learning classifier trained to identify property characteristic conditions from a set of pixel groupings; determining, by the processing circuitry based in part on the property characteristic classification and the condition classification, a risk estimate of damage to the property due to one or more disasters; and returning, to the user at the remote computing device via a graphical user interface responsive to receiving the request, a condition assessment of the property characteristic including the condition classification and the risk estimate of damage to the property due to the one or more disasters”.

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 TIEN C. NGUYEN whose telephone number is 571-270-5108. The examiner can normally be reached on Monday-Friday (6am-2pm EST).

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Ben Sigmond can be reached on 303-297-4411. The fax phone number for the organization where this application or proceeding is assigned is 571-270-6108.

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

Art Unit: 3694

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.

Any response to this action should be mailed to:

Commissioner of Patents and Trademarks

P.O. Box 1450 Alexandria, VA 22313-1450

or faxed to 571-273-8300.

Hand delivered responses should be brought to the United States Patent and Trademark Office Customer Service Window:

Randolph Building 401 Dulany Street Alexandria, VA 22314.

/TIEN C NGUYEN/
Primary Examiner, Art Unit 3694

Notice of References Cited	Application/Control No. 15/714,376		Applicant(s)/Patent Under Reexamination Okazaki, Takeshi	
	Examiner TIEN C NGUYEN		Art Unit 3694	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6732120-B1	05-2004	Du; Mike	G01C21/20	715/764
*	B	US-8775219-B2	07-2014	Swanson; Aaron L.	G06Q50/16	705/4
*	C	US-20090265193-A1	10-2009	COLLINS; Dean	G06Q30/0185	705/4
*	D	US-20150325064-A1	11-2015	Downey; Jonathan	G08G5/0026	701/29.3
*	E	US-9846915-B2	12-2017	Howe; Richard L.	G06Q40/08	1/1
*	F	US-20160086285-A1	03-2016	Jordan Peters; Julie A.	G06Q40/08	705/4
*	G	US-20130226667-A1	08-2013	Terrazas; Alex	G06Q30/0205	705/7.34
*	H	US-20050063563-A1	03-2005	Soliman, Samir S.	H04N1/00204	382/104
*	I	US-8731234-B1	05-2014	Ciarcia; Christopher Albert	G06K9/00637	382/100
*	J	US-20140032433-A1	01-2014	Eick; Stephen G.	G06Q50/163	705/314
*	K	US-20100215212-A1	08-2010	Flakes, JR.; Malcolm S.	G01M5/0025	382/100
*	L	US-8346578-B1	01-2013	Hopkins, III; John Chandler	G06Q40/00	382/100
*	M	US-20100179787-A2	07-2010	Pershing; Chris	G06Q10/00	702/156

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Systems and Methods for Insurers to Monitor Continuously Structural Status of Insured Homes, IP.com Number: IPCOM000177511D, December 16, 2008. (Year: 2008).
	V	
	W	
	X	

*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.

Issue Classification 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

CPC						
Symbol					Type	Version
G06Q	/	40	/	08	F	2013-01-01
G06N	/	3	/	04	I	2013-01-01
G06N	/	3	/	08	I	2013-01-01
G06K	/	9	/	6267	I	2013-01-01
G06K	/	9	/	00637	I	2013-01-01
G06K	/	9	/	6256	I	2013-01-01
G06K	/	9	/	6212	I	2013-01-01
G06T	/	11	/	60	I	2013-01-01
G06K	/	9	/	00671	I	2013-01-01
G06F	/	16	/	51	I	2019-01-01
G06K	/	9	/	6273	I	2013-01-01
G06N	/	3	/	0454	I	2013-01-01
G06K	/	9	/	4604	A	2013-01-01
G06T	/	2210	/	04	A	2013-01-01
G06K	/	9	/	4642	A	2013-01-01
G06K	/	9	/	4652	A	2013-01-01

CPC Combination Sets				
Symbol	Type	Set	Ranking	Version
/				

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/TIEN C NGUYEN/ Primary Examiner, Art Unit 3694	11 November 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

INTERNATIONAL CLASSIFICATION			
CLAIMED			
G06Q	/	40	/ 00
NON-CLAIMED			
/		/	

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
705	4

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					
705	2	5	3	40	38	39
382	100	155				
713	176					
705	314					
709	224					

NONE		Total Claims Allowed:	
(Assistant Examiner) (Date)		20	
/TIEN C NGUYEN/ 11 November 2019		O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner) (Date)		1	1

Issue Classification 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	10	10	19	19										
2	2	11	11	20	20										
	3	12	12	6	21										
4	4	13	13	7	22										
	5	14	14	3	23										
	6	15	15												
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8	8	17	17												
9	9	18	18												

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 20	
/TIEN C NGUYEN/ Primary Examiner, Art Unit 3694 (Primary Examiner) _____ (Date) _____		11 November 2019 (Date)	O.G. Print Claim(s) 1 O.G. Print Figure 1

<i>Search Notes</i> 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

CPC - Searched*		
Symbol	Date	Examiner
G06Q	11/11/2019	/tn/

CPC Combination Sets - Searched*		
Symbol	Date	Examiner
G 06Q 40/08, G 06Q 40/02, G 06Q 10/10, G 06F19/328, G 06Q 30/02.	11/11/2019	/tn/

US Classification - Searched*			
Class	Subclass	Date	Examiner
705	2	11/11/2019	/tn/
705	3	11/11/2019	/tn/
705	4	11/11/2019	/tn/
705	35	11/11/2019	/tn/
705	39	11/11/2019	/tn/
705	38	11/11/2019	/tn/
705	37	11/11/2019	/tn/
701	516	11/11/2019	/tn/
382	103	11/11/2019	/tn/
340	539.11	11/11/2019	/tn/
707	736	11/11/2019	/tn/
348	47	11/11/2019	/tn/

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

/TIEN C NGUYEN/ Primary Examiner, Art Unit 3694	
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<i>Search Notes</i> 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

Search Notes		
Search Notes	Date	Examiner
Updated East and PALM.	11/11/2019	/tn/
Inventor search.	11/11/2019	/tn/
Google search.	11/11/2019	/tn/
Assignee search.	11/11/2019	/tn/
IP.com NPL search.	11/11/2019	/tn/

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
705/ G06K	4/ 9/00	11/11/2019	/tn/
705/ G06F	4/ 17/30	11/11/2019	/tn/
705/ G06F	4/ 9/62	11/11/2019	/tn/

/TIEN C NGUYEN/ Primary Examiner, Art Unit 3694	
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<i>Index of Claims</i> 	Application/Control No. 15/714,376	Applicant(s)/Patent Under Reexamination Okazaki, Takeshi
	Examiner TIEN C NGUYEN	Art Unit 3694

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

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47										
CLAIM			DATE							
Final	Original	11/11/2019								
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20	20	=								
6	21	=								
7	22	=								
3	23	=								



**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	15714376
Filing Date	2017-09-25
First Named Inventor	Takeshi Okazaki
Art Unit	3694
Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

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	10311302		2019-06-04	Kottenstette et al.	
	2	9141872		2015-09-22	Marchisio et al.	
	3	9569690		2017-02-14	Marchisio et al.	
	4	9858645		2018-01-02	Malitz	
	5	9031325		2015-05-12	Ouzounis	
	6	8682079		2014-03-25	Ouzounis	
	7	9589210		2017-03-07	Estrada et al.	
	8	10013774		2019-07-03	Estrada et al.	

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9	9147132		2015-09-29	Marchisio et al.	
10	9619734		2017-04-11	Marchisio et al.	
11	9495618		2016-11-15	Tabb	
12	9767565		2017-09-19	Estrada et al.	
13	10157479		2018-12-18	Estrada et al.	
14	9904849		2018-02-27	Estrada et al.	
15	9230168		2016-01-05	Gueguen	
16	8145578		2012-03-27	Pershing et al.	
17	8670961		2014-03-11	Pershing et al.	
18	9514568		2016-12-06	Pershing et al.	
19	8731234		2014-05-20	Ciarcia et al.	

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20	9070018		2015-06-30	Ciarcia et al.	
21	8995757		2015-03-31	Ciarcia et al.	
22	8825454		2014-09-02	Pershing	
23	9135737		2015-09-15	Pershing	
24	8818770		2014-08-26	Pershing	
25	9129376		2015-09-08	Pershing	
26	8078436		2011-12-13	Pershing et al.	
27	8170840		2012-05-01	Pershing	
28	8209152		2012-06-26	Pershing	
29	10217207		2019-02-26	Marra et al.	
30	10178303		2019-01-08	Castillo et al.	

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31	9639960		2017-05-02	Loveland et al.	
32	8775219		2014-07-08	Swanson et al.	
33	10402676		2019-09-03	Wang et al.	
34	8977520		2015-03-10	Stephens et al.	
35	10346935		2019-07-09	Thornberry et al.	
36	9183538		2015-11-10	Thornberry et al.	
37	9330494		2016-05-03	Schultz	
38	9959667		2018-05-01	Schultz	
39	10198857		2019-02-05	Schultz	
40	8401222		2013-03-19	Thornberry et al.	
41	8515125		2013-08-20	Thornberry et al.	

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42	8542880		2013-09-24	Thornberry et al.
43	9329749		2016-05-03	Thornberry et al.
44	9244589		2016-01-26	Thornberry et al.
45	9933254		2018-04-03	Thornberry et al.
46	8873842		2014-10-28	Robinson et al.
47	10410289		2019-09-10	Tofte et al.
48	10102589		2018-10-16	Tofte et al.
49	10134092		2018-11-20	Harvey et al.
50	9875509		2018-01-23	Harvey et al.

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1	20150317740	2015-11-05	Emison et al.
2	20170161559	2017-06-08	Du et al.
3	20170330032	2017-11-16	Du et al.
4	20140245165	2014-08-28	Battcher et al.
5	20140245210	2014-08-28	Battcher et al.
6	20150370928	2015-12-24	Pershing
7	20130311240	2013-11-21	Pershing et al.
8	20170053436	2017-02-23	Pershing et al.
9	20120209782	2012-08-16	Pershing et al.
10	20160155097	2016-06-02	Venkatesha
11	20150025914	2015-01-22	Lekas

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12	20160350907		2016-12-01	Simula et al.	
13	20150363717		2015-12-17	Lim	
14	20160063642		2016-03-03	Luciani et al.	
15	20140278697		2014-09-18	Thornberry et al.	
16	20150178416		2015-06-25	Stephens et al.	
17	20140237430		2014-08-21	Thornberry et al.	
18	20150310557		2015-10-29	Engelhorn	
19	20150310558		2015-10-29	Cuttell et al.	
20	20170154131		2017-06-01	Loveland et al.	
21	20170277980		2017-09-28	Taylor et al.	
22	20150302529		2015-10-22	Jagannathan	

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Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

23	20140019166	2014-01-16	Swanson et al.
24	20160259994	2016-09-08	Ravindran et al.

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	1	2017040691	WO	A1	2017-03-09	CAPE ANALYTICS, INC.		
	2	2017151673	WO	A1	2017-09-08	DIGITALGLOBE, INC.		
	3	2015009798	WO	A1	2015-01-22	DIGITALGLOBE, INC.		
	4	2015017366	WO	A1	2015-02-05	DIGITALGLOBE, INC.		
	5	2015038358	WO	A1	2015-03-19	DIGITALGLOBE, INC.		
	6	2016053791	WO	A1	2016-04-07	DIGITALGLOBE, INC.		
	7	2014151122	WO	A1	2014-09-25	EAGLE VIEW TECHNOLOGIES, INC.		

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8	2017142788	WO	A1	2017-08-24	PICTOMETRY INTERNATIONAL CORP.		
9	2012054239	WO	A2	2012-04-26	PICTOMETRY INTERNATIONAL CORP.		
10	2012054239	WO	A3	2012-04-26	PICTOMETRY INTERNATIONAL CORP.		
11	2013142406	WO	A1	2013-09-26	PICTOMETRY INTERNATIONAL CORP.		
12	2017186515	WO	A1	2017-11-02	SIEMENS AKTIENGESELLSCHAFT		
13	2013123354	WO	A1	2013-08-22	XACTWARE SOLUTIONS, INC.		
14	2015017855	WO	A1	2015-02-05	XACTWARE SOLUTIONS, INC.		
15	2018058044	WO	A1	2018-03-29	AON BENFIELD INC.		

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NON-PATENT LITERATURE DOCUMENTS

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	International Search Report and Written Opinion issued in International Application No. PCT/US2017/053265 on December 11, 2017.	

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2	International Patent Report on Patentability issued in International Application No. PCT/US2017/053265 on March 26, 2019.
3	LIN, et al., Network in Network, International Conference on Learning Representations, 2014, pp. 10.
4	KRIZHEVSKY, et al., ImageNet Classification with Deep Convolutional Neural Networks, Advances in neural information processing systems, 2012, pp. 9.

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Examiner Signature	/TIEN C NGUYEN/	Date Considered	11/11/2019
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Art Unit	3694
Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

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.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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	/Natalie J. Grace/	Date (YYYY-MM-DD)	2019-11-05
Name/Print	Natalie J. Grace	Registration Number	65803

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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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	399871	receiv\$3 near7 request\$3	USPAT	OR	ON	2019/11/11 05:27
L2	142259	(property or properties or house or houses or "real property" or resident\$3) near7 (characteristic\$3 or identification\$3)	USPAT	OR	ON	2019/11/11 05:29
L3	7105	1 and 2	USPAT	OR	ON	2019/11/11 05:29
L4	8039	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 05:29
L5	46894	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 05:30
L6	791	4 and 5	USPAT	OR	ON	2019/11/11 05:30
L7	30	3 and 6	USPAT	OR	ON	2019/11/11 05:30
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L9	134	("5193185" "5214757" "5418906" "5426780" "5751612" "5953722" "5963956" "5968109" "5974419" "6047280" "6282489").PN. OR ("6732120").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:32
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11/11/2019 10:19:22 AM

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EAST Search History

		"20120250010" "20120271461" "20130206915" "20130216089" "20130238168" "20140061376" "20140259549" "20140267627" "20140277842" "20140316614" "20140316616" "20140336928" "20150325064" "20150343644" "20150344136" "20150377405" "20160004795" "20160176542" "4818990" "5575438" "7400384" "7496226" "7872794" "7929125" "8060270" "8207484" "8212995" "8346578" "8818572" "8830485" "8872818" "8874283" "8896819" "8997362" "9009000" "9129355" "9152863" "9162753" "9256225" "9256994" "9273981").PN. OR ("9513635").URPN.				
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L20	49	("20020109829" "20030137645" "5345304" "6865034").PN. OR ("7400384").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:40
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L1	449	(extract\$3) with ((aerial\$3) near7 (imag\$3))	USPAT	OR	ON	2019/11/11 10:32
L2	41745	pixel\$3 near7 (group\$3 or grouping\$3)	USPAT	OR	ON	2019/11/11 10:33
L3	54	1 and 2	USPAT	OR	ON	2019/11/11 10:33

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L4	6016	(property or properties or house or houses or "real property" or resident\$3) near7 (classif\$3)	USPAT	OR	ON	2019/11/11 10:34
L5	1	3 and 4	USPAT	OR	ON	2019/11/11 10:34
L6	47173	(risk\$3 or damag\$3) near7 (estimat\$3 or determin\$3)	USPAT	OR	ON	2019/11/11 10:35
L7	1	5 and 6	USPAT	OR	ON	2019/11/11 10:35
L8	40	("20050251427" "20060095304" "20080103841" "20090063234" "20090265193" "20090276708" "20100179787" "20100215212" "20100257477" "20130117078" "20130297353" "20140032433" "20140039935" "20140149144" "20150332355" "20160086285" "6098070" "6219930" "7676061" "8078875" "8170840" "8209152" "8346578" "8401222" "8401877" "8515125" "8670961" "8731234" "8756085" "8774525" "8775219" "8818572" "8818770" "8825454" "8874454" "8929586" "8977520" "8995757" "9002719").PN. OR ("9846915").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:38
L9	51	("2623291" "2623292" "3029522" "3890715" "4131998" "4353988" "4389782" "4435769" "4507872" "4517748" "4896428" "5128859" "5293309" "5317503" "5377098" "5491902").PN. OR ("6219930").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:39
L10	17	("20020154574" "20040016159" "20040073434" "2431827" "3111736" "3456373" "6219930" "6775935").PN. OR ("7331133").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40
L11	127	("20010041993" "20020055861" "20020072975" "20020120475" "20020133721" "20020158968" "20020161533" "20030028296" "20030112263" "20030120519" "20030154111" "20030233261" "20040039577" "20040044549" "20040103010" "20040128155" "20040133317" "20040186744" "20050046597" "20050083413" "20050108065" "20050125117" "20050131596" "20050146604" "20050251427" "20060114531" "20060132291" "20060155616" "20060200307" "20070061109" "20070100669" "20070247331" "20070250232" "20080046261" "20080189142" "20080222005"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40

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		"20080267487" "20080281658" "20090002364" "20090015585" "20090018859" "20090092336" "20090138290" "20090150200" "20090265193" "20090290787" "20090318121" "20100057498" "20100214797" "20100293114" "20100316288" "20110022489" "20110026673" "20110041088" "20110060648" "20110093159" "20110209074" "20110218825" "20110264582" "20110313936" "20110313951" "20120029759" "20120109660" "20120131504" "20120136802" "20120245767" "20120297337" "20130080291" "20130177134" "20130317861" "20130325753" "20140074865" "20140081876" "20140082563" "20140085086" "20140095339" "20140201022" "20140316825" "20150012169" "20170147991" "3308845" "3675800" "4569531" "4981318" "5317503" "5343628" "5392388" "5657233" "5673025" "5833294" "5839112" "5853215" "6052631" "6554183" "6843599" "6920197" "7089592" "7331133").PN. OR ("7497618" "7602143" "7636676" "7889931" "7974859" "8061752" "8095394" "8131417" "8151209" "8311856" "8335606" "8407139" "8478480" "8650068" "8712893" "8799034" "8954226" "9020096" "9291544" "9292544" "9424606" "9684934" "9791590" "D396455" "D461822" "D722606" "D726741" "D727928").PN. OR ("10304137").URPN.				
L12	125	("2002/0133721").URPN.	USPAT	OR	ON	2019/11/11 10:40
L13	71	("20010032192" "20020120846" "20020133721" "20030074471" "20030187783" "20040039686" "20040111305" "20050039036" "20050043961" "20050084083" "20050091524" "20050160280" "20050190905" "20050278550" "20060149674" "20060236395" "20070084912" "20070106582" "20070112667" "20070203732" "20080040275" "20080109392" "20080172316" "20080203170" "20080253645" "20080283596"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40

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		"20090012896" "20090099959" "20090132347" "20090210444" "20100005013" "20100076890" "20100094791" "20100106611" "20100145836" "20100169163" "20100191661" "20100223164" "20100228656" "20110022483" "20110173116" "20120101927" "5627886" "6330546" "6598030" "6636833" "6658393" "6839682" "7058597" "7089592" "7246740" "7263506" "7313545" "7562814" "7603331" "7761379" "7793835" "7925607" "7984500" "7991689" "8020763").PN. OR ("8458069").URPN.				
L14	427	("5335265" "5335278" "5345595" "5351290").PN. OR ("5627886").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:41
L15	622	("5032979" "5517519" "5579222" "5590245" "5614940" "5619656" "5627886" "5678041" "5696965" "5706507" "5727159" "5796952").PN. OR ("6018619").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:41
L16	8	("20140316614" "20150371543" "20160012730" "20160224932" "20160292696" "20170011340" "20170011343" "20170148467").PN. OR ("10102758").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:42
L17	8348	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 10:42
L18	49314	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 10:42
L19	849	L17 and L18	USPAT	OR	ON	2019/11/11 10:42
L20	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L21	7	("20060239537" "20130141540" "20150169723").PN. OR ("9389084").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L22	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L23	10	("2013/0226667").URPN.	USPAT	OR	ON	2019/11/11 10:57
L24	849	L17 and L18	USPAT	OR	ON	2019/11/11 10:58
L25	12	("20040239688" "20050063563" "20060267803" "20120038633" "20150317597" "20160300375"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:58

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		"20160366546" "20170371897" "7248285" "7590259" "9652681" "9939813").PN. OR ("10290137").URPN.				
L26	10	("2012/0038633").URPN.	USPAT	OR	ON	2019/11/11 10:58
L27	12	("20040239688" "20050063563" "20060267803" "20120038633" "20150317597" "20160300375" "20160366546" "20170371897" "7248285" "7590259" "9652681" "9939813").PN. OR ("10290137").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:59
L28	10	("2012/0038633").URPN.	USPAT	OR	ON	2019/11/11 10:59
S1	399871	receiv\$3 near7 request\$3	USPAT	OR	ON	2019/11/11 05:27
S2	142259	(property or properties or house or houses or "real property" or resident\$3) near7 (characteristic\$3 or identification\$3)	USPAT	OR	ON	2019/11/11 05:29
S3	7105	S1 and S2	USPAT	OR	ON	2019/11/11 05:29
S4	8039	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 05:29
S5	46894	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 05:30
S6	791	S4 and S5	USPAT	OR	ON	2019/11/11 05:30
S7	30	S3 and S6	USPAT	OR	ON	2019/11/11 05:30
S8	4	("5519809" "5559707" "5966135" "6732120").PN. OR ("9760649").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:31
S9	134	("5193185" "5214757" "5418906" "5426780" "5751612" "5953722" "5963956" "5968109" "5974419" "6047280" "6282489").PN. OR ("6732120").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:32
S10	26181	(property or properties or house or houses or "real property" or resident\$3) near7 (damag\$3)	USPAT	OR	ON	2019/11/11 05:33
S11	106	(property or properties or house or houses or "real property" or resident\$3) near7 (damag\$3) with disaster\$3	USPAT	OR	ON	2019/11/11 05:33
S12	4	S11 and S3	USPAT	OR	ON	2019/11/11 05:33
S13	2	("20180089763").PN.	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2019/11/11 05:34
S14	0	("2018/0089763").URPN.	USPAT	OR	ON	2019/11/11 05:35
S15	10	S11 and S4	USPAT	OR	ON	2019/11/11 05:35

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S16	13	("20080262789" "20090265193" "20090326383" "7317416" "7944559" "8346578").PN. OR ("8775219").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:36
S17	174	("2009/0265193").URPN.	USPAT	OR	ON	2019/11/11 05:37
S18	80	("20080059068" "20090265193" "20100012776" "20100215212" "20100228418" "20100286859" "20110270470" "20120197461" "20120250010" "20120271461" "20130206915" "20130216089" "20130238168" "20140061376" "20140259549" "20140267627" "20140277842" "20140316614" "20140316616" "20140336928" "20150325064" "20150343644" "20150344136" "20150377405" "20160004795" "20160176542" "4818990" "5575438" "7400384" "7496226" "7872794" "7929125" "8060270" "8207484" "8212995" "8346578" "8818572" "8830485" "8872818" "8874283" "8896819" "8997362" "9009000" "9129355" "9152863" "9162753" "9256225" "9256994" "9273981").PN. OR ("9513635").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:37
S19	16	("2015/0325064").URPN.	USPAT	OR	ON	2019/11/11 05:39
S20	49	("20020109829" "20030137645" "5345304" "6865034").PN. OR ("7400384").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:40
S21	80	("20080059068" "20090265193" "20100012776" "20100215212" "20100228418" "20100268409" "20100286859" "20110270470" "20120170797" "20120197461" "20120250010" "20120271461" "20130206915" "20130216089" "20130238168" "20140061376" "20140259549" "20140267627" "20140277842" "20140316614" "20140316616" "20140324405" "20140336928" "20150325064" "20150343644" "20150344136" "20150377405" "20160004795" "20160176542" "4818990" "5575438" "7400384" "7496226" "7872794" "7929125" "8060270" "8207484" "8212995" "8346578" "8818572" "8830485" "8872818" "8874283" "8896819" "8997362" "9009000" "9129355" "9152863" "9162753" "9256225" "9256994" "9273981"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:40

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EAST Search History

		"9310221" "9329599" "9340283" "9403593" "9406237").PN. OR ("9609288").URPN.				
S22	8	"8775219"	USPAT	OR	ON	2019/11/11 06:19
L17	8348	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 10:42
L18	49314	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 10:42
L19	849	L17 and L18	USPAT	OR	ON	2019/11/11 10:42
L20	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L21	7	("20060239537" "20130141540" "20150169723").PN. OR ("9389084").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L22	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L23	10	("2013/0226667").URPN.	USPAT	OR	ON	2019/11/11 10:57
L24	849	L17 and L18	USPAT	OR	ON	2019/11/11 10:58
L25	12	("20040239688" "20050063563" "20060267803" "20120038633" "20150317597" "20160300375" "20160366546" "20170371897" "7248285" "7590259" "9652681" "9939813").PN. OR ("10290137").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:58
L26	10	("2012/0038633").URPN.	USPAT	OR	ON	2019/11/11 10:58
L27	12	("20040239688" "20050063563" "20060267803" "20120038633" "20150317597" "20160300375" "20160366546" "20170371897" "7248285" "7590259" "9652681" "9939813").PN. OR ("10290137").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:59
L28	10	("2012/0038633").URPN.	USPAT	OR	ON	2019/11/11 10:59
L11	127	("20010041993" "20020055861" "20020072975" "20020120475" "20020133721" "20020158968" "20020161533" "20030028296" "20030112263" "20030120519" "20030154111" "20030233261" "20040039577" "20040044549" "20040103010" "20040128155" "20040133317" "20040186744" "20050046597" "20050083413"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40

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		"20050108065" "20050125117" "20050131596" "20050146604" "20050251427" "20060114531" "20060132291" "20060155616" "20060200307" "20070061109" "20070100669" "20070247331" "20070250232" "20080046261" "20080189142" "20080222005" "20080267487" "20080281658" "20090002364" "20090015585" "20090018859" "20090092336" "20090138290" "20090150200" "20090265193" "20090290787" "20090318121" "20100057498" "20100214797" "20100293114" "20100316288" "20110022489" "20110026673" "20110041088" "20110060648" "20110093159" "20110209074" "20110218825" "20110264582" "20110313936" "20110313951" "20120029759" "20120109660" "20120131504" "20120136802" "20120245767" "20120297337" "20130080291" "20130177134" "20130317861" "20130325753" "20140074865" "20140081876" "20140082563" "20140085086" "20140095339" "20140201022" "20140316825" "20150012169" "20170147991" "3308845" "3675800" "4569531" "4981318" "5317503" "5343628" "5392388" "5657233" "5673025" "5833294" "5839112" "5853215" "6052631" "6554183" "6843599" "6920197" "7089592" "7331133").PN. OR ("7497618" "7602143" "7636676" "7889931" "7974859" "8061752" "8095394" "8131417" "8151209" "8311856" "8335606" "8407139" "8478480" "8650068" "8712893" "8799034" "8954226" "9020096" "9291544" "9292544" "9424606" "9684934" "9791590" "D396455" "D461822" "D722606" "D726741" "D727928").PN. OR ("10304137").URPN.				
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EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	399871	receiv\$3 near7 request\$3	USPAT	OR	ON	2019/11/11 05:27
L2	142259	(property or properties or house or houses or "real property" or resident\$3) near7 (characteristic\$3 or identification\$3)	USPAT	OR	ON	2019/11/11 05:29
L3	7105	1 and 2	USPAT	OR	ON	2019/11/11 05:29
L4	8039	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 05:29
L5	46894	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 05:30
L6	791	4 and 5	USPAT	OR	ON	2019/11/11 05:30
L7	30	3 and 6	USPAT	OR	ON	2019/11/11 05:30
L8	4	("5519809" "5559707" "5966135" "6732120").PN. OR ("9760649").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:31
L9	134	("5193185" "5214757" "5418906" "5426780" "5751612" "5953722" "5963956" "5968109" "5974419" "6047280" "6282489").PN. OR ("6732120").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:32
L10	26181	(property or properties or house or houses or "real property" or resident\$3) near7 (damag\$3)	USPAT	OR	ON	2019/11/11 05:33
L11	106	(property or properties or house or houses or "real property" or resident\$3) near7 (damag\$3) with disaster\$3	USPAT	OR	ON	2019/11/11 05:33
L12	4	11 and 3	USPAT	OR	ON	2019/11/11 05:33
L13	2	("20180089763").PN.	US-PGPUB; USPAT; USOCR; DERWENT	OR	ON	2019/11/11 05:34
L14	0	("2018/0089763").URPN.	USPAT	OR	ON	2019/11/11 05:35
L15	10	11 and 4	USPAT	OR	ON	2019/11/11 05:35
L16	13	("20080262789" "20090265193" "20090326383" "7317416" "7944559" "8346578").PN. OR ("8775219").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:36
L17	174	("2009/0265193").URPN.	USPAT	OR	ON	2019/11/11 05:37
L18	80	("20080059068" "20090265193" "20100012776" "20100215212" "20100228418" "20100286859" "20110270470" "20120197461" "20120250010" "20120271461"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:37

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		"20130206915" "20130216089" "20130238168" "20140061376" "20140259549" "20140267627" "20140277842" "20140316614" "20140316616" "20140336928" "20150325064" "20150343644" "20150344136" "20150377405" "20160004795" "20160176542" "4818990" "5575438" "7400384" "7496226" "7872794" "7929125" "8060270" "8207484" "8212995" "8346578" "8818572" "8830485" "8872818" "8874283" "8896819" "8997362" "9009000" "9129355" "9152863" "9162753" "9256225" "9256994" "9273981").PN. OR ("9513635").URPN.				
L19	16	("2015/0325064").URPN.	USPAT	OR	ON	2019/11/11 05:39
L20	49	("20020109829" "20030137645" "5345304" "6865034").PN. OR ("7400384").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:40
L21	80	("20080059068" "20090265193" "20100012776" "20100215212" "20100228418" "20100268409" "20100286859" "20110270470" "20120170797" "20120197461" "20120250010" "20120271461" "20130206915" "20130216089" "20130238168" "20140061376" "20140259549" "20140267627" "20140277842" "20140316614" "20140316616" "20140324405" "20140336928" "20150325064" "20150343644" "20150344136" "20150377405" "20160004795" "20160176542" "4818990" "5575438" "7400384" "7496226" "7872794" "7929125" "8060270" "8207484" "8212995" "8346578" "8818572" "8830485" "8872818" "8874283" "8896819" "8997362" "9009000" "9129355" "9152863" "9162753" "9256225" "9256994" "9273981" "9310221" "9329599" "9340283" "9403593" "9406237").PN. OR ("9609288").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 05:40
L1	449	(extract\$3) with ((aerial\$3) near7 (imag\$3))	USPAT	OR	ON	2019/11/11 10:32
L2	41745	pixel\$3 near7 (group\$3 or grouping\$3)	USPAT	OR	ON	2019/11/11 10:33
L3	54	1 and 2	USPAT	OR	ON	2019/11/11 10:33
L4	6016	(property or properties or house or houses or	USPAT	OR	ON	2019/11/11

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EAST Search History

		"real property" or resident\$3) near7 (classif\$3)				10:34
L5	1	3 and 4	USPAT	OR	ON	2019/11/11 10:34
L6	47173	(risk\$3 or damag\$3) near7 (estimat\$3 or determin\$3)	USPAT	OR	ON	2019/11/11 10:35
L7	1	5 and 6	USPAT	OR	ON	2019/11/11 10:35
L8	40	("20050251427" "20060095304" "20080103841" "20090063234" "20090265193" "20090276708" "20100179787" "20100215212" "20100257477" "20130117078" "20130297353" "20140032433" "20140039935" "20140149144" "20150332355" "20160086285" "6098070" "6219930" "7676061" "8078875" "8170840" "8209152" "8346578" "8401222" "8401877" "8515125" "8670961" "8731234" "8756085" "8774525" "8775219" "8818572" "8818770" "8825454" "8874454" "8929586" "8977520" "8995757" "9002719").PN. OR ("9846915").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:38
L9	51	("2623291" "2623292" "3029522" "3890715" "4131998" "4353988" "4389782" "4435769" "4507872" "4517748" "4896428" "5128859" "5293309" "5317503" "5377098" "5491902").PN. OR ("6219930").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:39
L10	17	("20020154574" "20040016159" "20040073434" "2431827" "3111736" "3456373" "6219930" "6775935").PN. OR ("7331133").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40
L11	127	("20010041993" "20020055861" "20020072975" "20020120475" "20020133721" "20020158968" "20020161533" "20030028296" "20030112263" "20030120519" "20030154111" "20030233261" "20040039577" "20040044549" "20040103010" "20040128155" "20040133317" "20040186744" "20050046597" "20050083413" "20050108065" "20050125117" "20050131596" "20050146604" "20050251427" "20060114531" "20060132291" "20060155616" "20060200307" "20070061109" "20070100669" "20070247331" "20070250232" "20080046261" "20080189142" "20080222005" "20080267487" "20080281658"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40

11/11/2019 10:19:22 AM

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EAST Search History

		"20090002364" "20090015585" "20090018859" "20090092336" "20090138290" "20090150200" "20090265193" "20090290787" "20090318121" "20100057498" "20100214797" "20100293114" "20100316288" "20110022489" "20110026673" "20110041088" "20110060648" "20110093159" "20110209074" "20110218825" "20110264582" "20110313936" "20110313951" "20120029759" "20120109660" "20120131504" "20120136802" "20120245767" "20120297337" "20130080291" "20130177134" "20130317861" "20130325753" "20140074865" "20140081876" "20140082563" "20140085086" "20140095339" "20140201022" "20140316825" "20150012169" "20170147991" "3308845" "3675800" "4569531" "4981318" "5317503" "5343628" "5392388" "5657233" "5673025" "5833294" "5839112" "5853215" "6052631" "6554183" "6843599" "6920197" "7089592" "7331133").PN. OR ("7497618" "7602143" "7636676" "7889931" "7974859" "8061752" "8095394" "8131417" "8151209" "8311856" "8335606" "8407139" "8478480" "8650068" "8712893" "8799034" "8954226" "9020096" "9291544" "9292544" "9424606" "9684934" "9791590" "D396455" "D461822" "D722606" "D726741" "D727928").PN. OR ("10304137").URPN.				
L12	125	("2002/0133721").URPN.	USPAT	OR	ON	2019/11/11 10:40
L13	71	("20010032192" "20020120846" "20020133721" "20030074471" "20030187783" "20040039686" "20040111305" "20050039036" "20050043961" "20050084083" "20050091524" "20050160280" "20050190905" "20050278550" "20060149674" "20060236395" "20070084912" "20070106582" "20070112667" "20070203732" "20080040275" "20080109392" "20080172316" "20080203170" "20080253645" "20080283596" "20090012896" "20090099959"	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:40

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EAST Search History

		"20090132347" "20090210444" "20100005013" "20100076890" "20100094791" "20100106611" "20100145836" "20100169163" "20100191661" "20100223164" "20100228656" "20110022483" "20110173116" "20120101927" "5627886" "6330546" "6598030" "6636833" "6658393" "6839682" "7058597" "7089592" "7246740" "7263506" "7313545" "7562814" "7603331" "7761379" "7793835" "7925607" "7984500" "7991689" "8020763").PN. OR ("8458069").URPN.				
L14	427	("5335265" "5335278" "5345595" "5351290").PN. OR ("5627886").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:41
L15	622	("5032979" "5517519" "5579222" "5590245" "5614940" "5619656" "5627886" "5678041" "5696965" "5706507" "5727159" "5796952").PN. OR ("6018619").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:41
L16	8	("20140316614" "20150371543" "20160012730" "20160224932" "20160292696" "20170011340" "20170011343" "20170148467").PN. OR ("10102758").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:42
L17	8348	aerial\$3 near7 imag\$3	USPAT	OR	ON	2019/11/11 10:42
L18	49314	(geographic\$3) near7 (region\$3 or boundar\$3)	USPAT	OR	ON	2019/11/11 10:42
L19	849	L17 and L18	USPAT	OR	ON	2019/11/11 10:42
L20	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L21	7	("20060239537" "20130141540" "20150169723").PN. OR ("9389084").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L22	6	("20060122776" "20070025595" "20130226667" "20190050625" "20190130641" "9389084").PN. OR ("10339646").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2019/11/11 10:57
L23	10	("2013/0226667").URPN.	USPAT	OR	ON	2019/11/11 10:57

11/11/2019 10:19:22 AM

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BIB DATA SHEET

CONFIRMATION NO. 8275

SERIAL NUMBER 15/714,376	FILING or 371(c) DATE 09/25/2017 RULE	CLASS 705	GROUP ART UNIT 3694	ATTORNEY DOCKET NO. 474139US01		
APPLICANTS Aon Benfield Inc., Chicago, IL INVENTORS Takeshi Okazaki, Tokyo, JAPAN; ** CONTINUING DATA ***** This appln claims benefit of 62/398,665 09/23/2016 ** FOREIGN APPLICATIONS ***** ** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** 10/05/2017						
Foreign Priority claimed ☐ Yes ☒ No 35 USC 119(a-d) conditions met ☐ Yes ☒ No Verified and Acknowledged <u>/TIEN C NGUYEN/</u> Examiner's Signature		☐ Met after Allowance Initials	STATE OR COUNTRY JAPAN	SHEETS DRAWINGS 15	TOTAL CLAIMS 20	INDEPENDENT CLAIMS 3
ADDRESS Gardella Grace P.A. 80 M Street SE, 1st Floor Washington, DC 20003 UNITED STATES						
TITLE Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis						
FILING FEE RECEIVED 1600	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			

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)

Application Number	15714376
Filing Date	2017-09-25
First Named Inventor	Takeshi Okazaki
Art Unit	3694
Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

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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	9928553		2018-03-27	Harvey et al.	
	2	10173773		2019-01-08	Flick	
	3	10137984		2018-11-27	Flick	
	4	10163164		2018-12-25	Tofte et al.	
	5	9501700		2016-11-22	Loveland et al.	
	6	9679227		2017-06-13	Taylor et al.	
	7	10453147		2019-10-22	Davis	
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Application Number	15714376
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First Named Inventor	Takeshi Okazaki
Art Unit	3694
Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

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
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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²	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
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NON-PATENT LITERATURE DOCUMENTS

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		

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/TIEN C NGUYEN/	Date Considered	11/11/2019
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*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	15714376
Filing Date	2017-09-25
First Named Inventor	Takeshi Okazaki
Art Unit	3694
Examiner Name	TIEN C. NGUYEN
Attorney Docket Number	474139US01

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.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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	/Natalie J. Grace/	Date (YYYY-MM-DD)	2019-11-05
Name/Print	Natalie J. Grace	Registration Number	65803

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.**

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.
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 inspections 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.

PART B – FEE(S) TRANSMITTAL

Complete and send this form, together with the applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

By fax, send to: (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)

146018
Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO	CONFIRMATION NO
15/714,376	09/25/2017	Takeshi Okazaki	474139US01	8275

TITLE OF INVENTION: Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	02/20/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, TIEN C	3694	705-004000

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 03-09 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. **Gardella Grace P.A.**

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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE or COUNTRY)

Aon Benfield Inc.

Chicago, IL

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

4a. Fees Submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment (Please first reapply any previously paid fee shown above):

- ☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 601484

5. Change of Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27.
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid Certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

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

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

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Natalie J. Grace/

Date 2019-11-26

Typed or printed name Natalie J. Grace

Registration No. 65,803

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B 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 30 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.

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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.
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Electronic Patent Application Fee Transmittal				
Application Number:		15714376		
Filing Date:		25-Sep-2017		
Title of Invention:		Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis		
First Named Inventor/Applicant Name:		Takeshi Okazaki		
Filer:		Natalie J. Grace/Kristin Sims		
Attorney Docket Number:		474139US01		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
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	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

Electronic Acknowledgement Receipt

EFS ID:	37858781
Application Number:	15714376
International Application Number:	
Confirmation Number:	8275
Title of Invention:	Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis
First Named Inventor/Applicant Name:	Takeshi Okazaki
Customer Number:	146018
Filer:	Natalie J. Grace/Kristin Sims
Filer Authorized By:	Natalie J. Grace
Attorney Docket Number:	474139US01
Receipt Date:	26-NOV-2019
Filing Date:	25-SEP-2017
Time Stamp:	09:38:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 1000
RAM confirmation Number	E2019AP039105510
Deposit Account	601484
Authorized User	Kristin Sims

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)
 37 CFR 1.20 (Post Issuance fees)
 37 CFR 1.21 (Miscellaneous fees and charges)

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)	474139US01_IssueFee.pdf	362179	no	2
			30762bd97fa64b6d9c82f0d6999a06010b19fb77		

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30390	no	2
			c662f24449001a5245048b2a2c4db3b7fef9e13b		

Warnings:

Information:

Total Files Size (in bytes):			392569
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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
COMMISSIONER FOR PATENTS
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ALEXANDRIA VA 22313-1451

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Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003



**Courtesy Reminder for
Application Serial No: 15/714,376**

Attorney Docket No: 474139US01

Customer Number: 146018

Date of Electronic Notification: 11/20/2019

This is a courtesy reminder that new correspondence is available for this application. If you have not done so already, please review the correspondence. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

An email notification regarding the correspondence was sent to the following email address(es) associated with your customer number:

ngrace@gardellagraces.com

docketing@gardellagraces.com

To view your correspondence online or update your email addresses, please visit us anytime at **<https://ppair-my.uspto.gov/pair/PrivatePair>**.

If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov or call 1-866-217-9197.



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.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/714,376	01/07/2020	10529029	474139US01	8275

146018 7590 12/18/2019
Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003

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 26 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):

Takeshi Okazaki, Tokyo, JAPAN;
Aon Benfield Inc., Chicago, IL

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.



UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
15/714,376

RECEIPT DATE / TIME
08/29/2024 04:58:18 PM Z ET

ATTORNEY DOCKET #
474139US01

Title of Invention

Platform, Systems, and Methods for Identifying Property Characteristics and Property Feature Maintenance Through Aerial Imagery Analysis

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # 10529029

CONFIRMATION # 8275

FILED BY Donna O'Callaghan

PATENT CENTER # 66976038

FILING DATE 09/25/2017

CUSTOMER # 146018

FIRST NAMED
INVENTOR Takeshi Okazaki

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Natalie Grace

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
AON00004USU1 - Statement of Ownership_tbf.pdf	3	Assignee showing of ownership per 37 CFR 3.73	1680 KB
AON00004USU1 - Aon Re Inc. Executed POA_tbf.pdf	2	Power of Attorney	399 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
AON00004USU1 - Statement of Ownership_tbf.pdf	1F18E7D34EB81B8DD023A8952F52560D6DDF316A66A3E796A 23A4651154E0370353B9F436018F3CD05D9065CBCA26021E93 9DE94975AE1ADC9274C36063DC7E9

AON00004USU1 - Aon Re Inc.
Executed POA_tbf.pdf

C5153D5A85DD13108A6325D170B885B1B3CA8B68FD811E8B4
21110DD4B48648D19A3D624F54AF80FADE6FB3D0984702982
A75E9BDA90D9F0ADDDB8CA5FE15F4BD

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 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.

STATEMENT UNDER 37 CFR 3.73(c)Applicant/Patent Owner: Aon Re, Inc.Application No./Patent No.: 10,529,029Filed/Issue Date: January 7, 2020Titled: PLATFORM, SYSTEMS, AND METHODS FOR IDENTIFYING PROPERTY CHARACTERISTICS AND PROPERTY FEATURE MAINTENANCE THROUGH AERIAL IMAGERY ANALYSISAon Re, Inc., a corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose one of options 1, 2, 3 or 4 below):

1. ☒ The assignee of the entire right, title, and interest.
2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):
- ☐ The extent (by percentage) of its ownership interest is _____. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose one of options A or B below):

- A. ☐ 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.
- B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Takeshi Okazaki To: Aon Benfield Inc.The document was recorded in the United States Patent and Trademark Office at
Reel 050623, Frame 0112, or for which a copy thereof is attached.2. From: Aon Benfield Inc. To: Aon Re, Inc.The document was recorded in the United States Patent and Trademark Office at
Reel 068292, Frame 0838, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). 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 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.

STATEMENT UNDER 37 CFR 3.73(c)

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.

4. 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.

5. 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.

6. 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(s).

☐ As required by 37 CFR 3.73(c)(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.

/Natalie J. Grace/

Signature

Natalie J. Grace

Printed or Typed Name

August 29, 2024

Date

65,803

Title or Registration Number

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.

Under the Paperwork Reduction Act of 1995, no person is 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:

51886

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 assignment 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:

51886

OR

☐

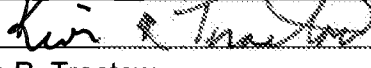
Firm or individual name		
Address		
City	State	Zip
Country		
Telephone		Email

Assignee name and address: Aon Re, Inc.
200 East Randolph Street, Chicago, Illinois 60601

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		Date	June 18, 2024
Name	Kevin R. Traetow	Telephone	452-886-8164
Title Co-President			

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with an information collection subject to the requirements of the Paperwork Reduction Act of 1995, unless the information collection has a currently valid OMB Control Number. The OMB Control Number for this information collection is 0651-0035. Public burden for this form is estimated to average 18 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden to the Chief Administrative Officer, United States Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450 or email InformationCollection@uspto.gov. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.** If filing this completed form by mail, 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.

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. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013). <https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf>

Routine uses of the information in this record may include disclosure to: 1) law enforcement, in the event that the system of records indicates a violation or potential violation of law; 2) a Federal, state, local, or international agency, in response to its request; 3) a contractor of the USPTO having need for the information in order to perform a contract; 4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record; 5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record; 6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations; 7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals; 8) 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)); 9) the Office of Personnel Management (OPM) for personnel research purposes; and 9) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Additional Uses

Additional USPTO uses of the information in this record may include disclosure to: 1) the International Bureau of the World Intellectual Property Organization, if the record is related to an international application filed under the Patent Cooperation Treaty; 2) the public i) after publication of the application pursuant to 35 U.S.C. 122(b), ii) after issuance of a patent pursuant to 35 U.S.C. 151, iii) 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 inspections, or an issued patent, or iv) without publication of the application or patent under the specific circumstances provided for by 37 CFR 1.14(a)(1)(v)-(vii); and/or 3) the National Archives and Records Administration, for inspection of records.



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
15/714,376	09/25/2017	Takeshi Okazaki	474139US01

51886
Finch & Maloney PLLC
50 Commercial St.
Suite 300
Manchester, NH 03101

CONFIRMATION NO. 8275
POA ACCEPTANCE LETTER



OC000000077806289

Date Mailed: 09/18/2024

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/29/2024.

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.

/atesfai/



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
15/714,376	09/25/2017	Takeshi Okazaki	474139US01

146018
Gardella Grace P.A.
80 M Street SE, 1st Floor
Washington, DC 20003

CONFIRMATION NO. 8275

POWER OF ATTORNEY NOTICE



OC000000077806234

Date Mailed: 09/18/2024

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/29/2024.

- 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.

/atesfai/