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Eagle View EX2002 (Part 1 of 4)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		2009-05-15
	First Named Inventor	Chris Pershing	
	Art Unit		
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	1	Gulch E., et al., "On the Performance of Semi-Automatic Building Extraction," In the International Archives of Photogrammetry and Remote Sensing, Vol. 23, 8 pages, 1998.						☐
	2	"How precigeo Roof Works." http://web.archive.org/web/20070107012311/roof.precigeo.com/how-precigeo-roof-works.htm , retrieved April 30, 2009, 1 page.						☐

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3	"Microsoft's MSN Virtual Earth: The Map is the Search Platform," Directions Magazine, http://www.directionsmag.com/article.php?article_id=873&trv=1 , retrieved February 6, 2009, 10 pages.	☐
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9	Ziegler, R, et al. "3D Reconstruction Using Labeled Image Regions," Mitsubishi Electric Research Laboratories, http://www.merl.com , 2003, 14 pages.	☐

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ON THE PERFORMANCE OF SEMI-AUTOMATIC BUILDING EXTRACTION

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ABSTRACT

A Semi-Automatic Building Extraction system using two or more digitized overlapping aerial images has been enhanced by increased automation for the measurement of saddle-back-roof buildings, hip-roof buildings and boxes. All newly developed modules have been incorporated in the object oriented design of the system. The new methods consist of a ground-point and roof-top matching tool and a robust determination of shape parameters, like e.g. gutter length and width. The current performance of building extraction is quantitatively and qualitatively evaluated. We examine the increased efficiency using the automated tools, the success rate of individual modules and the overall success rate using a combination of methods. A methodology for quantitative comparison is tested on footprints of buildings from classical stereo measurements and from semi-automatic measurements. A qualitative comparison in 3D of multiple measurements of complete buildings is performed on three different datasets.

1 INTRODUCTION

We describe our experiences with a Semiautomatic Building Extraction System which has been developed since 1993 at the Institute for Photogrammetry, University of Bonn. This system was presented in several publications since 1993 (Lang and Schickler, 1993, Englert and Gülch, 1996, Gülch, 1996, Gülch and Müller, 1997, Gülch, 1997, Müller, 1997, Müller, 1998).

The original system had been extended to the measurement of volumetric primitives (Englert and Gülch, 1996), migrated to an object oriented design (Gülch and Müller, 1997), and enhanced by various automation tools and tested on large datasets (Gülch, 1997, Müller, 1997, Müller, 1998). A primitive can be a complete building model, like a saddleback-roof or hip-roof building or a part of a building, depending on the image scale and the required level of detail. Since several years, we do have methods to measure the height of single primitives which require an already form adjusted model in one image, or methods to perform a final fine tuning adjustment which requires very good approximate values. Having observed also difficulties on measuring the ground height (we currently assume a horizontal ground plane) caused by disturbances in the close vicinity of the buildings we had to develop new methods to overcome those problems. We have decided to automatically determine height and form parameters of the primitives, requiring only very few operations by the user, and adopted the classical way of measuring ground heights in the neighborhood (if not inherited). Both methods are described in detail in (Müller, 1997) and (Läbe and Gülch, 1998). The algorithms have to be fast enough (some seconds) to be applicable in this prototype system for on-line measurements. We can accept that time, if we otherwise need less manual operations. The goal for the newly developed automation is first of all directed to speed up the measurement process with a high success rate in sub-urban areas, with not too

dense structures and an image scale in the order of 1:5000 to 1:15000. We focus right now on basic building types, like saddleback-roof or flat-roof buildings representing a large percentage of buildings or building aggregates. However, other primitives can be handled in exactly the same way. In chapter 2 we describe the current status of the system and the actual work flow.

One task of evaluation of performance is to monitor the increased efficiency of new tools in terms of time and the success or failure rate of the automated parts themselves. These internal checks are needed to identify remaining problem areas. The external performance, checked against classical measurements is needed for acceptance in practice. We have started to develop methodologies for quantitative comparison, right now focused on 2D footprints and qualitative comparisons in 2D and 3D based on visual inspection.

In chapter 3 we will present the tests for the individual automated modules and the monitoring of increased performance. In chapter 4 we present first results of a quantitative comparison of ground plans measured by two different methods and qualitative comparisons of 3D models from three different periods. We conclude with an outlook on further investigations and developments.

2 THE SEMI-AUTOMATIC SYSTEM

The acquisition process is controlled by a human operator, who interprets the image contents and measures the 3D-shape. Automated tools assist the operator. In the following we discuss the currently implemented tools with emphasis on the automated parameter estimation.

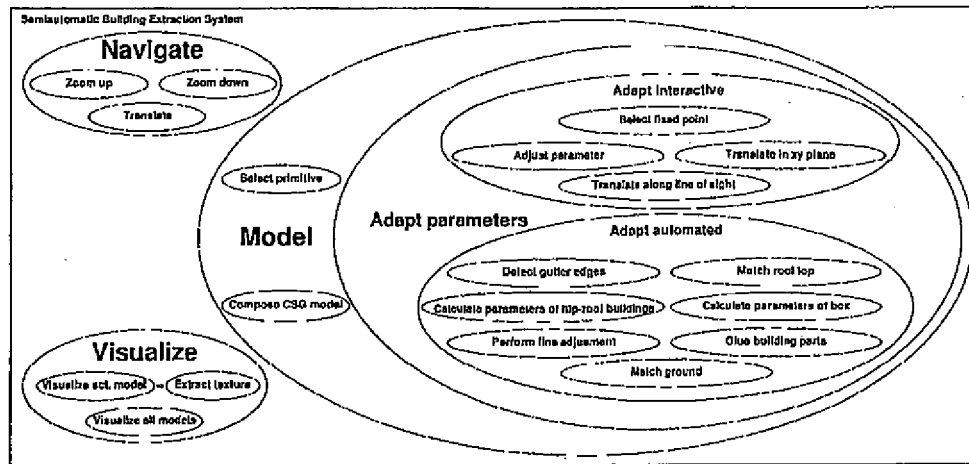


Figure 1: Use Cases of the Semiautomatic System.

2.1 Software Design

Developing a semiautomatic system is a complex process, that requires constant integration and updating of software modules and user interfaces. It requires a management of complex tasks and objects and of huge amounts of data. It is a long term process, which should make reuse of well established existing modules possible and allow for full extensibility. Maintenance and portability are of utmost importance for future applications. To facilitate these processes we apply an object-oriented design for the software involved. Figure 1 shows the implemented use cases. The system can now be used as a *executable Program* or as an *Application Programming Interface (API)*. In the first case, the operator acquires data using the *Graphical User Interface (GUI)* of the system (cf. Fig. 2), in the second case, the programmer is able to extend the system or to integrate the system in own software, using the object-oriented class structure of the API (Gülch and Müller, 1997).

2.2 Navigation

The input data of the system is a set of aerial images, from which an image pyramid was processed and their orientation data. Patches from two of these aerial images are simultaneously visualized in the workspace of the operator. The operator is able to change between the resolution steps of the pyramid and the position of the image patch with some mouse clicks.

2.3 Modeling tools

Automatic as well as interactive systems need an internal model of the objects to be acquired. Buildings show an amazingly high diversity in structure which is increasing due to new styles being developed or invented. However, a large percentage of buildings show regularities which allow to describe them using a small set of rules. A Constructive Solid Geometry (CSG) representation of parametric models has been proved as a practical internal model (Müller, 1998).

2.3.1 Selection of Primitives. In our model representation CSG-primitives are parametric models which are classified into several types. These types differ in their geometry and set of parameters. Examples of the currently implemented ten types are saddleback-roof or hip-roof. The first Interaction step of modeling is to select one of these types. After this selection a projection of the parametric models into the screen windows takes place. The models are shown as wire-frames. For this process previously processed orientation data of the images is used. Each parametric model is specified by a set of parameters. Values of these parameters have to be adapted either manually or automatically.

2.3.2 Parameter Adaptation - Manually. The interactive adaptation of the form and pose parameters is performed in monocular mode. Stereo display is not necessary. The adaptation of the parameters is done in a sequence of steps, each specifying one or two parameters of the model. The parameters are changed in dependence of the sequence of two points specified by mouse clicks and in dependence of the type of primitive. Therefore the number of interaction steps is between 50 % and 100 % of the number of parameters. The interactive height adaption is performed by dragging a slider that moves the defined model in one image, along the rays defined by the model points and the projection center until the model fits in the other image(s). In this way, not only a single point is measured, but all visible model lines are used to adjust the height, by adapting them in the other image(s). This method is faster and more reliable than measuring homologous points. We can reach a gross time of about 70 sec per primitive using this slider compared to 86 sec by measuring homologous points.

2.3.3 Parameter Adaptation - Automatically. The difference between an interactive and a Semiautomatic System is given by the automated tools integrated in the Semiautomatic System. These automated tools support the interaction process and accelerate the acquisition of data. The automation processes run online and should not block the operators interaction. Therefore runtime behavior of these tools is a critical property.



Figure 2: Graphical User Interface (GUI) of the Semiautomatic System.

The line segments in each image are computed off-line and are loaded during the interaction for the part of the images where the actual measurement takes place. These line segments are used by some automated tools.

Following automated tools are actually integrated:

Ground point and roof top matching. To automatically compute the absolute height of the top of a roof or of the ground we use cross-correlation on the grey values of the images with an epipolar search strategy (Müller, 1997). This can be compared to classical point-transfer in Photogrammetry.

RANSAC. The *R*ANdom *S*AMPLE *C*ONSensus principle can be used as a powerful technique to determine a best fit of building parameters from a given set of image edges. An activity diagram of the RANSAC procedure for measuring a hip-roof building is shown in Figure 3. The procedure starts with calculation of edge sets out of image edges, which are candidates for unknown model edges. The building parameters are calculated from an edge sample, whose edges were randomly chosen from each edge set. After a range check the weight of the computed model is calculated using fit of image edges. This procedure is repeated until the weight all possible samples is calculated or a threshold for the number of samples is reached. The building parameters with the best calculated weight are chosen as the result of the process. RANSAC is currently used for form parameter estimation (e.g. gutter height, width and length) for saddleback-roof, hip-roof and flat-roof buildings as well as for height determination of flat-roof buildings.

Clustering. Another robust method to estimate parameters is *Clustering*. Clustering is highly recommendable for problems with few unknowns and a high redundancy (Förstner, 1989). Clustering has been applied to determine gutter width and height for saddleback-roof buildings and to compare it with the RANSAC approach. Within the algorithm a n -dimensional array is used where n is the number of unknown parameters (here $n = 2$). Each parameter

has to be discretized. Therefore a finite parameter space is required and the result may be not accurate due to the discretization. Every value of the array is the weight for the special combination of parameters represented by the array indices. While computing the result of the robust estimation every observation is taken into account. Every observation leads to a set of possible combinations of parameters which correspond to the observation. For these combinations the weight is increased. In the most simple case the combination of parameters with the best weight is chosen as the solution.

Fine adjustment. An automatic line adjustment (Läbe and Ellenbeck, 1996) by a robust spatial estimation, using all line segments in all images provides an optimal fit of the selected model to the image data.

2.3.4 Composition of a CSG model. After adapting the parameters of the primitives, the operator is able to compose a CSG tree by selecting one of the three logical operations *union*, *difference* or *intersection*. The actual acquired CSG model is shown as a tree (cf. Figure 2).

Describing a building by the combination of primitives or combined primitives requires a precise "docking" of the primitives (Englert and Gülch, 1996). This docking is supported by matching and glueing facilities. The former allows to match at least two edges of different primitives and the latter matches and glues exactly two faces of different primitives together.

2.4 Work flow of form and pose estimation

To summarize: the operator has to perform in the best case three or four operations only for measuring *basic building types* which is less than in the case of classical photogrammetric point measurement. Two of the operations are simple *selections* and not *measurement* tasks.

In the case of a *saddle-back-roof building* four operations are needed: *select* the building type (saddle-back), *adjust*

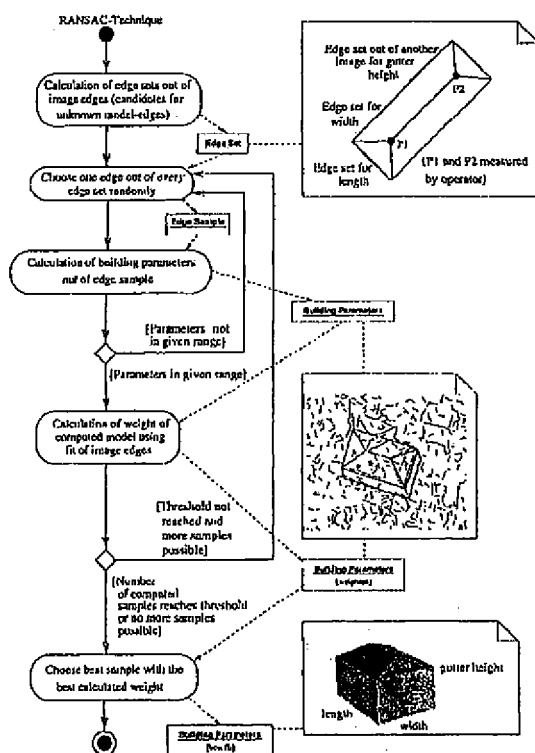


Figure 3: RANSAC Technique applied to the measurement of a hip-roof building.

the 3D model (primitive) of a saddle-back to two points (two gable points) in one image, thus determining the rotation around the Z-axis, and the length of the building and finally select one ground point in the vicinity (in one image) and the system automatically determines the remaining four unknown parameters: a) the absolute roof height, b) the ground height, c) the width of the building and d) the gutter height. The absolute roof height and the ground height are independently determined by cross-correlation and epipolar search. The detection of the gutter height and the determination of the width of the building is done by Clustering or RANSAC. An example of the different steps is given in Fig. 4. A final robust adjustment of all parameters of each volumetric model in all images can further improve the overall result.

The general operation-flow for the *lop-sided saddleback-roof building* is similar to the symmetric saddleback-roof building. The absolute roof height and the ground height are separately determined by the cross-correlation module, and the remaining parameters are computed by the RANSAC technique. The difference is that the lop-sided saddleback-roof building has one additional parameter (or five unknown parameters): Because of the missing symmetry of the roof-top two widths have to be calculated in the RANSAC procedure.

In the case of a *hip-roof building* the operator performs practically the same operations: select the building type (hip-roof), adjust the 3D model (primitive) to two points (two roof top points) in one image, thus determining the rotation around the Z-axis, and the length of the roof top and finally selects one ground point in the vicinity (in one image) and

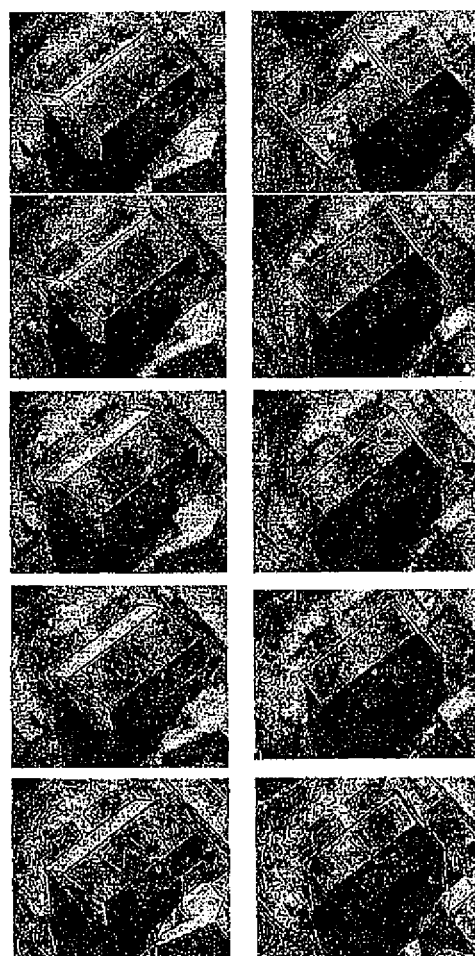


Figure 4: Example of measuring a saddleback-roof building. 1st row: Operator measures two gable points in the left image. 2nd row: Automatic roof-top height. 3rd row: Automatic gutter matching. 4th row: Automatic ground height. 5th row: Fine adjustment and result.

the system automatically determines the remaining five unknown parameters: a) the absolute height of the roof top, b) the ground height, c) the length of the building, d) the width of the building, and e) the gutter height. The search for length, width and gutter height is performed by a RANSAC technique.

In the case of a *flat-roof building (box)*, even less parameters have to be given: the operator selects the building type (box), adjust the 3D model (primitive) to one point (one corner point) in one image, and finally selects one ground point in the vicinity (in one image) and the system automatically determines the remaining five unknown parameters: a) the absolute height of the flat roof, b) the ground height, c) the length of the building, d) the width of the building, and e) the rotation around the Z-axis. The search for all parameters except the ground height is performed by a RANSAC technique.

2.5 Visualization

A visualization of the results is done by generating a VRML (Virtual Reality Modelling Language) file of the building models and exporting it to a VRML-browser. There are several kinds of visualization available: (a) visualization of all extracted models, (b) visualization of the actual model or (c) visualization of the actual model with extracted texture.

3 TESTING AUTOMATED MODULES

Each of the automated modules as well as the combination is tested for the success rate. The efficiency is compared to earlier versions of the system.

3.1 Success rate

All modules for automated parameter estimation are investigated concerning their success rate. We distinguish between a) full success without any further intervention by the operator, b) one or two additional attempts or c) failure, which requires a more or less complete correction and manual adjustment by the operator.

3.1.1 Datasets. We have started to examine the modules on two different datasets. The first dataset A consists of a pair of two aerial images with moderate to good image quality. Within the second dataset B (from the project described in (Läbe and Ellenbeck, 1996)) we use image patches of the buildings to be measured. For every building 6 image patches exist. As Figures 5 and 6 show the image quality from dataset B is much lower than the one of the image pair (A). In both datasets the image scale is 1:12500. Dataset A is scanned with $12.5\mu\text{m}$, dataset B with $11\mu\text{m}$ pixel size. So the ground resolution is comparable. In both datasets the density of buildings is moderate. There is enough space nearby to select a suitable ground point. The buildings are of different size ranging from about 75m^2 to more than 500m^2 ; there are single buildings or buildings connected to others. Some buildings have disturbances and they are partly surrounded by bushes and trees. There have been measured parts of complex buildings as well. No approximate values for the unknown parameters were used, but we define a certain range for the parameters for the RANSAC approach. For that purpose we have decided to work in object space units for higher flexibility and better understanding. We have chosen slightly different ranges for the different building types to be able to check the influence. The values are the same for all examined buildings in all datasets except the absolute roof height range in case of a box which is set different in the two datasets. But the setting of this parameter is not very critical, as the range is usually known from the flight plan, but of course the setting influences the performance of the parameter estimation.

3.1.2 Correlation. The test for the correlation procedure has been performed on the roof-top and on ground points separately on saddleback and hip-roof buildings in both datasets. In the case of a roof-top we use only one trial as the point is chosen automatically between the two given precisely located roof-top points. For the 109 roof-tops it works well (up to 87% success rate) as long there are no big disturbances due to e.g. chimneys right on the roof top. In case of failure the operator measures the height manually.

For the ground height determination several trials are possible because the success depends on the "intelligent" choice of the point. There must be enough texture and no 3D disturbances around that point. Here big differences between inexperienced (not documented here) and experienced operators can be observed. The high success rate for the ground points (83%) in a first test on only 30 buildings is mostly due to the skills of that operator in selecting a "good" point. Further investigations are necessary on the effect of training on the performance of that module.

3.1.3 RANSAC and Clustering. The RANSAC and the Clustering approaches are tested with the datasets A and B. In a first attempt the automated procedures are started. For the second and third attempt the operator could change the used images and/or in case of a box select another corner point or run the procedure once again. The success rate is counted as success after maximal three attempts (details in (Läbe and Gülch, 1998)) with the operator accepting the result.

Some examples of successful and false determination of the parameters computed by the RANSAC algorithm in both datasets are shown in Figures 5 and 6.

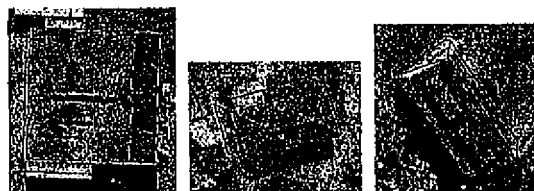


Figure 5: Examples for RANSAC algorithm results in dataset A. Two successful measurements and one failure (wrong gutter height and width).

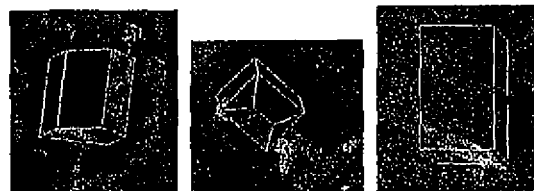


Figure 6: Examples for RANSAC algorithm results in dataset B. Two successful measurements and one failure (wrong rotation, length and width).

The success rates for about 160 saddleback-roof buildings (up to 80 %) and the 46 hip-roof buildings (up to 88 %) are extremely promising, whereas the calculation of the parameters of the 55 flat-roof building (box) is problematic (up to 43% success rate). The performance for the top-sided saddleback-roof (not documented here) is expected to be similar to the saddleback-roof and the hip-roof buildings.

The results show, that the influence of a lower image quality (like in dataset B) can not be compensated by a higher amount of image patches.

For the saddleback-roof building we compare the Clustering and the RANSAC methods. Both methods give similar results. We favor, however, the RANSAC approach for better extensibility and the potential of handling a much higher amount of parameters. Using the RANSAC approach we

can further see that additional attempts by changing the image used to select the samples improve the results.

A better performance of the *hip-roof buildings* in dataset A (only 12% failure) compared to dataset B (34% failure) is most probably due to the higher image quality. Even if we have to estimate one parameter more for the hip-roof building compared to the saddleback-roof building we get a comparable or even better performance, as we have chosen slightly more restrictive parameter ranges for the hip-roof building.

The current algorithm for finding the parameters of the box has additional problems. The operator gives one corner point only and the computer has to find edges which begin at this corner and belong to the roof of the box. Using a normal edge extraction it is clear that extracted line segments are not connected to the corner point itself. So the search area around the point has to be large which leads to more false image edges. Often short image edges which are near a corner point are the reason for a bad estimation of the rotation around the Z-axis. Then the other parameters of the box can not be computed either correctly. The box in Figure 6 (right) can serve as an example for failure of that type. A solution would be to give an edge instead of a corner point as a start information, which would not increase the amount of operations for the user. The amount of successful second and third attempts for the box is very large compared to the number of successful first attempts. This is a hint for a too low threshold for the number of samples computed in the RANSAC loop. This means we had assumed a too low number of outliers when determining that threshold. We are expecting a significant higher success rate for the first attempt when we increase this threshold. On the other hand side of course the computation time for all boxes will be longer.

3.1.4 Combining methods. In the dataset A we examined the determination of all four unknown parameters (roof height, ground height, gutter width and height) of 30 *saddleback-roof buildings* but without the final adjustment step (cf. Table 1). In this test we applied correlation for the heights and Clustering for the gutter parameters in a predefined strategy. As a result 10 of the buildings were correctly adjusted in the first attempt, 8 buildings required the manual adjustment of 1 parameter only. For 11 buildings we applied the Clustering procedure between 1 and 3 times and we finally needed to adjust between 1 and 3 parameters manually. For one building the procedure did not work at all (cf. saddleback-roof building in Fig. 5).

With the same image material we tested the overall procedure (without fine-adjustment) to determine all five parameters (roof height, ground height, gutter length, width and height) of 10 *hip-roof buildings*. The results show an even better behavior: 6 of the buildings were correctly measured with 1 attempt only, for the remaining 4 buildings, we had to correct 1 parameter (mainly the gutter width) and once to choose another ground point.

A general problem for the height determination either by correlation or the robust techniques are image edges which are parallel to the epipolar lines. In those cases we currently require operator assistance and manual measurement.

The question of operator strategy is still open. When the first automatic attempt fails the operator must decide if he tries the automatic procedure again or if he adapts the

Success	SB	HR
Total	30	10
Correctly adjusted	10	6
Manual adjustment of 1 parameter	8	4
1-3 iterations or 1-3 parameters	11	0
Complete failure	1	0

Table 1: Success rates of combination of parameter estimation tools (Correlation and Clustering/RANSAC) for saddleback-roof buildings (SB) and hip-roof buildings (HR).

missing parameters manually. It is as well a compromise between computation times and time for manual adjustment. There is still a lack of experience to select the optimal strategy.

If the selected model does not fit well to reality the result will be some kind of generalization, which means the operator has to accept it or choose the proper model instead. The optimal way depends of course on the task and the available resolution provided by the image material.

3.2 Efficiency

For the gross acquisition time we monitor the navigation through the image and image pyramids, the model adaptation times and the time for creating the constructive solid geometry tree of building parts. Table 2 shows the increased efficiency in the acquisition process from about 120 seconds to about 40 seconds per primitive, counted as gross acquisition time. With more training on the automation tools and the strategy we expect even better results at least in sub-urban areas.

4 QUANTITATIVE AND QUALITATIVE COMPARISONS

Having buildings extracted by two different methods or at different times or with different operators we need a method to compare the resulting representations and check for completeness. The methodologies for comparison developed so far follow two lines: a quantitative approach and a qualitative approach based on visual inspection. We aim at comparing to ground truth, but due to lack of such information we develop the methods for comparison of measurement procedures of similar accuracy level. In all cases we currently refer to the identical object or to parts of it and take the identification of corresponding objects a given. The current strategy of quality control is directed towards on-line re-measuring selected buildings visualized in the Semi-Automatic System, which would solve the correspondence problem.

4.1 Comparing 2D footprints

First we focus on 2D footprints to develop the methodology for the comparison of two measurements of the footprint of the same building (like in Fig. 8). For a *qualitative* comparison we use an overlay method of 2D polygons presented in a VRML browser for visual inspection. For a *quantitative* comparison we use probability densities to describe the imprecision of measurements and the uncertainty of abstraction based on a method developed to determine topological relationships between imprecise spatial objects from two independent datasets (Winter, 1996). Details of the this approach are given in (Ragia and Winter, 1998). The

Version	Project	Details	Complexity	Primitives	Sec./Primitive
-1995 Hase	Different Areas	Suburban-urban	medium	249	124.8
1996 Hase+	Oedekoven I	Suburban	high	5498	86.4
1996 Hase+	Frankfurt I	Downtown	high	549	111.5
1996 Hase+	Rostock	Urban	high	371	149.6
1997 ObEx0.7.1	Oedekoven III	Suburban	high	525	70.0
1998 ObEx0.8.2	Oedekoven IVsmall	Suburban	medium	29	41.0

Table 2: Increased efficiency due to automation.

distances between the two boundaries along the so called zone-skeleton are computed. The distances characterize the deviation from being equal. The discretized distance function along the special skeleton can be represented as a histogram as shown in Fig. 7 and Fig. 8 (2nd row).

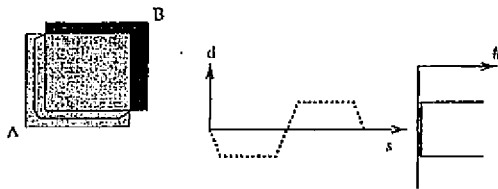


Figure 7: Quantitative comparison of two overlapping areas using an histogram of distances d to the zone-skeleton.

We get values of $d < 0$ for $A \setminus B$ and $d > 0$ for $B \setminus A$, which enables to distinguish between these two cases.

A Gaussian histogram indicates similarity, a bi-modal histogram indicates systematic errors (like translation), and a biased histogram indicates missing or additional parts (abstraction) or gross errors.

An example of a real dataset is given in Fig. 8. We can see that the area of the first measurement (A) contains the area of the second measurement (B) to a large extend (negative d). The second area contains the first one only partly (positive d) and there is a large difference in the form ($d < -0.8m$). It is in principle possible to introduce the different accuracy levels of measurements into the process to improve the method. This method still needs extensive testing, further elaboration and extension to 3D models.

4.2 Comparing 3D models

For a *qualitative* comparison of 3D models from at least two measurements we use the Virtual Reality Modeling Language. The extracted 3D primitives are transformed in VRML format and visualized with a VRML-browser, that allows the 3D viewing and walk- or fly-throughs of the extracted scene. For the 3D visualization of extracted building parts we use different colors and transparency mode to a) detect gross errors in e.g. height measurements and b) to study and visually compare the chosen selection and combination of primitives. Results from three different measurements of the same building are given in Figures 9 and 10. In Fig. 9 we can see a good result with practically the same generalization level and the same parameters in all measurements. In Fig. 10 we have a bad result. One operator had forgotten an essential part of the building complex (box lower left). Also the roof-top height of one part differs by several meters from the other two measurements and the reality. For the inspection of large amounts of data we certainly need a pre-processing step that focus the operator's attention only to the critical cases. Such a method can

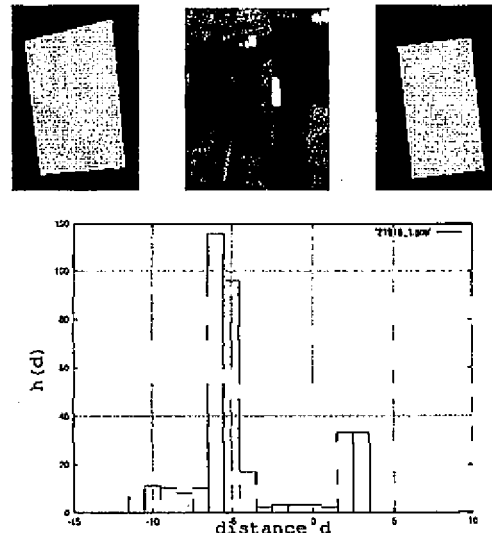


Figure 8: 2D - quantitative comparison of footprints. 1st row: Area (A) Measurement at an Analytical Plotter, Image patch with building, Area (B) Semi-automatic measurement. 2nd row: Histogram of the morphological distances in [dm] between the skeleton and the boundaries of the building from the two measurements (image by courtesy of T-Mobil and Aerowest).

be based on the developed approach described above, but still needs to be designed and implemented.



Figure 9: 3D - qualitative comparison. Good result, as all three measurements differ only slightly.

4.3 Completeness

Concerning the check of completeness of measurements we follow two strategies: (a) the visualization of old measurements in the Semi-Automatic System with the potential of on-line correction or additional measurements by the operator (supported by the automated tools) and (b) a more automated approach based on image matching in urban areas with commercial software and automatic analysis of the

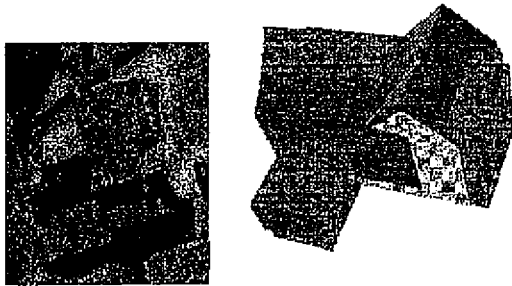


Figure 10: 3D - qualitative comparison. Bad result, as all three measurements differ very much.

resulting digital surface model. Both strategies are currently investigated on two different datasets.

5 CONCLUSIONS

We have presented a prototype system for the efficient semiautomatic extraction of 3D building information from imagery with a high degree of detail in urban and suburban areas. We rely on the human operator to solve the interpretation, but we supply automated tools that efficiently support the interaction. The presented methods for robust estimation of pose and form parameters of volumetric building models from digital imagery have been evaluated on more than 250 buildings. The chosen strategy to support the operator with automated on-line tools seems feasible. From the psychological point of view we believe it is a better way to introduce automation than letting the operator only to correct the results calculated off-line by the computer. Due to the integration in an interaction environment the algorithms can be used and tested even if the success rate of single modules (up to 88%) in suburban areas has not yet reached a status which can be described as "works in nearly all cases". For the saddleback-roof and hip-roof buildings the results of the tests fulfill our expectations. For the box the search strategy should be changed. For this building type the minimum number of parameters which the operator has to give has already been reached. For the saddleback-roof and hip-roof buildings the possibility to reduce the operator action to the measurement of one point exists. To generally increase the success rates for the robust techniques more information sources than only image edges may be necessary.

Besides an initial acquisition of 3D buildings the updating process (change detection) as well as the validation and editing of 3D models derived by other methods will be of increasing importance in the future. We regard the developed system a suitable tool to perform these tasks. With the developed and envisaged methodologies for quality control based on quantitative and qualitative tools we should be able to perform a fast inspection.

The increased efficiency during the development is very promising, but we still lack the empirical comparison of time measurements to classical photogrammetric methods on large datasets. Due to the lack of international tests on a broader basis we currently perform such a test in co-operation with a company.

Our developments show an increased performance in semi-automated building extraction, with the real potential as an easy-to-use measurement and inspection tool.

ACKNOWLEDGEMENTS

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Step 2 is to measure the gutters. See [Roof 1 - Gutter Schematic](#) and see [Roof 1 - Gutter Schematic + Aerial Image](#). Our measurements include only that portion of the perimeter of the roof that is down sloped. The results are presented in tabular format, identifying the length of each gutter section. see [Gutter-Table](#).

Step 3 is to identify each roof face (from a vertical aerial image). Our trained operators consult multiple aerial images to correctly spot the ridgelines. Next, we must measure the faces; since the faces are sloped we need to correct for pitch. (Pitch is determined using a number of proprietary techniques, involving shadows and/or oblique imagery.) see [Roof 1-Face Schematic](#) and see [Roof 1-Face Schematic + Aerial Imagery](#) for a visual description of the measurement process. After measuring the "flat" size of each roof face and correcting for pitch, the face area totals can be summed up as the size of the roof. See [Face-Table-1](#) for a tally of the measurements.

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Step 4 is only performed in the event a [Roof 1](#) Roof is unable to isolate pitch to a specific measurement. In this case, a multi-column spreadsheet is returned - with roof measurements provided for each possible pitch. After a visit to the site, and a 2-minute measurement of roof-pitch from the rafters (no need to climb the roof as [precigeoRoof](#) has determined the face measurement), the appropriate column can be read. See [Face-Table-2](#) for an example of how multi-pitch measurements are provided.

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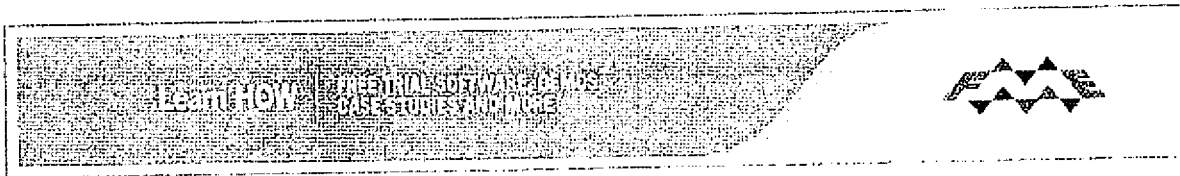
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Microsoft's MSN Virtual Earth: The Map is the Search Platform

By [Adena Schutzberg](#) and [Joe Francica](#) ,
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Microsoft announces its own world.

Microsoft previewed its new search platform, MSN Virtual Earth, at the D Conference ("All things digital") in Carlsbad, California, this week. Most commentators immediately linked the announcement to word from Google last week about an update to Keyhole called Google Earth. It's hard to make a comparison with Google Earth since it's still just a "virtual" virtual world. Virtual Earth is a "real" virtual world, in the sense that Mark Law of the MapPoint Business Unit showed us live code. (Release is expected this summer.) He noted during a demonstration earlier this week that should a programmer tweak something, we might see an error. (We didn't).

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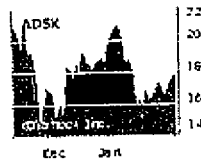
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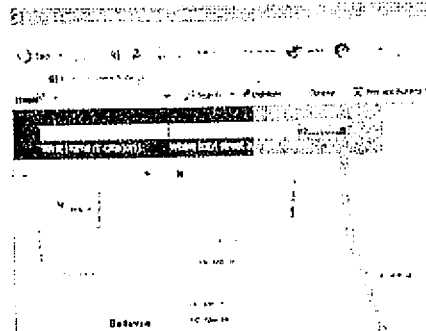
Beginnings

Virtual Earth has been spinning in Internet time, according to Law. The project was literally suggested to Microsoft CEO Bill Gates in a paper by members the MapPoint Business Unit. It was submitted, with many others, to Bill Gates for his annual "Think Week" reading. And, apparently, it came out a winner. The MapPoint Business Unit, with a new member, the TerraServer team, began work on the project in January.

The idea, explained Law, is to reveal the "real earth in a virtual way," a way that was online, searchable and discoverable. He likened it to another "channel" on MSN akin to Entertainment, Money and others. As one geography professor would put it, "Microsoft wants to offer a way to look at the world through geographic eye glasses (as opposed to Entertainment or Money ones.)"

Navigation and Interface

Law and the press



MSN Virtual Earth fills the entire window, "bleeding" to the edge. Note navigation and scale tools. (Click for larger image)

materials released during the week made a big deal out of the "whole screen," "full bleed" nature of Virtual Earth. That simply means the map fills the whole screen and data and dialog boxes all appear "on top" of it. It's not a thumbnail map or a portlet; in Virtual Earth, the user "lives in" the map.

MapPoint maps, which are the core data, have a new look and feel. Panning now operates like Google maps: click and drag and the map moves in real time. Users can scroll the mouse wheel to zoom in and out or use a compass-like "game control" to navigate. As Law put it, "We tapped into things we know how to do here at Microsoft." Indeed.

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The "Scratch Pad" holds locations of interest and can be used to e-mail or blog an itinerary.

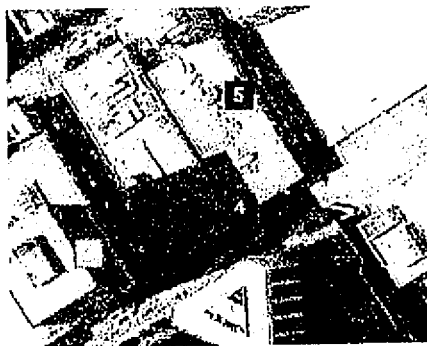
and you can add one or more results to the Scratch Pad. The Scratch Pad itself can be e-mailed or blogged (at MSN Spaces, Microsoft's blogging environment, of course) for reference or to share with friends or family.

Want to do another search on top of the hotel search? Its results overlay the hotels, in a different color. That's very elegant and useful. But it gets better! Pan the map and the searches automatically update in real time for the new geography! That, Law noted, is unique, though we're sure it will not be for long.

Basic routing (with a very "Google-like" interface) will be available in the first release and more advance options, to be introduced later, may include the ability to rearrange stops.

Data

The street maps



Query results can be displayed on a variety of backgrounds

including TerraServer imagery. cartography has been updated from the existing MapPoint look. If you prefer imagery, click on that option and TerraServer USA aerial data appear (black and white and fairly detailed in some areas). Want the best of the map and the imagery? Choose the hybrid option to see the map transparently overlaid on the imagery. Law called this unique, though a "once available" MapQuest

One new innovation is the Scratch Pad, a place to "hold" the locations of interest during a search and discover session. Search on an address, it appears on the Scratch Pad. Search on another, it appears there, too. Search for a hotel near one of the addresses



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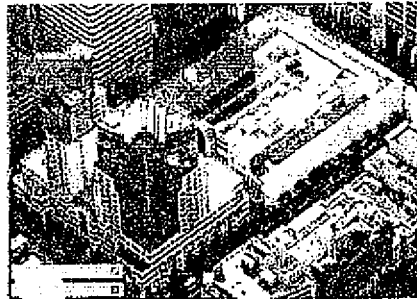
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- ☐ always
- ☐ sometimes
- ☐ only when I travel to interesting places
- ☐ never
- ☐ I don't know what geotagging is

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feature allowed a small map square to hover over the image and update as the mouse panned around. We were impressed by how well the map data matched the imagery - far better than the data we'd seen. Law noted that Microsoft did its own in-house data updates, but no details on the processes were shareable.



Some people, of course, have trouble making sense of

Pictometry's oblique imagery will underlie query results. Image courtesy of Pictometry International Corp. (Click for larger image)

orthoimages, so Microsoft has signed a five year deal with Pictometry to provide oblique images, as well as its 6" orthoimages. The oblique layer is still in development (Microsoft is apparently mosaicking the images in some clever way) so we saw just a still image as an example. In time though, images from four different angles will be available, and the user will be able to "look around" a building or block. Microsoft noted that Pictometry already had captured 132 U.S. counties which cover 10 major urban areas. Others are under development. Law promised that in time the street maps would even snap to the oblique imagery, though that won't be in the first release.

Other data layers are expected after the initial release, including weather and traffic "and ones you've not even thought of," said Law. Also on the horizon: the ability to add your own data layers. In the earlier releases there will be just the ability to annotate locations, however. That perhaps led to Law's comment about Virtual Earth being a "social networking tool based on location."

APIs

It appears as though in the early days, users will be able to share Virtual Earth URLs, much like they do MapPoint URLs. Whether the whole interface will be made available as a service is unclear. According to a statement released by Microsoft:

"The first version of the Virtual Earth Project will include a URL.



The hybrid option shows transparent map features over imagery. (Click for larger image)

parameter API for creating rich links into the Virtual Earth, including support for location-based searches, location lookups, map style selection (including the new labeled aerial imagery) and much more. Future releases of the Virtual Earth will include additional developer support and APIs for integrating Virtual Earth functionality directly in third party Web applications."

Development and Release Plan

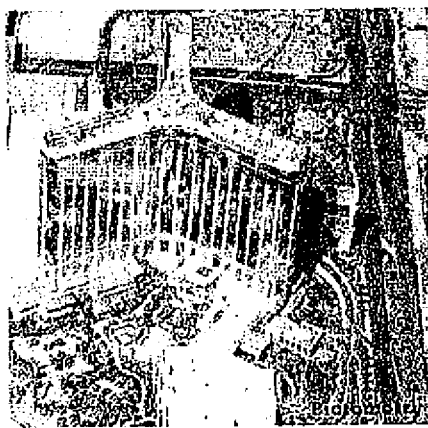
Virtual Earth will debut this summer. Forty-five days later, the first update is expected. Ninety days later, a full new release is expected. Law made it clear the team did not want to wait for 200 enhancements to provide an update, but would put one out even if only two or three were available.

On the Business Side

In this "war of the worlds" between Microsoft and Google, it is the partners, the "little guys," that are supplying the incremental value to the online mapping search portals. In the case of Google, the acquisition of Keyhole was central to the geographic search and display of remotely sensed imagery. In the case of MSN Virtual Earth, Pictometry is providing the unique perspective by allowing access to its library of oblique (and high resolution ortho) aerial imagery. The announcement Monday by Microsoft and Pictometry signals one of these incremental value plays that Microsoft is offering to lure online viewers in hopes of catching Google in the "geosearch" wars. The big prize is advertising revenue. This move might be considered another attempt by Microsoft to dominate the Internet search landscape the way it has won the battles for operating systems and desktop productivity software.

Pictometry's tag line is "See Anywhere, Measure Anything, Plan Everything." Microsoft is getting the "See Anywhere" part. The "measure" or "plan" capabilities remain the purview of Pictometry's proprietary product offerings and will only be available for purchase either through Pictometry

directly at its Pictometry Online website, and likely in the future directly through MSN Virtual Earth. But Microsoft is adding its own twist as well by mosaicking the oblique imagery into a seamless view. Therefore the competitive advantage over Google/Keyhole at this time is a 2.5D view of the landscape. Where Google's imagery looks "flattened" as the viewing angle comes off nadir, the Pictometry view will show the building faces such that you can read the names of the establishments. And now you can see the tie in with advertising. Want to find the nearest Starbucks sequestered among the skyscrapers? No problem.



"This is
hugely

Pictometry's oblique images, like this one of Mandalay Bay in Las Vegas, will soon be a part of MSN Virtual Earth. Image courtesy of Pictometry International Corp. (Click for larger image - 1 Mb file.)

profitable for Pictometry," said Dan Pennacchia, Chief Marketing Officer of Pictometry, referring to the deal with Microsoft. Pictometry, with Microsoft touting its name across the Web, now has the potential to reach beyond its current focus on the local government marketplace to extend to business to business (B2B) opportunities in real estate, insurance and banking. Pictometry already has a relationship with CB Richard Ellis (a commercial real estate developer, a division of Caldwell Banker) and many media firms which look to the company for its ability to provide a perspective view of metro areas.

Microsoft has locked in an advantage with Pictometry's library of imagery. The MSN Virtual Earth deal is an exclusive arrangement with the company. Pictometry can provide its data to no other mapping portal for five years. All 132 counties in the United States that Pictometry has flown, representing approximately 25% of the population, will be available to the MSN Virtual Earth portal, but only about 15 will be available at the time the portal launches. Larger metro areas

such as Los Angeles, New York, Boston, Atlanta, etc. are planned for inclusion in the first release. If there is overlap in cities where Pictometry has already supplied imagery to a city's Web portal (there are but two such situations in the U.S.), Pictometry is working out solutions.

The agreement with Microsoft was a relatively recent adventure for Pictometry. The company hooked up with Microsoft through a mutual colleague in the TerraServer group. Microsoft was looking for other ways to enhance the MapPoint portal. At the same time, Bill Gate's "Think Week" was approaching and the MapPoint group was looking for ways to get Gate's attention. Pictometry executives held a meeting with Microsoft not more than six months ago and that led to this week's announcement.

What's the Fuss?

The big question here is "why?" Why imagery? Why oblique imagery? Why seamless aerial views? Why are the search wars all of a sudden looking to mapping technology? Believe it or not, the answer is simply money. In the search wars, Pennacchia noted that one or two marketshare points means millions of dollars in advertising. When you can not only put a dot on the map to show where the Starbucks is, but also show a picture of the sign in front of the store to let you know you have the right building, that's a unique competitive advantage.

And that's just if you were searching online. What about the location-based service from a Sprint, Nextel, Cingular or Verizon Wireless phone? You're walking down the street and your GPS-equipped cell phone shows you an image of the store. That's a unique competitive advantage. And what if you are driving on unfamiliar streets looking to establish a little cache with the new office crew by bringing them some Krispy Kremes? Up pops the image map on your in-vehicle Internet portal. Donuts found! That's a unique competitive advantage.

Microsoft described the opportunity with Pictometry this way: "MSN Virtual Earth sets forth a new search frontier that extends traditional local searching into a deeply immersive search experience, where consumers see what it's like to be in a location and explore what they can do there. The unique aerial imagery from Pictometry enables Microsoft to deliver a one-of-a-kind immersive local search experience for our customers."

In short, it's all about branding, both from Microsoft's and Pictometry's perspective. Microsoft establishes "a unique competitive advantage;" Pictometry becomes known to a completely new audience to offer its products and services in both the B2B and business to consumer markets. Watch this space.

Your Comments

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Nadir vs. zenith (#1)

by Matteo Luccio, GIS Monitor and Earth Observation Magazine

Date: May 26, 2005 02:38 AM

Adena, Joe:

You wrote: "Google's imagery looks 'flattened' as the viewing angle comes off nadir ..." Didn't you mean zenith?

Best,

Matteo

Virtual Earth (#2)

by Clyde Spencer, Ball Aerospace & Technologies

Date: May 26, 2005 12:16 PM

You didn't mention NASA's World Wind. Are you familiar with it? If not, you might want to go to <http://worldwind.arc.nasa.gov/download.html> and check it out.
Clyde Spender

Nadir vs. Zenith Response (#3)

by Joe Frandca, Directions Magazine

Date: May 26, 2005 13:08 PM

Hi Matteo:

I refer your question about the definition of Nadir vs. Zenith to that given by the Canadian Center for Remote Sensing Glossary of remote sensing terms:

http://dweb.ccrs.nrcan.gc.ca/ccrs/db/glossary/frames_e.cfm?&GlossID=2805

This definition states, "Nadir can be both a point and a line. It is the point on the ground vertically beneath the sensor. In other words, when a straight line is drawn between the sensor and the centre of the Earth, the nadir is the point where that line intersects the surface of the Earth. When the contiguous nadir points are joined along the ground, they form the nadir line."

And also this clarification: "in photography, there are two nadir points. The first is on the ground, which is the point on the ground directly underneath the camera. The second point is the photographic nadir which is the point on the photograph at the end of a vertical line from the ground nadir."

So, as you come "off nadir", in this case the nadir line,

you are changing the viewing angle of instrument recording the image. In truth, I suspect the point above the nadir where the instrument is recording the image would be generically defined as the "zenith", but as an "old remote sensor" I never heard it referred to in those terms. See the reference above and let us know how you interpret the definition.

map.search.ch as inspiration? (#4)

by Bernhard Seefeld, search.ch

Date: May 26, 2005 14:27 PM

Given the timing (proposal in January) and some part of the functionality, it seems like <http://map.search.ch>, which launched last October, might have been one of the inspirations for the proposal. Which, reading the selection procedure, is of course a very nice compliment for the development team!

No Subject (#5)

by Frustrated, NoDoz

Date: May 26, 2005 15:02 PM

Why is MSN doing MSN Virtual Earth? The same reason Google is doing location hits. Read Tim Draper's interview with Eric Schmidt:

http://www.alwayson-network.com/comments.php?id=P7971_0_4_0_C

Where will the revenue come from? What segment? The answer lies in studying MapQuest's ad revenue versus enterprise business revenue.

Nadir vs. zenith (#6)

by Matteo Luccio, GIS Monitor and Earth Observation Magazine

Date: May 30, 2005 20:00 PM

Joe,

Thanks for your response. I was using the standard astronomical definition of nadir and zenith. For example: "A line dropped from your zenith, through your geographic position, and consequently through the earth's center, intercepts the celestial sphere on the opposite side of your zenith. This point of intersection on the other side of the celestial sphere is the nadir of your zenith. Nadir represents the lowest point relative to your position, while zenith represents the highest." Warren Norville, *Celestial Navigation*, 2nd Ed. (Camden, Maine: International Marine Publishing Company, 1984).

I wasn't familiar with the definition of nadir as a line. That's good to know, but not relevant to our particular discussion. As for the two nadir points in photography, I am totally mystified by the second sentence: "The second point is the photographic nadir, which is the point on the photograph at the end of a vertical line from the ground nadir." I assume that by "vertical line" it means a line that passes through the camera's position on Earth's surface and the geometric center of the planet. I also assume that "at the end" means on

the other side of Earth from the camera. But what does "on the photograph" mean? Literally visible on the photograph or virtual/implied?

Thanks,

Matteo

Nadir vs. zenith (#7)

by Matteo Luccio, GIS Monitor and Earth Observation Magazine

Date: May 30, 2005 22:16 PM

Joe, Adena,

It occurs to me that the whole issue boils down to this: by using the term nadir you are referring to the position of the camera's target, directly underneath the camera, rather than the position of the camera. Here's an example in which it is used the same way:

<http://www.imagesatintl.com/default.asp?catid={C3836EEE-A141-4314-9E7D-B137378069F5}>

Thanks,

Matteo

developers interview on channel 9 (#8)

by chippy,

Date: June 2, 2005 11:38 AM

You may be interested in a channel 9 interview with the developers of virtual earth - and discussions of future 130mb wmv

http://download.microsoft.com/download/6/4/a/64a8e731-6cf5-4609-999c-1da1c2767040/virtual_earth_2005_channel9_video.wmv



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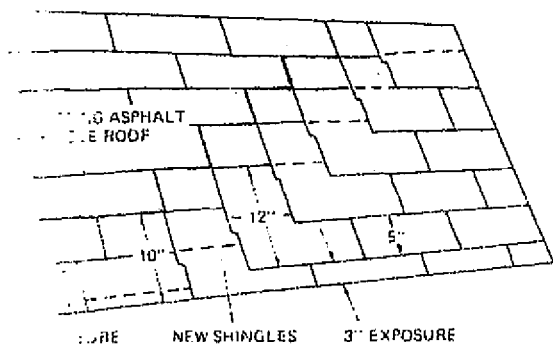


Fig. 5-9 Exposure is the distance between the exposed edges of shingles.

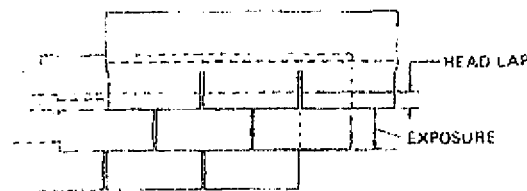


Fig. 5-10 Head lap and top lap.

Limitations are shown in Fig. 5-11. Any shingle may be used on roofs with normal slopes. Normal is rise or more per horizontal foot. An exception is for square-butt strip shingles. They may be used if the pitch is less than 4 inches per foot, it is used on roll roofings. In the range of 4 inches down to 2 inches per foot, the following rules apply:

Roll roofing may be applied by the exposed nail method if the pitch is not lower than 2 inches per

- Roll roofings applied by the concealed nail method may be used on pitches down to, but not below, 1 inch per foot. This is true if (1) they have at least 3 inches of top lap, and (2) they have double coverage roofing with a top lap of 19 inches.

Any of the above may be applied on a deck with a pitch steeper than the stated minimum. Pitch is given as a fraction. For example, a roof has a rise of 8 feet and a run of 12 feet. Then its pitch is

$$\frac{8}{2 \times 12} \text{ or } \frac{8}{24} \text{ or } \frac{1}{3}$$

Pitch is equal to the rise divided by 2 times the run. Or

$$\text{Pitch} = \frac{\text{rise}}{2 \times \text{run}}$$

Slope

Slope is how fast the roof rises from the horizontal. See Fig. 5-12. Slope is equal to the rise divided by the run. Or

$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

Slope and *pitch* are often used interchangeably. However, you can see there is a difference. Some roofers' manuals use them as if they were the same.

Before a roof can be applied, you have to know how many shingles are needed. This calls for estimating the area to be covered. First determine the number of square feet. Then divide the number of square feet by 100 to produce the number of squares needed.

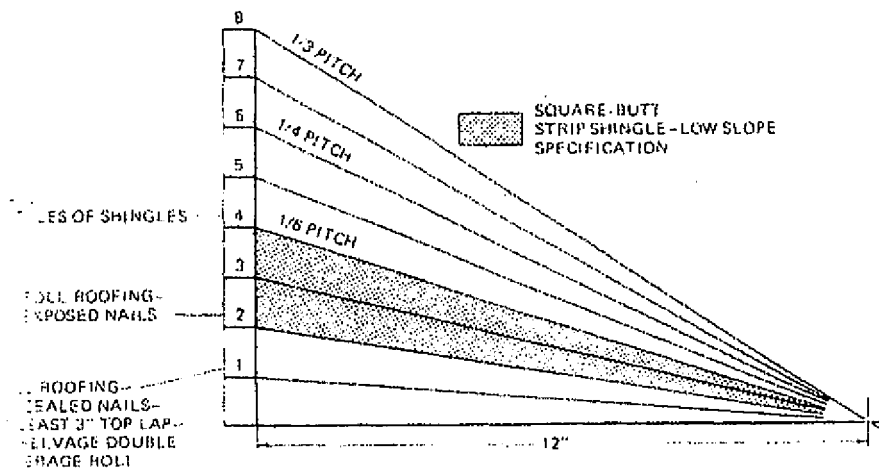
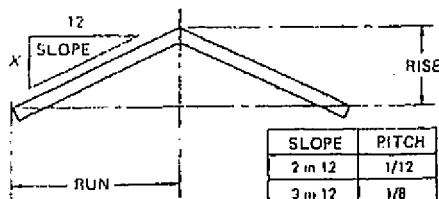


Fig. 5-11 Minimum pitch requirements for different asphalt roofing products.



Assume:
Rise = 4'; Run = 12'

Slope: 4 in 12 or 4 in 12

Pitch: $\frac{4}{12} = \frac{1}{3}$

SLOPE	PITCH
2 in 12	1/6
3 in 12	1/4
4 in 12	1/3
5 in 12	5/24
6 in 12	1/2
7 in 12	7/24
8 in 12	2/3
10 in 12	5/6
12 in 12	1

Slope = $\frac{\text{rise}}{\text{run}}$

Pitch = $\frac{\text{rise}}{2 \times \text{run}}$

Fig. 5-12 Slope, pitch, and run of a roof.

ESTIMATING ROOFING QUANTITIES

Roofing is estimated and sold in squares. A square of roofing is the amount required to cover 100 square feet. To estimate the required amount, you have to compute the total area to be covered. This should be done in square feet. Then divide the amount by 100. This determines the number of squares needed. Some allowance should be made for cutting and waste. This allowance is usually 10 percent. If you use 10 percent for waste and cutting, you will have the correct number of shingles. A simple roof with no dormers will require less than 10 percent.

Complicated roofs will require more than 10 percent for cutting and fitting.

Estimating Area

The areas of simple surfaces can be computed easily. The area of the shed roof in Fig. 5-13 is the product of the eave line and the rake line ($A \times B$). The area of the simple gable roof in Fig. 5-13 equals the sum of the two rakes B and C multiplied by the eave line A . A gambrel roof is estimated by multiplying rake lines A , B , C , and D by eave line E . See Fig. 5-13.

Complications arise in roofs such as the one in Fig. 5-14. Ells, gables, or dormers can cause special problems. Obtain the lengths of eaves, rakes, valleys, and ridges from drawings or sketches. Measuring calls for dangerous climbing. You may want to estimate without climbing. To do this:

1. The pitch of the roof must be known or determined.
2. The horizontal area in square feet covered by the roof must be computed.

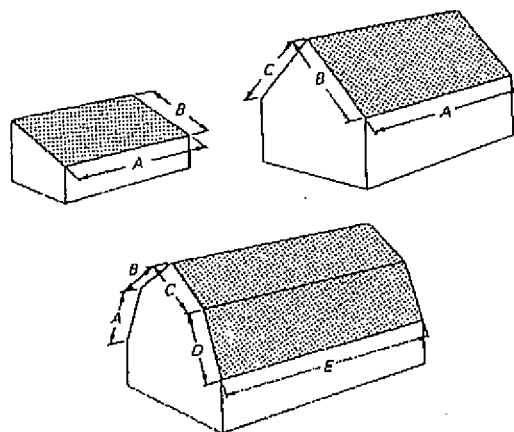


Fig. 5-13 Simple roof types and their dimensions: Shed, gable, and gambrel. (Red and Son)

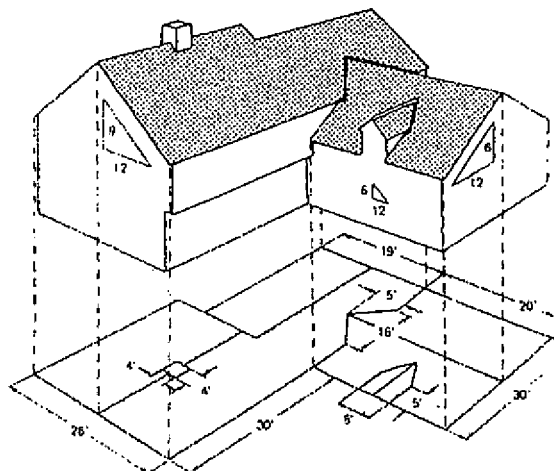


Fig. 5-14 Complicated dwelling roof shown in perspective, plan views. (Red and Son)

Pitch is shown in Fig. 5-15. The pitch of a roof is stated as a relationship between rise and span. If the span is 24'0" and the rise is 8'0", the pitch will be 8/24 or 1/3. If the rise were 6'0", then the pitch would be 6/24 or 1/4. The 1/4-pitch roof rises 8 inches per foot of horizontal run. The 1/2-pitch roof rises 6 inches per foot of run.

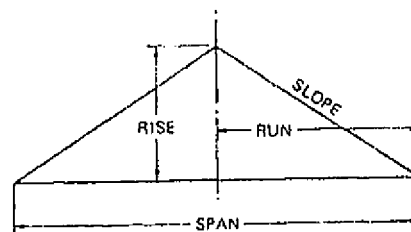
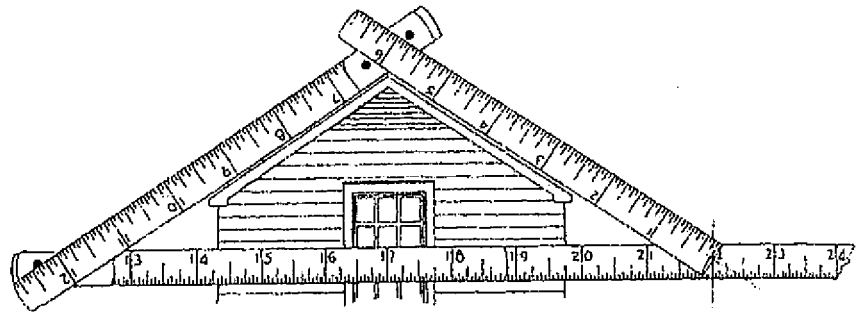
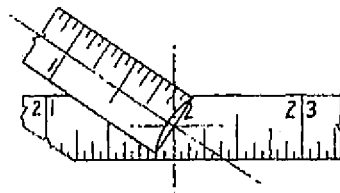


Fig. 5-15 Pitch relations.

Fig. 5-16 Using the carpenter's rule to find the roof pitch. (BNA and SNA)



You can determine the pitch of any roof without going onto the ground. Use a carpenter's folding rule in the following manner:
 1. Form a triangle with the rule. Stand across the road from the building. Hold the rule at arm's length. Align the roof slope with the sides of the triangle. Be sure that the base of the triangle is held horizontal. It will appear within the triangle as shown in Fig. 5-16. Take a reading on the base section of the rule. Note the reading point shown in Fig. 5-17. Locate in the top line, headed *Rule Reading* in Fig. 5-18, the point nearest your reading. Below this point is the pitch and the rise per foot of run. Here the reading on the rule is 22. Under 22 in Fig. 5-18, the pitch is designated as a rise of 8 inches per foot of horizontal run.



READING POINT

Fig. 5-17 Reading the carpenter's rule to find the point needed to find the pitch. (BNA and SNA)

Horizontal Area

Figure 5-14 is a typical dwelling. The roof has valleys, dormers, and variable-height ridges. Below the perspective the total ground area is covered by the roof. All measurements needed can be made from the ground. Or they can be made within the attic space of the house. No climbing on the roof is needed.

Computation of Roof Areas

Make all measurements. Draw a roof plan. Determine the pitches of the various elements of the roof. Use the carpenter's rule. The horizontal areas can now be quickly worked out.

Include in the estimate only those areas having the same pitch. The rise of the main roof is 9 inches per foot. That of the ell and dormers is 6 inches per foot.

The horizontal area under the 8-inch-slope roof will be

$$\begin{aligned} 26 \times 30 &= 780 \text{ square feet} \\ 19 \times 30 &= 570 \text{ square feet} \\ \text{Total} &= 1350 \text{ square feet} \end{aligned}$$

Less

$$\begin{aligned} 8 \times 5 &= 40 \text{ (triangular area under ell roof)} \\ 4 \times 4 &= 16 \text{ (chimney)} \\ \hline &= 56 \text{ square feet} \end{aligned}$$

$$1350 - 56 = 1294 \text{ square feet total}$$

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The area under the 6-inch-rise roof will be

$$20 \times 30 = 600 \text{ square feet}$$

$$8 \times 5 = \frac{40}{640} \text{ (triangular area projecting over the main house)}$$

Duplications

Sometimes one element of a roof projects over another. Add duplicated areas to the total horizontal area. If the eaves in Fig. 5-14 project only 4 inches, there will be

1. A duplication of 2 ($7 \times \frac{1}{2}$) or $4\frac{1}{2}$ square feet under the eaves of the main house. This is where they overhang the rake of the ell section.
2. A duplication under the dormer eaves of 2 ($5 \times \frac{1}{2}$) or $3\frac{1}{2}$ square feet.

3. A duplication of $9\frac{1}{2} \times 1$ or $9\frac{1}{2}$ square feet under the eaves of the main house. This is where they overhang the rake of the ell section.

The total is 11 $\frac{1}{2}$ or 12 square feet. Item 2 should be added to the area of the 6-inch-pitch roof. Items 1 and 3 should be added to the 9-inch-pitch roof. The new totals will be 640 + 4 or 644 for the 6-inch pitch and 1294 + 8 or 1302 for the 9-inch pitch.

Converting Horizontal to Slope Areas

Now convert horizontal areas to slope areas. Do this with the aid of the *conversion table*, Table 5-1. Horizontal areas are given in the first column. Corresponding slope areas are given in columns 2 to 12.

The total area under the 9-inch rise is 1302 square feet.

Table 5-1 Conversion Table

Rise, Inches per Foot of Horizontal Run	1	2	3	4	5	6	7	8	9	10	11	12
Pitch, Fractions	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{1}{8}$	$\frac{1}{6}$	$\frac{5}{24}$	$\frac{1}{4}$	$\frac{7}{24}$	$\frac{1}{3}$	$\frac{3}{8}$	$\frac{5}{12}$	$\frac{11}{24}$	$\frac{1}{2}$
Conversion Factor	1.004	1.014	1.031	1.054	1.083	1.118	1.157	1.202	1.250	1.302	1.356	1.414
Horizontal area in square feet or length in feet												
1	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4
2	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.7	2.8
3	3.0	3.0	3.1	3.2	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2
4	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.0	5.2	5.4	5.7
5	5.0	5.1	5.2	5.3	5.4	5.6	5.8	6.0	6.3	6.5	6.8	7.1
6	6.0	6.1	6.2	6.3	6.5	6.7	6.9	7.2	7.5	7.8	8.1	8.5
7	7.0	7.1	7.2	7.4	7.6	7.8	8.1	8.4	8.8	9.1	9.5	9.9
8	8.0	8.1	8.3	8.4	8.7	8.9	9.3	9.6	10.0	10.4	10.8	11.3
9	9.0	9.1	9.3	9.5	9.7	10.1	10.4	10.8	11.3	11.7	12.2	12.7
10	10.0	10.1	10.3	10.5	10.8	11.2	11.6	12.0	12.5	13.0	13.6	14.1
20	20.1	20.3	20.6	21.1	21.7	22.4	23.1	24.0	25.0	26.0	27.1	28.3
30	30.1	30.4	31.0	31.6	32.5	33.5	34.7	36.1	37.5	39.1	40.7	42.4
40	40.2	40.6	41.2	42.2	43.3	44.7	46.3	48.1	50.0	52.1	54.2	56.6
50	50.2	50.7	51.6	52.7	54.2	55.9	57.8	60.1	62.5	65.1	67.8	70.7
60	60.2	60.8	61.9	63.2	65.0	67.1	69.4	72.1	75.0	78.1	81.4	84.8
70	70.3	71.0	72.2	73.8	75.8	78.3	81.0	84.1	87.5	91.1	94.9	99.0
80	80.3	81.1	82.5	84.3	86.6	89.4	92.6	96.2	100.0	104.2	108.5	113.1
90	90.4	91.3	92.8	94.9	97.5	100.6	104.1	108.2	112.5	117.2	122.0	127.3
100	100.4	101.4	103.1	105.4	108.3	111.8	115.7	120.2	125.0	130.2	135.6	141.4
200	200.8	202.8	205.2	210.8	216.6	223.6	231.4	240.4	250.0	260.4	271.2	282.6
300	301.2	304.2	309.3	316.2	324.9	335.4	347.1	360.6	375.0	390.6	406.8	424.2
400	401.6	405.6	412.4	421.6	433.2	447.2	462.8	480.8	500.0	520.8	542.4	565.6
500	502.0	507.0	515.5	527.0	541.5	559.0	578.5	601.0	625.0	651.0	678.0	707.2
600	602.4	608.4	618.6	632.4	649.8	670.8	694.2	721.2	750.0	781.2	813.6	848.4
700	702.8	709.8	721.7	737.8	758.1	782.6	809.9	841.4	875.0	911.4	949.2	989.6
800	803.2	811.2	824.8	843.2	864.4	889.4	925.6	961.6	1000.0	1041.6	1084.8	1131.2
900	903.6	912.6	927.8	948.6	974.7	1006.2	1041.3	1081.8	1125.0	1171.8	1220.4	1272.6
1000	1004.0	1014.0	1031.0	1054.0	1083.0	1118.0	1157.0	1202.0	1250.0	1302.0	1356.0	1414.0

Under the column headed 9 (for 9-inch rise) on conversion table is found:

	<i>Horizontal Area</i>		<i>Slope Area</i>
Opposite	1000	is	1250.0
Opposite	300	is	375.0
Opposite	00	is	00.0
Opposite	<u>2</u>	is	<u>2.5</u>
Totals	1302		1627.5

The total area under the 6-inch rise is 644 square feet.

	<i>Horizontal Area</i>		<i>Slope Area</i>
Opposite	600	is	670.8
Opposite	40	is	44.7
Opposite	<u>4</u>	is	<u>4.5</u>
Totals	644		720.0

The total area for both pitches is $1627.5 + 720 = 2347.5$ square feet.

Now, add a percentage for waste. This should be 10 percent. That brings the total area of roofing required to 2582 square feet. Divide 2582 by 100 and get 25.82 or, rounded, 26 squares.

One point about this method should be emphasized. The method is possible because of one fact. For any given horizontal area, at a given pitch, a roof will always contain the same number of square feet regardless of its design. A shed, a gable, and a hip roof, with or without dormers, will each require exactly the same square footage of roofing—that is, if each is spread over the same horizontal area with the same pitch.

Accessories

Quantities of starter strips, edging strips, ridge shingles, and valley strips all depend upon linear measurements. These measurements are taken along the eaves, the ridge, and valley. Eaves and ridge are horizontal. The rakes and valleys run on a slope. Quantities for the horizontal elements can be taken off the roof plan. True length of rakes and valleys must be taken from conversion tables.

LENGTH OF RAKE

Determine the length of the rake of the roof. Measure the horizontal distance over which it extends. In this case the rakes on the ends of the main house span dis-

tances are 26 and 19 feet. More rake footage is $26 + 19 + 13 + 3\frac{1}{2} = 61\frac{1}{2}$ feet.

Refer to Table 5-1 under the 9-inch-rise column. Opposite the figures in column 1 find the length of the rake.

	<i>Horizontal Run</i>	<i>Length of Rake</i>
	60	75.00
	1	1.3
	<u>0.5</u>	<u>0.6</u>
Totals	61.5	76.9 (actual length of the rake)

Use the same method and apply it to the rake of the ell. This will indicate its length, including the dormer, to be 39.1 inches. Add these amounts to the total length of eaves. The figure obtained can be used for an estimate of the amount of edging needed.

Hips and Valleys

Hip-and-valley lengths can be determined. Use the run off the common rafter. Then refer to the hip-and-valley table, Table 5-2.

Common rafter run is one-half the horizontal distance that the roof spans. This determines the length of a valley. The run of the common rafter should be taken at the lower end of the valley.

Figure 5-14 shows the portion of the ell roof that projects over the main roof. It has a span of 16 feet at the lower end of the valley. Therefore, the common rafter at this point has a run of 8'0".

There are two valleys at this roof intersection. Total run of the common rafter is 16'0". Refer to Table 5-2. Opposite the figures in the column headed *Horizontal*, find the linear feet of valley. Then check the column under the pitch involved.

One of the intersecting roofs has a rise of 6 inches. The other has a rise of 9 inches. Length for each rise must be found. The average of the two is then taken. This gives a close approximation of the true length of the valley.

Thus,

<i>Horizontal</i>	<i>6-inch rise</i>	<i>9-inch rise</i>
10	15	16
<u>6</u>	<u>9</u>	<u>9.6</u>
16	24	25.6

$$24 + 25.6 = 49.6$$

$$49.6 \div 2 = 24.8 \text{ length of valleys}$$

Table 5-2 Hip-and-Valley Conversions

Rise, Inches per Foot of Horizontal Run	4	5	6	7	8	9	10	11	12	14	16	18
Pitch { Degrees Fractions	18°26' 1/6	22°37' 5/24	26°34' 1/4	30°16' 7/24	33°41' 1/3	36°52' 3/8	39°48' 5/12	42°31' 11/24	45° 1/2	49°24' 7/12	53°8' 2/3	56°19' 3/4
Conversion Factor	1.452	1.474	1.500	1.524	1.564	1.600	1.642	1.684	1.732	1.814	1.944	2.062
Horizontal Length in Feet												
1	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.8	1.9	2.1
2	2.9	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.9	4.1
3	4.4	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2	5.4	5.8	6.2
4	5.8	5.9	6.0	6.1	6.3	6.4	6.6	6.7	6.9	7.3	7.8	8.2
5	7.3	7.4	7.5	7.6	7.8	8.0	8.2	8.4	8.7	9.1	9.7	10.3
6	8.7	8.8	9.0	9.1	9.4	9.6	9.9	10.1	10.4	10.9	11.7	12.4
7	10.2	10.3	10.5	10.7	10.9	11.2	11.5	11.8	12.1	12.7	13.6	14.4
8	11.6	11.8	12.0	12.2	12.5	12.8	13.1	13.5	13.9	14.5	15.6	16.5
9	13.1	13.3	13.5	13.7	14.1	14.4	14.8	15.2	15.6	16.3	17.5	18.6
10	14.5	14.7	15.0	15.2	15.6	16.0	16.4	16.8	17.3	18.1	19.4	20.6
20	29.0	29.5	30.0	30.5	31.3	32.0	32.8	33.7	34.6	36.3	38.9	41.2
30	43.6	44.2	45.0	45.7	46.9	48.0	49.3	50.5	52.0	54.4	58.3	61.9
40	58.1	59.0	60.0	61.0	62.6	64.0	65.7	67.4	69.3	72.6	77.8	82.0
50	72.6	73.7	75.0	76.2	78.2	80.0	82.1	84.2	86.6	90.7	97.2	103.1
60	87.1	88.4	90.0	91.4	93.8	96.0	98.5	101.0	103.9	108.8	116.6	123.7
70	101.6	103.2	105.0	106.7	109.5	112.0	114.9	117.9	121.2	127.0	136.1	144.2
80	116.2	117.9	120.9	121.9	125.1	128.0	131.4	134.7	138.6	145.1	155.5	165.0
90	130.7	132.7	135.0	137.2	140.8	144.0	147.8	151.6	155.9	163.3	175.0	185.6
100	145.2	147.4	150.0	152.4	156.4	160.0	164.2	168.4	173.2	181.4	194.4	206.2

Dormer Valleys

The run of the common rafter at the dormer is 2.5 feet. Check Table 5-2. It is found that:

Horizontal	6-inch rise
2.0	3.0
0.5	0.75
2.5	3.75 (length of valley)

Two such valleys will total 7.5 feet.

The total length of valley will be $24.8 + 7.5 = 32.3$ feet. Use these figures to estimate the flashing material required.

ROOFING TOOLS

Most roofing tools are already in the carpenter's toolbox. Tools needed for roofing are shown in Fig. 5-19.

Roof brackets Can be used to clamp onto a ladder.

Ladders A pair of sturdy ladders with ladder jacks are needed. Shingles are placed on the roof using a hoist on the delivery truck. These ladders come in handy for side roofing.

Staging These are planks for the ladder jacks. They hold the roofer or shingles. They are very useful on mansard roof jobs.

Apron The carpenter's apron is very necessary. It holds the nails and hammer. Other small tools can go into it. It saves time in many ways. It keeps necessary tools handy.

Hammer The hammer is a necessary device for roofing. It should be a balanced hammer for less wrist fatigue.

Chalk and line This combination is needed to set guidelines. Shingles need alignment. The chalk line is needed to make sure the shingles line up.

Tin snips Heavy-duty tin snips are needed for trimming flashing. They can also be used for trimming shingles.

Kerosene A cleaner is needed to remove tar from roofs. Asphalt from shingles can be removed from tools with kerosene.

Tape measure A roofer has to make many measurements. This is a necessary tool.

Utility knife A general-purpose knife is needed for close trimming of shingles.

Putty knife This is used to spread roofing cement.

Carpenter's rule This makes measurements and serves to determine the pitch of a roof. See Fig. 5-1.

Stapler Some new construction roofing can be done with a stapler. This device replaces the hammer and nails.

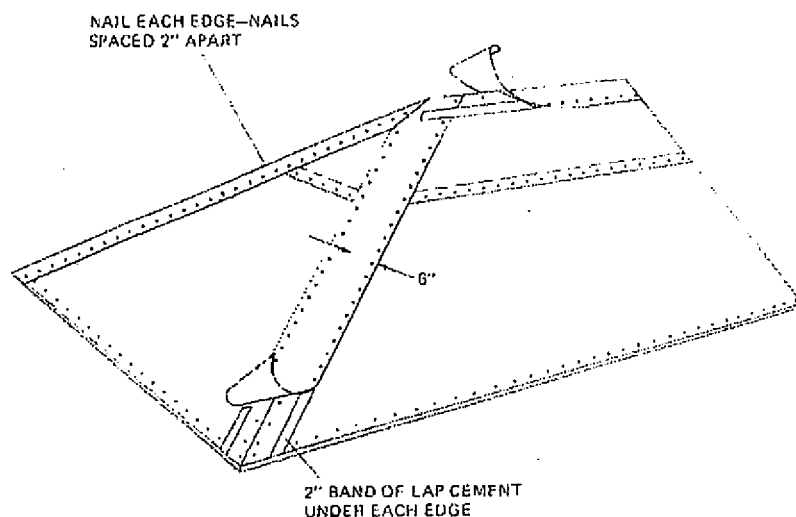


Fig. 5-78 Hip-and-ridge application of roll roofing.

shingles. Then the western United States discovered the cedar shingle. It is resistant to water and rot. If properly cared for, it will last at least 50 years. Application of this type of roofing material calls for some different methods.

Sizing Up the Job

You need to know a few things before ordering these shingles. First, find the pitch of your roof. See Fig. 5-79. Simply measure how many inches it rises for every foot it runs.

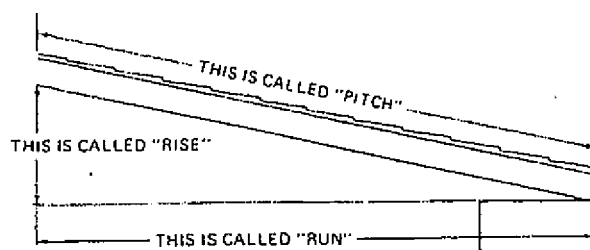


Fig. 5-79 Figuring the pitch of a roof. (Roof Grade System, 6:12, 12:12, 12:16, 12:24, etc.)

Remember that a square contains four bundles. It will cover 100 square feet of roof area. See Fig. 5-80.

Roof Exposure

Exposure refers to the area of the shingle that contacts the weather. See Fig. 5-81. Exposure depends upon roof pitch. A good shingle job is never less than three layers thick. See Table 5-6 for important information about shingles.

There are three lengths of shingles: 16 inches, 18 inches, and 24 inches.

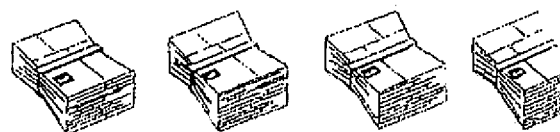
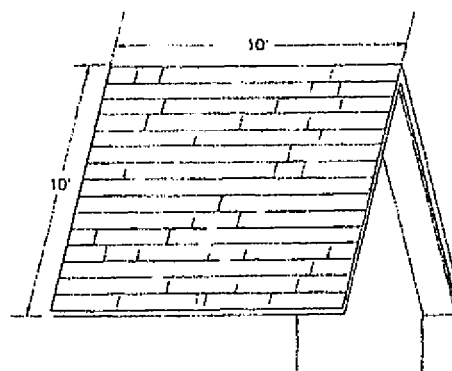


Fig. 5-80 A square of shingle contains four bundles. (Shingle & Nails and Spikes Bundles)

If the roof pitch is 4 inches in 12 inches or steeper (three-ply roof):

- For 16-inch shingles, allow a 5-inch exposure.
- For 18-inch shingles, allow a 5½-inch exposure.
- For 24-inch shingles, allow a 7-inch exposure.

If the roof pitch is less than 4 inches in 12 inches but not below 3 inches in 12 inches (four-ply roof):

- For 16-inch shingles, allow a 3½-inch exposure.
- For 18-inch shingles, allow a 4½-inch exposure.
- For 24-inch shingles, allow a 5½-inch exposure.

If the roof pitch is less than 3 inches in 12 inches, cedar shingles are not recommended. These exposures

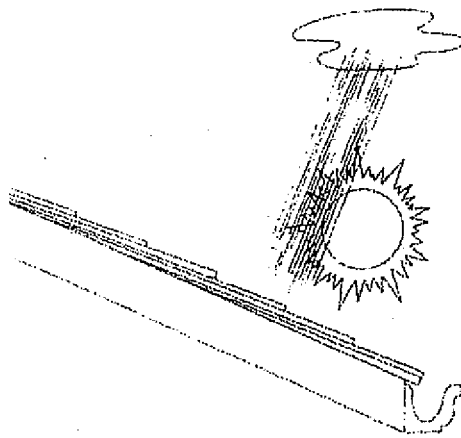


Fig. 5-81 Shingle exposure to the weather.

are for no. 1 grade shingles. In applying no. 3 shingles, make sure you check with the manufacturer.

Estimating Shingles Needed

Determine the ground area of your house. Include the eaves and cornice overhang. Do this in square feet. If the roof pitch found previously:

- Rises 3 in 12, add 3 percent to the square foot total.
- Rises 4 in 12, add 5 percent to the square foot total.
- Rises 5 in 12, add 8 percent to the square foot total.
- Rises 6 in 12, add 12 percent to the square foot total.
- Rises 8 in 12, add 20 percent to the square foot total.
- Rises 12 in 12, add 42 percent to the square foot total.

Table 5-6 Summary of Sizes, Packing, and Coverage of Wood Shingles

Shake Type, Length, and Thickness, Inches	No. of Courses per Bundle	No. of Bundles per Square	Approximate Coverage (in Square Feet) of One Square, When Shakes are Applied with 1/2-Inch Spacing, at Following Weather Exposures (in Inches):									
			5 1/2	6 1/2	7	7 1/2	8 1/2	10	11 1/2	14	16	
18 x 1/2 medium resawn	9/9*	5*	55'	65	70	75*	85*	100'				
18 x 3/4 heavy resawn	9/9*	5*	55'	65	70	75*	85*	100'				
24 x 3/8 handsplit	9/9*	5		65	70	75*	85	100'	115'			
24 x 1/2 medium resawn	9/9*	5		65	70	75*	85	100'	115'			
24 x 3/4 heavy resawn	9/9*	5		65	70	75*	85	100'	115'			
24 x 1/2 to 3/4 lapersplit	9/9*	5		65	70	75*	85	100'	115'			
18 x 3/4 true-edge straight-split	14* straight	4								100	112	
18 x 3/4 straight-split	19* straight	5	65	75	80	90*	100'					
24 x 3/4 straight-split	16* straight	5		65	70	75*	85	100'	115'			
15 starter-finish course	9/9*	5	Use supplementary with shakes applied with not over 10-inch weather exposure.									

*Packed in 18-inch-wide frames

*Five bundles will cover 100 square feet of roof area when used as starter-finish course at 10-inch weather exposure; six bundles will cover 100 square feet wall area when used at 8 1/2-inch weather exposure; seven bundles will cover 100 square feet roof area when used at 7 1/2-inch weather exposure.

*Maximum recommended weather exposure for three-ply roof construction

*Maximum recommended weather exposure for two-ply roof construction: seven bundles will cover 100 square feet of roof area when applied at 7 1/2-inch weather exposure.

*Maximum recommended weather exposure for sidewalk construction: six bundles will cover 100 square feet when applied at 8 1/2-inch weather exposure.

*Maximum recommended weather exposure for starter-finish course application: five bundles will cover 100 square feet when applied at 10-inch weather exposure.

*Maximum recommended weather exposure for application on roof pitches between 4 in 12 and 8 in 12

*Maximum recommended weather exposure for application on roof pitches of 8 in 12 and steeper

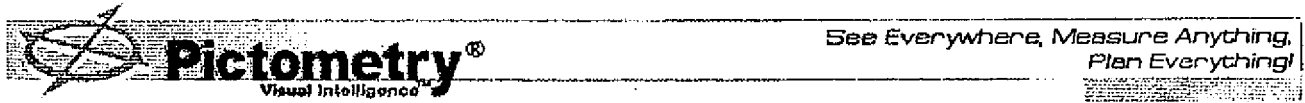
*Maximum recommended weather exposure for single-coursed wall construction

*Maximum recommended weather exposure for two-ply roof construction

*Packed in 20-inch-wide frames

*Maximum recommended weather exposure for double-coursed wall construction

*All coverage based on 12-inch spacing between shakes



PRESS RELEASES

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**Pictometry Announces Software and Web-based Solution for
Engineers, Architects, and Planners**

Software Provides On-Screen Measurements of Buildings and Properties On High-Resolution Oblique and
Orthogonal Digital Images; Web Site Provides Access to Image Database

ROCHESTER, NY – January 22, 2004 – Pictometry International Corp., maker of the world's leading information system that incorporates georeferenced oblique and orthogonal aerial imaging software, announced today the availability of its Pictometry Online™ web site for engineering, architectural, and planning firms.

Pictometry Online is a fee-based service that enables registered firms to research, select, and purchase high-resolution aerial images from its web site database that has over one and a half million images of leading municipal centers. The high-resolution georeferenced images, along with Pictometry software, enable engineers, architects, and planners to view, measure, and plan on up to 12 different views of every square foot in their community. Applications for Pictometry Online include helping firms save time and resources by pre-inspecting sites for new projects before sending out surveyors and inspection crews, as well as conducting preliminary site measurements without leaving the office. Pictometry images can also be incorporated with leading third-party design software and GIS solutions that enhance project concepts to clients in a way that is more visually compelling and easier to understand.

A number of firms are already using the web site and software. "We consider our firm to be very progressive when it comes to adopting new tools that will not only help our clients better understand the projects we are working on for them, but also help us reduce expenses and shorten the time to completion," said Kenneth Cummings of Parrone Engineering in Rochester, NY. "Our CEO immediately saw the value that Pictometry could bring to us, and we've been successfully using it in more ways than we ever imagined."

Pictometry catalogues its visual database by counties. Some of the many major metropolitan areas that are included in the database include Los Angeles, San Francisco, New York City, Boston, and Atlanta. "Pictometry Online represents a break-through in high-resolution oblique and orthogonal digital aerial imaging that has already proven its value in today's highly competitive engineering and architectural market," said Dante Pennacchia, Senior Vice President of Sales and Marketing. "We will continue to add more areas throughout the year as they become available."

Once a firm has registered on Pictometry Online, they can view and purchase images with or without Pictometry software. Images purchased without Pictometry software are called non-Intelligent Images. These images enable firms to clearly see entire project areas and can be incorporated into other software systems. Engineers, architects, and planners looking to obtain image measurements, such as elevation, height, distance, and area, will need to purchase Pictometry software, called EFS, and purchase Intelligent Images™.

Special promotional pricing is now available from Pictometry on both images and software for a limited time. Companies that wish to see sample images, view a demonstration of Pictometry software, and obtain promotional pricing can visit www.pictometry.com/aec.

About Pictometry

Pictometry International Corp. is a rapidly growing software company that provides visual intelligence information systems. The company's patented imaging process captures high-resolution oblique and orthogonal images of counties and states, and combines them with an interactive software solution that lets users see everywhere, measure anything, and plan everything. The company's customer base includes a growing list of county, state, and federal government organizations as well as private business users. Applications include assessors, planning officials, transportation, insurance, real estate, engineering, utilities, law enforcement, 9-1-1, homeland security, and fire departments. For more on Pictometry, visit www.pictometry.com

###

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preciseRoof is a roof-measuring service developed by the geocoding/aerial imagery experts at Whitegold Solutions. Used by roofers, adjusters and solar panel installers, preciseRoof provides a completely new way to measure roofs.

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preciseRoof is easy to use. Start by registering on the [precise](#) home page. Once you've registered, login and start a "roof-measuring job". For the most part, this involves downloading or "typing in" the street address (es) of the roof(s) to be measured.

The "rooftop measurement" process starts with geocoding; each address is geocoded to the precise (lat, long) of the home. Next multiple sources sources of aerial imagery are searched, looking for a picture that allows us to capture a detailed measurement of each roof.

preciseRoof is being used in the field by insurance adjusters, roofers and solar panel installers. One of the largest P/C insurers is now using preciseRoof to expedite claims handling after hailstorms.

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Welcome to precigeo™

Confucius said a picture is worth a thousand words. But as a source of marketing or underwriting intelligence, a 'processed' picture may be worth much more. Whitegold Solutions, Inc. is a team of database experts, GIS wizards and imagery-analysis pros. Our precision-geocoding, feature-extraction services (precigeo™) turn raw aerial imagery into a database of actionable business intelligence, i.e. text-based attributes associated with a particular home or business address. For example, using our precigeo™ solutions, you can:

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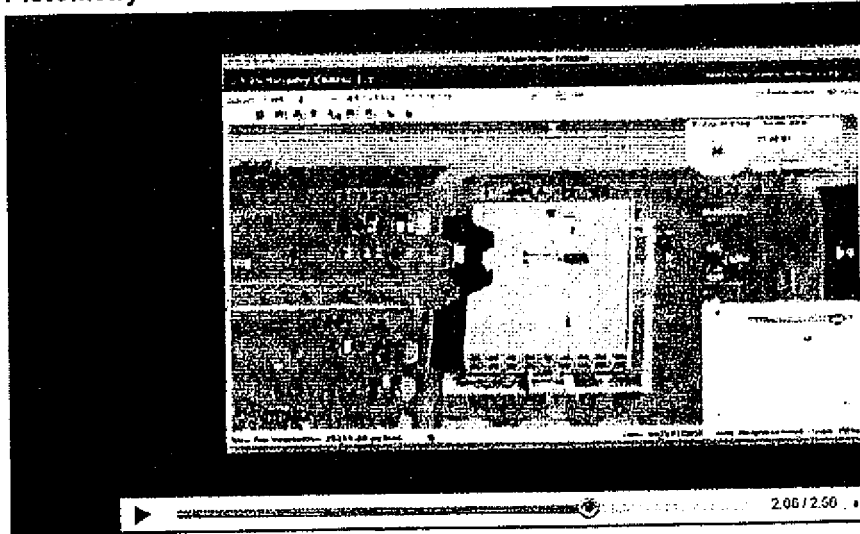
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8:01
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3D Reconstruction Using Labeled Image Regions

R. Ziegler, W. Matusik, H. Pfister, L. McMillan

TR2003-82 June 2003

Abstract

In this paper we present a novel algorithm for reconstructing 3D scenes from a set with other methods.

Symposium on Geometry Processing, 2003

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3D Reconstruction Using Labeled Image Regions

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Abstract

In this paper we present a novel algorithm for reconstructing 3D scenes from a set of images. The user defines a set of polygonal regions with corresponding labels in each image using familiar 2D photo-editing tools. Our reconstruction algorithm computes the 3D model with maximum volume that is consistent with the set of regions in the input images. The algorithm is fast, uses only 2D intersection operations, and directly computes a polygonal model. We implemented a user-assisted system for 3D scene reconstruction and show results on scenes that are difficult or impossible to reconstruct with other methods.

Categories and Subject Descriptors (according to ACM CCS): 1.2.10 [Artificial Intelligence]: Vision and Scene Understanding: modeling and recovery of physical attributes; I.3.3 [Computer Graphics]: Picture/Image Generation: display algorithms

1. Introduction

Creating photorealistic 3D models of a scene from multiple photographs is a fundamental problem in computer vision and image-based modeling. The emphasis for most computer vision algorithms is on automatic reconstruction of the scene with little or no user intervention. Consequently, these algorithms make *a priori* assumptions about the geometry or reflectance of the objects in the scene. In contrast, many image-based modeling systems require that the user directs the construction of a 3D model that is used as a scene representation. However, the specification of these 3D models can be difficult, and tools for it are not very flexible, i.e., they allow only for a very simple set of shapes.

In this paper we propose a system for 3D model creation that only requires simple 2D photo-editing operations from the user. The input to our system is a set of calibrated images of a scene taken from arbitrary viewpoints. The user first identifies 2D polygonal regions in each image using simple segmentation tools, such as polylines and intelligent scissors¹⁸. Each region is assigned an ID, such that regions with corresponding IDs in two or more images are projections of the same object in the world. For example, images of a person could be segmented into head, torso, legs, and hands. Figure 1 shows an example of input images and the corresponding user segmentation.

Our algorithm automatically computes the 3D geometric model that is consistent with the user's segmentation. The solution is unique, in that it is the maximum volume that reproduces the user's input. The algorithm is fast and directly computes one or more watertight polygon meshes of the scene. The model can be immediately displayed using graphics hardware, as shown in Figure 1.



Figure 1: Left: Example input photograph. Middle: User labeling of image regions. Right: 3D model reconstructed from nine labeled images.

A fundamental problem in 3D reconstruction is assigning correspondences between points in two or more images that are projections of the same point in three dimensions. Previous work uses pixels or object silhouettes to specify correspondence. Our approach is the first to use correspondence between arbitrary image regions. In this paper we present a new problem formulation for general scene reconstruction

from image regions. We define a necessary condition for the removal of labeling inconsistencies from multiple views. We develop a new algorithm, called *cell carving*, and show how it computes a unique solution to the problem. We also present an efficient implementation of cell carving that uses graphics hardware and standard 2D polygon intersections.

Our user-assisted 3D reconstruction system is able to reconstruct scenes that are very difficult or impossible to reconstruct with traditional methods: scenes with significant occlusion among multiple objects, large variations in geometric scale and detail, and a mix of textured, uniformly colored, specular, and transparent surfaces.

2. Previous Work

The problem of 3D model reconstruction from photographs has received a tremendous amount of attention in the computer vision literature. Excellent overviews can be found in ^{11,7}. Here we review the research that is most relevant to our work.

2.1. Multi-View Stereo Reconstruction

Multi-view stereo algorithms reconstruct 3D structure by automatically computing pixel correspondences across images. Stereo correspondence techniques work well when the distance between viewpoints (often called the baseline) is not too big. This is especially true for video sequences ²², where tracking is used to assist in correspondence matching between frames. To deal with large changes in viewpoints, some approaches extract partial 3D shape from a subset of the photographs using multi-baseline stereo algorithms ^{19,33,26}. However, to produce a single 3D model requires complex reconstruction and merge algorithms ^{32,5}, and there are no guarantees on global consistency with the entire set of photographs for the merged model.

Accurate point correspondences are difficult to compute in regions with homogeneous color and intensity. View-dependent effects, such as specular highlights or reflections, lead to correspondence mismatches. Obtaining dense correspondence for many image points is especially hard. Finally, differences between images due to occlusions are difficult to handle. This is a severe problem for general scene reconstruction where such occlusions happen frequently.

2.2. Shape From Silhouettes

Shape-from-silhouette techniques – for example ^{15,30} – compute the 3D model as the intersection of visual rays from the camera centers through all points on the silhouette of the object. Because of their simple and efficient computer vision processing, shape-from-silhouette methods are especially successful for real-time virtual reality applications ^{14,17}.

Shape-from-silhouette techniques reconstruct a shape

known as the *visual hull* ¹² – they can never recover concavities. Li et al. ¹³ improve the visual hull by adding depth from multi-view stereo, subject to some of the drawbacks mentioned above. Shape-from-silhouette methods fail for scenes with multiple, occluding objects, and they only work for outside-looking-in camera arrangements. [†] Our cell carving algorithm is able to reconstruct concavities. It handles arbitrary object occlusions and camera placements.

2.3. Photometric Techniques

Additional photometric constraints can be used to recover a shape that is demonstrably better than the visual hull ¹¹. Voxel coloring ²⁷ gradually carves out voxels from a 3D volume that are not color-consistent with all images. Recent approaches extend voxel coloring to arbitrary camera placements ^{4,11}, graphics hardware acceleration ²⁵, and multiple color hypothesis for each voxel ²⁹.

Voxel approaches do not work well for large scenes or objects with big differences in scale. Constructing a surface model for interactive viewing requires a lengthy process that may introduce inconsistencies in the mesh. Fundamentally, all photometric approaches rely on a locally computable analytic model of reflectance. This assumption fails for global illumination effects such as shadows, transparency, or inter-reflections. Since simultaneous recovery of surface shape, reflectance, and illumination is difficult, all photometric reconstruction techniques assume that surfaces are Lambertian or nearly so. They do not work for objects with homogeneous surface color. Our motivation for developing a user-assisted reconstruction method was to overcome these limitations and to reconstruct highly specular, transparent, and uniformly colored objects.

2.4. Image-based Modeling

Image-based modeling systems split the task of 3D model construction between the user and the computer. Some methods reconstruct a model from a single image using user-defined billboards ⁹ or depth images ¹⁰. Oh et al. ²⁰ use a single image and provide various tools to paint a depth image, edit the model, and change the illumination in the photograph. Despite the utility and versatility of these systems, specifying depth images for multiple photographs requires an impractical amount of user input. More importantly, there are no guarantees that the resulting 3D model is globally consistent with all the input photographs.

It is of considerable advantage to use geometric constraints when the scene is known to have a certain structure. Some systems use user-guided placement of polyhedral

[†] The scene must lie inside the convex hull of the cameras. The opposite configuration is called inside-looking-out.

primitives to reconstruct architectural scenes^{6,8}, others exploit the geometric characteristics of scenes with planes and parallel lines^{3,23}. Similar methods have been successfully adopted by commercial products^{2,21,24}. However, these approaches are not applicable for reconstructing arbitrary scenes, and they rely on lengthy optimization procedures.

Our method follows the tradition of image-based modeling by relying on the human for the difficult task of assigning region correspondences. Our algorithm is able to automatically reconstruct a globally consistent mesh without making geometric assumptions about the scene. Because cell carving uses geometry for reconstruction, it is able to include geometric constraints (for example, marking planar regions in each image).

3. Cell Carving Algorithm

We first look at the problem of n -view reconstruction using image region correspondence. As a solution to the problem we introduce the cell carving algorithm. In Section 6 we present an efficient implementation of cell carving using graphics hardware.

3.1. Problem Formulation

We are given n images of the same scene taken with calibrated cameras from arbitrary viewpoints. The scene is a static environment of two- and three-dimensional impenetrable objects. In this discussion, we consider each camera to be omni-directional with a spherical image plane at a unit distance from the center of projection (COP). All rays entering the camera are parameterized in terms of spherical coordinates (ρ, θ) . Later we will use the more familiar pinhole camera model.

Each point in the scene can be projected into any camera by intersecting the image sphere with the directed line from the point to the camera's COP. For any two points, we say that P_1 is visible from P_2 if the open segment P_1P_2 does not intersect any object in the scene. We produce an image by projecting all visible points in the scene onto the image sphere. A depth image is an image that stores the depth along the line of sight to each visible point. A depth discontinuity is an abrupt depth change in a depth image.

Suppose we take n images of a scene where all objects or parts of objects have some diffuse color. Each point in an image will contain the color of the closest visible object surface along the line-of-sight. Ignoring depth or color discontinuities for the time being, we call the set of all image points with the same color an *image region*. We call the color of an image region its *region ID*. An image that contains region IDs for each point is called a *label image*.

We can now pose the following reconstruction problem: Given n label images, what is the scene that produces them? As shown by Kutulakos and Seitz¹¹, there may be infinitely

many such scenes. To get a unique solution we restrict ourselves to finding the scene with maximum volume that produces the label images.[‡]

3.2. Consistency and Cells

Consider shooting a ray from a point p in the scene to a camera C . The ray intersects the label image of camera C at an image region with an associated region ID. A point is *consistent* with a set of *visible* cameras if it projects onto the same region IDs in these cameras. If the point is not visible in a camera, it is trivially consistent with that camera. A point is also trivially consistent if it is visible in only one camera. Figure 2 shows a 2D example with consistent and inconsistent points for a set of three cameras.

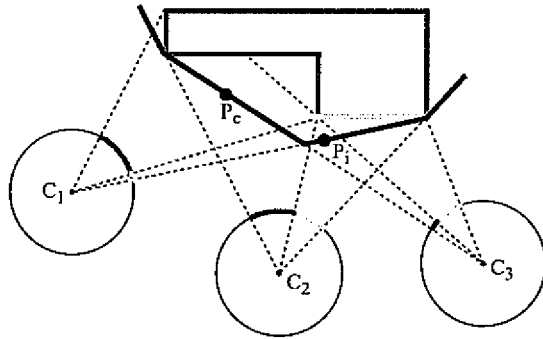


Figure 2: 2D example of consistency. P_1 is inconsistent because the region IDs of its projections are not the same. P_c is consistent. Cyan cells are inconsistent, and yellow cells consistent. The thick black outline is the initial volume.

Now consider shooting rays from a point p to all cameras and identifying all image regions where the rays intersect the image planes. Note that we do this without taking occlusions into account. We list the region IDs of the projections as a vector with one entry per camera. We call this vector the *point ID*. Each 3D point has exactly one point ID, but there may be many points with the same ID. We call the set of points with the same ID a *cell*. The point ID of points in a cell is called the *cell ID*.

A cell is called consistent with a set of cameras if and only if all points of the cell are consistent with these cameras. Because only visible points can be consistent, we can restrict the consistency checks to the boundary of cells. Figure 2 shows examples of consistent and inconsistent cells. Note that some cells are inconsistent inside the visual hull of the object.

Our definition of consistency is very similar to the definition of photo-consistency by Kutulakos and Seitz¹¹. The

[‡] Some other criteria could be used. For example, one could try to find the smoothest scene that produces the label images.

only difference is that we do not consider background regions because we assume omni-directional cameras for now. Kutulakos and Seitz¹¹ call the maximum volume that is photo-consistent the *photo hull*. If the label images are produced by projecting a scene as described above, then our reconstruction problem is equivalent to finding the photo hull. Kutulakos and Seitz prove that all points inside the photo hull are consistent, and that all points outside the photo hull are inconsistent. Using this fact, we prove the following theorem in Appendix A:

Theorem (Cell Reconstruction Theorem): Given n label images. The scene with maximum volume V that produces the label images is composed only of consistent cells C . Cells outside of V are inconsistent.

3.3. Necessary Conditions for Inconsistency

This theorem states that removal of all inconsistent cells will yield the maximum volume V that produces the label images. The next important question is how many different colors have to be observed on a cell to make it inconsistent? Kutulakos and Seitz¹¹ state that any point (cell) with at least two different colors is inconsistent. However, as Figure 3 demonstrates in 2D, two colors are not sufficient to label cells as inconsistent.

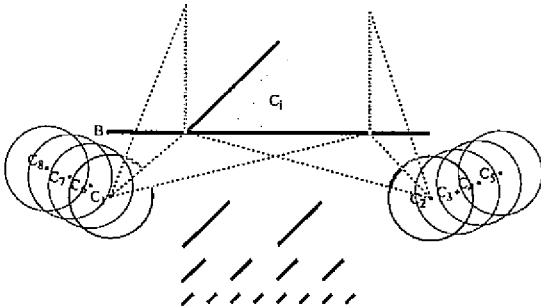


Figure 3: Two colors are insufficient to determine the inconsistency of cells in 2D.

The object in the figure contains a V-shaped concave region with two distinct uniform colors (red and yellow). The two cameras C_1 and C_2 are positioned such that each camera sees the projection of exactly one of the two colors. The initial volume for the scene is outlined by the thick black line B (we discuss initial volumes in Section 4).

The cell C_i (cyan) would be removed because of photo-inconsistency (cameras (C_1, C_2) see two different colors). However, this is incorrect, since the maximum volume that is photo-consistent with the images may include large parts of C_i . As shown on the bottom in the figure, the V-shaped concavity can be replaced by infinitely many shapes with two colors that are also not photo-consistent with the two cameras. In the limit, these shapes converge to a plane of

micro-facets that project a different color into each camera. As a matter of fact, one could place infinitely many cameras (e.g., C_3 to C_8) without ever being able to remove the cell C_i .

We need to observe at least three different colors to determine the inconsistency of a cell in 2D. The equivalent example in 3D consists of stacked cubes with different colors on each visible side viewed orthographically from the direction of the face normals. That means we need to observe at least four different colors to determine inconsistency in 3D.

Intuitively, the microfacets in Figure 3 separate the cameras into two classes, each of which observes exactly one color on the surface. It is impossible to find a geometric construction in 2D that would yield three classes of cameras, each observing a different color. A similar argument holds true for three dimensions.

The requirement of observing four different colors to determine inconsistency in 3D may be hard to meet in practice, especially with a small number of input photographs. Fortunately, our system enables the user to resolve these situations with additional image segmentation. If the user identifies all interior edges with depth discontinuities, we need only two colors for inconsistency checks.

For example, Figure 4 shows a scene with two cameras C_1 and C_2 . The user has introduced additional regions (shown

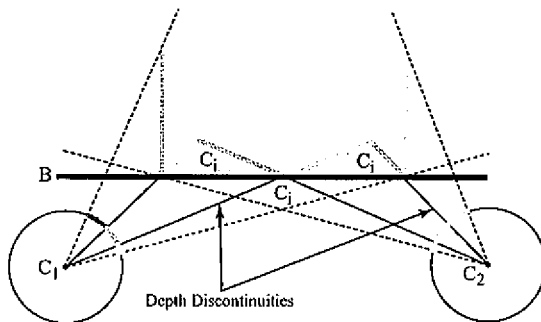


Figure 4: Segmentation along depth discontinuities allows to correctly determine consistency with fewer than four colors.

with different colors) along apparent silhouettes to indicated depth discontinuities in the image. As shown in the figure, the inconsistent cells C_i can now correctly be determined.

3.4. Reconstruction by Cell Carving

Now we describe a scene reconstruction algorithm. Given an initial set of cells V_i that contains the scene, the algorithm iteratively removes cells from V_i that are inconsistent in at least four cameras. The remaining cells are the maximum volume that produces the label images. We call this algorithm *cell carving*. Pseudo-code is shown in Figure 5.

```

Initialize the volume containing the true scene.
Cell Carve ( input images, initial volume )
while VolumeConsistent = FALSE do
  Project region IDs onto the current volume.
  Detect a point  $P$  on the volume surface that has inconsistent labeling in at least four cameras.
  if there are ID inconsistencies then
    Project inconsistent point  $P$  into all input images. It falls into a region with some ID in each image.
    Compute a cell  $C$  corresponding to these regions.
    Subtract  $C$  from the current volume.
  else
    VolumeConsistent = TRUE
  end if
end while

```

Figure 5: Cell carving algorithm.

Cell carving is a generalization of previous scene reconstruction algorithms. Assume the set of image regions is the set of all rectangular image pixels. If we use the scene radiance at each pixel as the pixel's region ID, cell carving reconstructs the photo hull. On the other hand, if the user assigns the same region ID to foreground and background objects, respectively, cell carving reconstructs the visual hull. The quality of the scene reconstruction depends on how much effort the user puts in specifying the image regions: Many small regions will result in more detailed 3D models than a few, large regions. This is also a generalization of voxel carving, in that the fidelity of the scene is not determined by some pre-determined voxel grid, but by actual geometry observed in the images.

The number of image regions determines the number of cells that make up the maximum volume. Assume we have n images and m regions in each image, then there are at most m^n cells. However, the vast majority of these cells are empty. There are configurations where there may be m^3 consistent cells, for example, if the images correspond to three sides of the orthographic cube. In our case, m is typically small (usually less than 20 regions per image). To reduce processing time and memory footprint even further, we construct cells only when needed, as described in Section 6.

4. Additional Constraints

So far, we have described the theoretical foundation of cell carving. We now discuss some additional constraints that make the algorithm practical for implementation.

We first restrict the omni-directional camera assumption to a perspective pinhole camera. Projections of lines in three dimensions now remain lines in the image plane. Conversely, regions defined by polygons lead to polyhedral cells in 3D. This allows us to use a fast method for constructing polyhedra¹⁶ that only uses 2D polygon intersections (see Section 6).

To uniquely identify cells, all points in the scene need to project to a region in all cameras. However, pinhole cameras have a limited viewing frustum. We simulate an omni-directional camera by assuming that the image plane is infinite. 3D points outside the viewing frustum project to a region on either side of the image plane with a unique *unknown ID*. Other image regions that should not be reconstructed (e.g., sky) may not be labeled by the user. We assign these unlabeled regions a unique *background ID*.

As discussed in¹¹, the maximum consistent volume may not be finite. It may be the volume that fills all free space and reproduces the label images. We restrict the scene with an initial bounding volume that is guaranteed to contain the reconstructed solution. The selection of the initial volume depends on the scene and camera arrangement. If all cameras see the objects in the scene, we compute the visual hull and use it as the initial volume. Otherwise we let the user specify an initial volume as described in the next section.

5. User Input

For scenes where calibration is unknown, we use standard computer vision methods³¹ to estimate the cameras' intrinsic and extrinsic parameters. The user selects about 20 feature points in each image and assigns point correspondences, from which the algorithm determines the position and orientation of all cameras. We found this procedure to be very robust.

If the visual hull of the scene cannot be computed because of the camera arrangement, we require that the user specifies the initial volume. To simplify the task, we show orthographic views of the cameras and the 3D feature points computed during calibration. The user then specifies corners of the scene bounding box.

The user segments each image into a set of arbitrary 2D image regions using any of the segmentation tools that are commonly available in photo-editing packages, such as brushes, snakes, region growing, flood fills, watershed algorithms, or intelligent paint. We have built a simple photo editing application (see Figure 6) that provides polylines and intelligent scissors¹⁸. The boundary of a region is defined by a polygon (possibly with holes) that consists of an outer boundary and zero or more inner boundaries. The intersection of adjacent polygons must be a set of common edges to both. The user also assigns a label L to each polygon corresponding to the different objects in the scene.

Color discontinuities: Labeling purely on the basis of color segmentation is not enough. There are cases where non-adjacent regions with the same label will cause excessive carving, as shown in Figure 7. The red object projects to red regions in the three cameras that are disconnected by the yellow region. We call this a *color discontinuity*. The two cells C_{ryr} (cyan) have the same cell ID: red-yellow-red. Because the frontmost of these two cells is inconsistent with

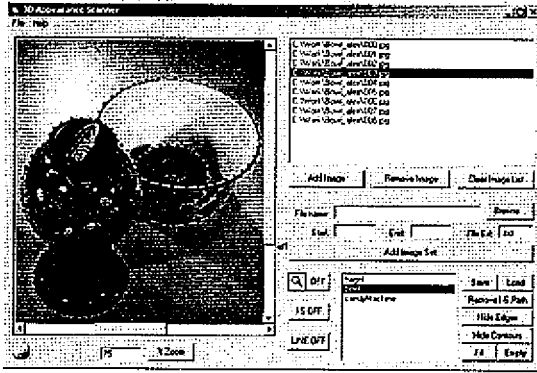
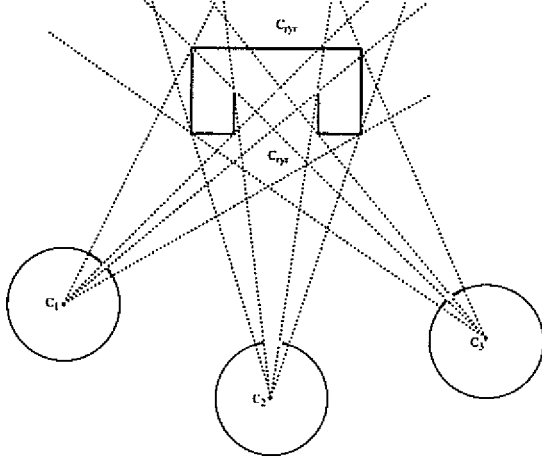


Figure 6: User segmentation and labeling.

Figure 7: A 2D example of color discontinuity. The same object (red) projects to disconnected image regions. Without distinct region IDs, both cells C_{Tyr} would be wrongly removed.

the three cameras, it will be removed. But that means the back cell will also be removed because it has the same cell ID. However, the back cell is trivially consistent because it is not visible and should be preserved.

Fortunately, there is an easy remedy to this situation: We automatically assign a unique index I to each disconnected image region. The pair $\langle L, I \rangle$ is used as the region ID, where L is the user-assigned label. With this approach, the two cells C_{Tyr} have different cell IDs, and only the front cell will be removed.

6. Cell Carving Implementation

We now describe an efficient implementation of cell carving that makes use of graphics hardware and fast 2D polygon intersections. Instead of constructing a complete volume of cells, we use lazy evaluation and create cells as needed. The reason is that we are only interested in the boundary repre-

sentation of the reconstruction. Figure 8 shows the pseudocode of our implementation.

```

1: Create volume  $V$  containing the true scene
2: Create a set  $I$  of label images
3: Compute the boundary cells  $V_c$  that approximate  $V$ 
4: Remove all cells with background IDs
5: repeat
6:   AllCellsConsistent = TRUE
7:   for Every cell  $c$  in  $V_c$  do
8:     for Every triangle  $t$  in  $c$  do
9:       for Every input image  $i$  in  $I$  do
10:        Project  $t$  onto image  $i$  with visibility
11:        Record region ID of its projection
12:      end for
13:       $k$  = Number of inconsistent images for  $t$ 
14:      if  $k \geq 4$  then
15:        AllCellsConsistent = FALSE
16:        Remove the inconsistent cell  $c$ 
17:        Construct the neighbors of  $c$ 
18:      end if
19:    end for
20:  end for
21: until AllCellsConsistent = TRUE

```

Figure 8: Cell carving implementation.

Line 1 and 2 – Pre-processing: As described in Section 5, we are given an initial volume that contains the scene. The user also provides a set of polygons with corresponding region IDs for each image. To quickly check which region ID a point projects to, we scan-convert and flood-fill the polygons with a color corresponding to their region ID.

Line 3 – Construction of the initial boundary cells: We either use the visual hull as the boundary representation of the initial volume, or the user creates a simple bounding box. Because our algorithm works only on cells, we replace this bounding box with a set of cells that encompass it. This way we avoid arbitrary and difficult Constructive Solid Geometry (CSG) operations between cells and the boundary representation.

To construct the initial boundary cells, we pick arbitrary points on the surface of the bounding box that are visible in some of the cameras. We then replace these points with their corresponding cells. To construct a cell, we use a fast algorithm by Matusik et al. ¹⁶, which computes the intersection of solids with fixed cross-sections. It reduces this computation to a set of polygon intersections that can be carried out efficiently in 2D. Its run time is nearly quadratic in the number of regions and nearly linear in the number of edges in these regions.

We repeat the construction of cells until no more bounding box is visible. To check visibility, one could use a BSP tree.

Instead, we use graphics hardware and render each cell independently with a different color. If triangles of the bounding box are still visible, we create the corresponding cells until the whole bounding box is covered.

Line 4 – Removing all cells with background IDs: To speed up the cell carving, we first remove all cells that project to a region with background ID. We check all boundary cells to see if they contain the background ID. To remove a cell we delete it from the list of boundary cells and add it to the list of removed cells. To fill holes when removing a boundary cell, we create its neighboring cells if they are not in the lists of boundary cells or removed cells.

To create the neighbors of a cell, an adjacency graph that stores the cell IDs of neighbors for all currently created cells could be used. Because there are typically a small number of cells, we use a less efficient search method to find adjacent cells. Cells outside the initial bounding volume are not created and instead added to the list of removed cells. A cell whose ID is not in the list of boundary cells or removed cells is created as described above.

Lines 7 to 20 – Detecting inconsistent cells: The main loop of the algorithm detects and removes inconsistent cells. We first determine the set of cameras for which a cell is inconsistent. For each cell we keep a list of triangles. For each triangle, we record in which image it is visible by projecting the triangle and recording the region ID of its projection. By construction, projections of cell triangles never cross the boundary of image regions. We then check in how many cameras a triangle has mismatched region IDs. If it is inconsistent with at least k cameras ($k = 4$ in 3D), we tag the corresponding cell as inconsistent. We then remove inconsistent cells and insert the neighboring cells as described above. We repeat this loop until there are no more inconsistent cells.

7. Results

We implemented the user interface to our system in Visual-Basic and the cell carving algorithm in C++. All results were computed on a 2 GHz Pentium 4 PC with 1 GB of RAM.

To be able to compare our 3D reconstruction to actual scene geometry, we used a synthetic scene with concavities and objects at different resolutions. We rendered the scene from six viewpoints using 3D StudioMax. Figure 9 shows the original geometry and the six segmented label images. The input images have a resolution of 1024×768 .

The upper row in Figure 10 shows the actual geometry for the synthetic scene rendered from novel viewpoints. The middle row in the figure shows the visual hull. Since all cameras are outside-looking-in, we were able to use the visual hull for the construction of the initial boundary cells. The lower row of Figure 10 shows the output of cell carving. Cell carving was able to carve out the teapot from the concavity. Note that the small teapot on the top is represented with more triangles than the rest of the scene.

Images of the following two scenes were taken with a Canon D30 digital camera at 2160×1440 resolution. Figure 11 shows nine images of the “bowl and bagel” scene with corresponding label images. The scene is interesting because it contains an object (the bagel) inside a concavity (the bowl). Figure 12 shows examples of the visual hull and cell carving geometry from novel viewpoints. In contrast to the visual hull, cell carving reconstructs some concavities, even with very few input images. The texture-mapped cell carving reconstruction is displayed with unstructured lumigraph rendering¹.

Figure 13 shows nine images and label images of the “table” scene. The scene contains many specular and transparent objects that are very difficult or impossible to reconstruct with computer vision methods. Figure 14 shows the cell carving geometry of the table objects from novel viewpoints. Most objects are represented with high geometric fidelity and the concavity in the glass is visible.

Figure 15 shows seven images and label images of the “garage” scene. The photographs were taken with a Canon S300 digital consumer camera at 1600×1200 resolution. Note that it is very difficult to provide overhead views in this setting.

Figure 16 shows the visual hull and the output of cell carving from novel viewpoints. The texture-mapped images were rendered using unstructured lumigraph rendering. As expected, cell carving reconstructs the concave geometry of the house corner much better than the visual hull. The difference is also visible in higher texture fidelity when using the cell carving model. It should be noted that seven input images are not enough to yield high quality rendering for some views, as can be seen in the companion animations. However, this scenario is likely to be typical for consumer use.

Table 1 shows quantitative results of our cell carving implementation for different scenes, such as pre-processing time (lines 3 and 4 in Figure 8), run time, number of iterations of the algorithm (lines 7 to 20 in Figure 8), and the number of cells and triangles in the final reconstruction. The

Scene	Preproc.	Time	Iter.	Cells	Tris
Synth	1 min	2 min	8	30	25k
Bowl	2 min	12 min	20	680	62k
Table	4 min	10 min	24	1,010	122k
Garage	2 min	2 min	8	150	16k

Table 1: Quantitative results for our implementation of cell carving.

runtime is dependent on the number of edges in all region contours and the total number of images. The number of cells is dependent on the number of regions and the number

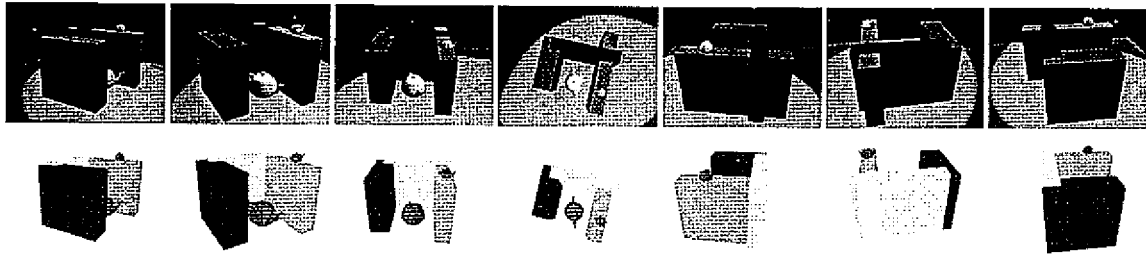


Figure 9: Seven images of a synthetic scene and the segmented label images.

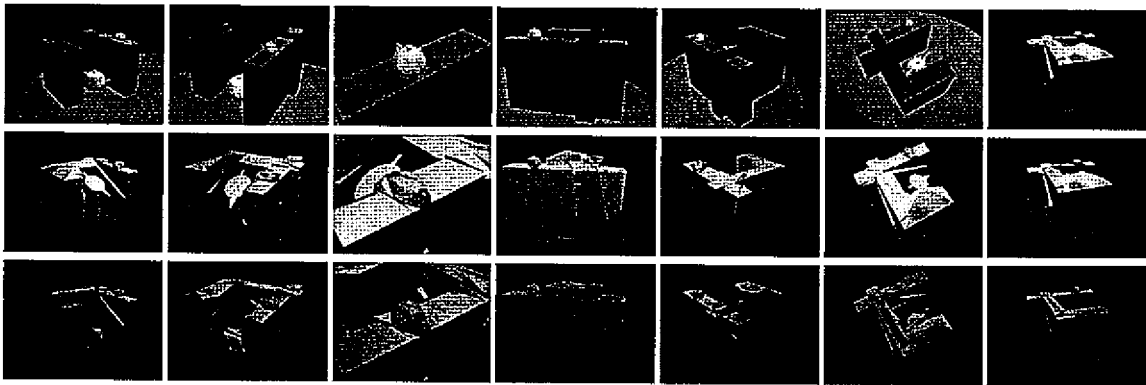


Figure 10: Upper row: Actual geometry of the synthetic scene. Middle row: Visual hull geometry. Lower row: Cell carving geometry. All images rendered from novel viewpoints that are not part of the input images.

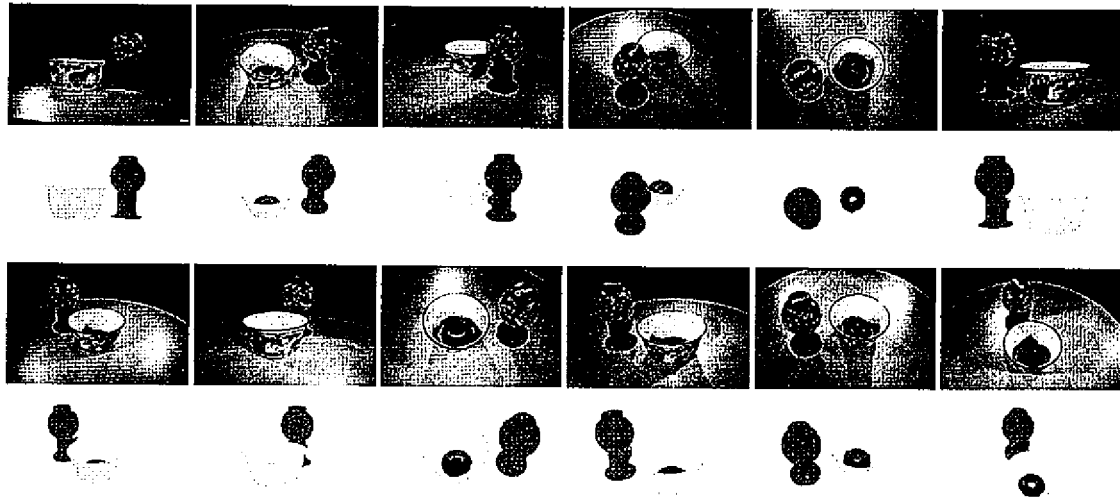


Figure 11: Twelve images of the bowl and bagel scene with label images.

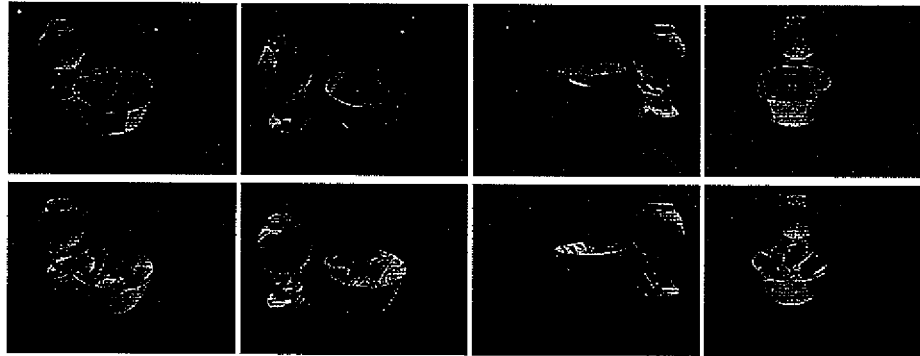


Figure 12: Upper row: Visual hull geometry. Lower row: Cell carving geometry. All images rendered from novel viewpoints that are not part of the input images.

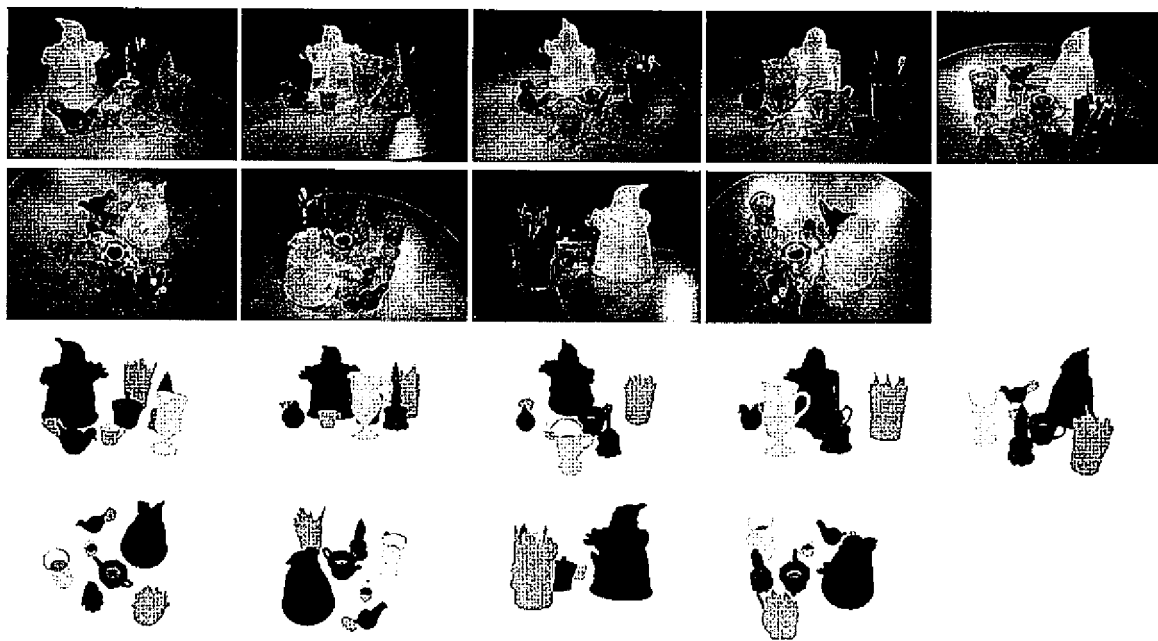


Figure 13: Images of the table scene with label images.

of cameras, whereas the number of triangles is dependent on the number of edges in all the region contours.

8. Future Work

We would like to reduce the amount of user input as much as possible. Automatic computation of the initial volume may be achieved using information about camera pose and region correspondences. At some point the user could be eliminated from the loop when unsupervised segmentation algorithms improve and when region correspondences can be assigned automatically.

We could use an analytical visibility solution for more

precision in our reconstruction. However, recent advances in graphics hardware – including floating point framebuffers and arithmetics – probably make this unnecessary. To get a smoother reconstruction, one could use other contour representations, such as splines. One could improve the reconstruction using other techniques, for example, multi-view stereo. Per-pixel depth estimates could be used to produce a mesh of the scene with displacement maps.

Furthermore, we would like to add additional geometric constraints. For example, the user could assign a planar constraint to certain image regions, such as walls and ground planes, to improve the reconstruction. We also would like

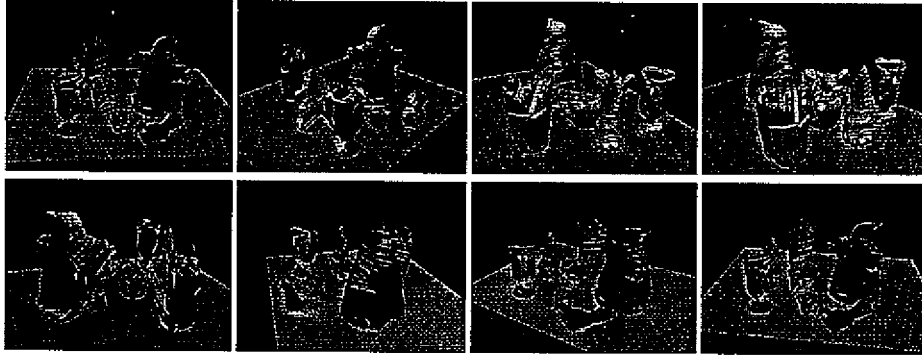


Figure 14: Cell carving geometry for the table scene.



Figure 15: Images of the garage scene with label images.

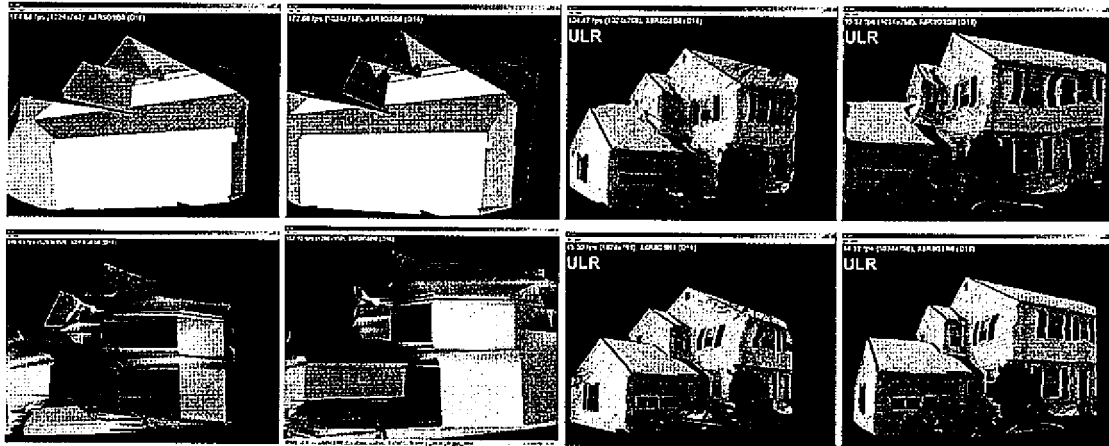


Figure 16: Upper row: Visual hull geometry of the garage scene. Lower row: Output of cell carving. Note how cell carving reconstructs the concavity. All images rendered from novel viewpoints.

to introduce interactive scene editing tools as used in Oh et al.²⁰. A promising idea is to use plenoptic image editing²⁸ that propagates edits in one image to all other images using the reconstructed 3D model.

9. Conclusions

We presented a novel method for reconstructing an arbitrary 3D scene from a set of input images. Instead of relying on computer vision algorithms for segmentation and object correspondence, our approach divides the tasks equitably between user and computer: Human beings are good at recognizing and finding corresponding objects in a set of images, whereas computers are well suited to automatically constructing the 3D model consistent with the user's labeling. We have introduced a new formulation of the 3D reconstruction problem for labeled image regions. We have shown necessary conditions for label consistency, and we have proved the correctness of using cells for reconstruction. Our novel cell carving algorithm can be efficiently implemented and produces polygon meshes that can be immediately texture-mapped and displayed.

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Appendix A: Cell Reconstruction Theorem

Lemma 1: A cell is the maximum volume that projects to the set of regions listed in its cell ID.

Proof (by contradiction): Assume there is another point in the scene outside the cell that projects to the same set of regions. By definition, it is part of the cell. QED.

Lemma 2: The intersection of cells with different cell IDs is empty.

Proof (by contradiction): Assume the intersection is not empty. There must be a point in the intersection of the two cells that has two different point IDs. By construction, every point in the scene has one and only one point ID. QED.

Lemma 3: The scene is completely partitioned by cells C , or $R^3 - \bigcup C_i = \emptyset$.

Proof: This follows directly from Lemma 1 and Lemma 2. QED.

Lemma 4: All points of a cell C have the same visibility in all cameras.

Proof (by contradiction): Suppose there are two points in the cell with different visibility in camera C_k , e.g., P_i is invisible, and P_j is visible. Because region IDs are determined by visible points, P_i and P_j must project to regions with different IDs in camera C_k . That means their point IDs are not the same, which is impossible if they are in the same cell. QED.

Lemma 5: Given n label images. The scene with maximum volume V that produces the label images is composed of cells C such that $\forall C: V \cap C = C$.

Proof (by contradiction): Suppose there is a cell C that is partially occupied by V . As shown by ¹¹, V contains all consistent points, and $V' = R^3 - V$ contains all inconsistent points. That means C must contain at least one consistent point P_c and one inconsistent point P_i . By definition, consistency is determined by the point ID and the point visibility. Point P_c and P_i have the same point ID by definition of a cell, and they have the same visibility because of lemma 4. That means their consistency is the same. QED.

Theorem (Cell Reconstruction Theorem): Given n label images. The scene with maximum volume V that produces the label images is composed only of consistent cells C . Cells outside of V are inconsistent.

Proof: By Lemma 3 and Lemma 5, R^3 and V are composed completely of cells. Assume there exists a consistent cell C_c that is not part of V . Because C_c is consistent, all points in C_c produce the same region IDs. That means we can add it to V . Assume there is an inconsistent cell C_i that is part of V . That means C_i produces different region IDs, so it can not be part of V . QED.

Corollary: The cell-carving algorithm correctly computes the maximum volume V that produces the label images.

Proof: The cell carving algorithm removes all inconsistent cells from R^3 . The remaining cells are in V by the cell reconstruction theorem. QED.

Electronic Patent Application Fee Transmittal

Application Number:				
Filing Date:				
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION			
First Named Inventor/Applicant Name:	Chris Pershing			
Filer:	David V. Carlson/Jamie Horner			
Attorney Docket Number:	290115.403			
Filed as Small Entity				
Utility under 35 USC 111(a) Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	82	82
Utility Search Fee	2111	1	270	270
Utility Examination Fee	2311	1	110	110
Pages:				
Claims:				
Claims in excess of 20	2202	8	26	208
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				670

Electronic Acknowledgement Receipt

EFS ID:	5346914
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	00500
Filer:	David V. Carlson/Jamie Horner
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Payment information:

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Payment was successfully received in RAM	\$670
RAM confirmation Number	5436
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			c2906e96ea8bb25d6f5b236b5cbbf98183e8d946		
Warnings:					
Information:					
10	NPL Documents	290115_403_Miller.pdf	368241	no	9
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Warnings:					
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11	NPL Documents	290115_403_Pictometry.pdf	71462	no	3
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12	NPL Documents	290115_403_Welcome.pdf	15068	no	1
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Warnings:					
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13	NPL Documents	290115_403_Precigeo.pdf	15900	no	1
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14	NPL Documents	290115_403_YouTube.pdf	46133	no	1
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Warnings:					
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15	NPL Documents	290115_403_Ziegler.pdf	631282	no	14
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16	Fee Worksheet (PTO-875)	fee-info.pdf	36581	no	2
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PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/197,904, entitled "USER INTERFACE SYSTEMS AND METHODS FOR ROOF ESTIMATION," filed October 31, 2008, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention:

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

2. Description of the Related Art:

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

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

[0005] There are factors that impact a roofing contractor's ability to provide a timely written estimate. One factor is the size of the roof contractor's company and the

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

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

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

SUMMARY

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

determine roof measurement information and generate a roof estimate report based on the generated model and/or the determined roof measurement information.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

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

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

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

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

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

[0017] Figure 8 is an example block diagram of a computing system for practicing embodiments of a roof estimation system.

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

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

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

DETAILED DESCRIPTION

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

[0022] Some embodiments of the roof estimation system include an interactive user interface configured to provide access to one or more of the functions of the roof estimation system. In one embodiment, the roof estimation system includes user interface controls that facilitate image registration, image lean correction, roof model generation, pitch determination, and roof model review. Image registration includes aligning, based at least in part on operator inputs, one or more images of a building

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

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

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

1. Roof Estimation System Overview

[0025] Figure 1 is a block diagram illustrating example functional elements of one embodiment of a roof estimation system. In particular, Figure 1 shows an example

Roof Estimation System (“RES”) 100 comprising an image acquisition engine 101, a roof modeling engine 102, a report generation engine 103, image data 105, model data 106, and report data 107. The RES 100 is communicatively coupled to an image source 110, a customer 115, and optionally an operator 120. The RES 100 and its components may be implemented as part of a computing system, as will be further described with reference to Figure 8.

[0026] More specifically, in the illustrated embodiment of Figure 1, the RES 100 is configured to generate a roof estimate report 132 for a specified building, based on aerial images 131 of the building received from the image source 110. The image source 110 may be any provider of images of the building for which a roof estimate is being generated. In one embodiment, the image source 110 includes a computing system that provides access to a repository of aerial images of one or more buildings. In addition, the aerial images 131 may include images obtained via manned or unmanned aircraft (*e.g.*, airplane, helicopter, blimp, drone, etc.), satellite, etc. Furthermore, the aerial images 131 may include images obtain via one or more ground-based platforms, such as a vehicle-mounted camera that obtains street-level images of buildings, a nearby building, a hilltop, etc. In some cases, a vehicle-mounted camera may be mounted in an elevated position, such as a boom. Example aerial images are described further with reference to Figures 2A-2B.

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

which are then used to look up (e.g., query a database) aerial images of the provided street address.

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

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

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

swimming pool, tennis court, etc.), on a nearby natural feature (*e.g.*, a tree, boulder, etc.), etc.

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

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

[0033] In addition, generating a model of the roof of a building may include correcting one or more of the aerial images for various imperfections. For example, the vertical axis of a particular aerial image sometimes will not substantially match the actual vertical axis of its scene. This will happen, for example, if the aerial images were taken at different distances from the building, or at a different pitch, roll, or yaw angles of the aircraft from which the images were produced. In such cases, an aerial image may be corrected by providing the operator 120 with a user interface control operable to adjust the scale and/or relative angle of the aerial image to correct for such errors. The correction may be either applied directly to the aerial image, or instead be stored (e.g., as an offset) for use in model generation or other functions of the RES 100.

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

[0035] In addition, generating a model of the roof of a building may include determining the pitch of one or more of the sections of the roof. In some embodiments, one or more user interface controls are provided, such that the operator 120 may accurately determine the pitch of each of the one or more roof

sections. An accurate determination of the roof pitch may be employed (by a human or the RES 100) to better determine an accurate cost estimate, as roof sections having a low pitch are typically less costly surfaces to repair and/or replace.

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

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

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

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

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

[0041] In some embodiments, one or more of the models stored as model data 106 are provided directly to the customer or other computing system, without first being

transformed into a report. For example, a model and/or roof measurement information based thereon may be exported and/or transmitted as a data file, in any suitable format, that may be consumed or otherwise utilized by some other computing system, such as a computer-aided design (“CAD”) tool, a drawing program, a labor and material estimation software, a project management/estimation software, etc.

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

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

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

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

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

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

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

printed report). In some embodiments, the roof estimate report may be in a format that may be consumed by a computer-aided design program.

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

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

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

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

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

as square meters or the number of “squares” of roofing material required for covering each roof section.

[0054] Figure 3F shows a fifth page 306 of the report and includes a line drawing 306a of the building roof where notes or comments may be written. The line drawing 306a includes a label for each roof section (shown here as “A”, “B”, “C”), such that comments may be conveniently related to specific roof sections.

[0055] In other embodiments, more or less information may be provided, or the illustrated information may be arranged in different ways. For example, the report may be provided in electronic form, such as a PDF file or a computer aided design software format. In some embodiments, the report may be “active” or editable, such that the user of the report may make changes to the report, based on on-site observations.

2. Roof Estimation System User Interface

[0056] Figures 4A-4F, 5A-5D, 6A-6D, and 7A-7C describe an example interactive user interface provided by one embodiment of the roof estimation system. As noted, the RES 100 described with reference to Figure 1 includes a user interface engine 104 that is configured to provide access to one or more functions of the RES 100, including image registration (described with respect to Figures 4A-4F), roof pitch determination (described with respect to Figures 5A-5D), roof model construction (described with reference to Figures 6A-6D), and roof model review (described with respect to Figures 7A-7C).

A. Image Registration

[0057] Figures 4A-4F are screen displays illustrating image registration and image lean correction in an example embodiment. In particular, Figure 4A shows a user interface screen 400 that is utilized by an operator to generate a three dimensional model of a roof of a building. The user interface screen 400 shows a roof modeling project in an initial state, after the operator has specified an address of a building and

after images of the building have been obtained and loaded into the roof estimation system.

[0058] The user interface screen 400 includes a control panel 401 and five images 402-406 of a building roof 407. The control panel 401 includes user selectable controls (e.g., buttons, check boxes, menus, etc.) for various roof modeling tasks, such as setting reference points for the images, setting the vertical (Z) axis for the images, switching between different images, saving the model, and the like. Each of the images 402-406 provides a different view of the building roof 407. In particular, images 402-406 respectively provide substantially top-down, south, north, west, and east views of the building roof 407. Each image 402-406 includes four marker controls (also called “reference points” or “registration markers”) that are used by the operator to set reference points in the image for purposes of image registration. The registration markers will be described further with respect to an enlargement of image portion 408 described with respect to Figures 4B-4C, below.

[0059] Figures 4B-4C show an enlarged view of image portion 408 during the process of image registration for image 402, which provides a top-down view of the building roof 407. As shown in Figure 4B, image portion 408 includes the building roof 407 and registration markers 410-413. The markers 410-413 are interactive user interface controls that can be directly manipulated (e.g., moved, rotated, etc.) by the operator in order to specify points to use for purposes of image registration. In particular, image registration includes determining a transformation between each of one or more images and a uniform 3D reference grid. The uniform 3D reference grid is used as a coordinate system for a 3D model of the roof. By registering multiple images to the reference grid, an operator may indicate a roof feature on an image (such as a roof edge), which may then be translated from the coordinate system of the image to the coordinate system of the reference grid, for purposes of including of the indicated feature in the 3D model.

[0060] Marker 410 is an origin marker control, and includes arms 410a-410c. Arms 410a and 410b are horizontal arms that are utilized to specify the X and Y axes (e.g.,

the horizontal plane) of the reference grid. Arm 410c is a vertical arm that may be utilized to specify the Z axis (e.g., the vertical axis) of the reference grid. The use of the vertical arm to specify the Z axis will be further described with respect to Figure 4E, below.

[0061] Typically, markers 410-413 are color coded, such that they may be distinguished from one another. For example, marker 411-413 may be respectively colored red, blue, and green. Origin marker 410 has a different appearance than markers 411-413, so may be of any color. In other embodiments, markers 411-413 may be distinguished in other ways, such as by utilizing different sized dashed lines, different line thicknesses, etc. In still other embodiments, markers are not distinguished any way from each other, such as by being of uniform shape, color, etc.

[0062] Figure 4C shows image portion 408 with markers 410-413 after they have been placed by an operator. Typically, registration markers are placed at four spatially distributed corners of the roof. As shown in Figure 4C, the operator has placed markers 410-413 at four different corners of the building roof 407. In particular, the operator first placed the origin marker 410 at the lower left corner of the building roof 407, and has adjusted (e.g., rotated) the arms 410a and 410b to align with the major horizontal axes of the roof. By adjusting the arms 410a and 410b of the origin marker 410, the rotational orientation of markers 411-413 is automatically adjusted by the roof estimation system. Next, the operator places markers 411-413 on some other corners of the roof. In general, the operator can place registration marker over any roof feature, but roof corners are typically utilized because they are more easily identified by the operator. After the operator is satisfied with the placement of markers 410-413, the operator typically registers a next image of the building roof 407, as will be described next.

[0063] Figures 4D-4F illustrate image registration for image 404, which provides a north view of the building roof 407. In particular, Figure 4D shows the user interface screen 400 described with reference to Figure 4A. Here, image 402 has been minimized, while image 404 has been enlarged so that the operator may register that

image by placing markers on image 404, as will be described below with respect to an enlarged view of image portion 418.

[0064] Figure 4E shows an enlarged view of image portion 418 during the process of image registration for image 404. Image portion 418 includes the building roof 407 and registration markers 420-423. Markers 420-423 respectively correspond to markers 410-413 described above. In particular, marker 420 is an origin marker control that includes arms 420a-420c. Arms 420a and 420b are horizontal arms that are utilized to specify the X and Y axes of the reference grid. Arm 420c is a vertical arm that may be utilized to specify the Z axis of the reference grid.

[0065] In the example of Figure 4E, the operator has moved each of markers 420-423 to a corner of the roof 407. Note that the markers 420-423 are moved to roof corners that correspond to those selected by the operator with markers 410-413, as described with reference to Figure 4C. In particular, origin marker 420 has been moved to the corner of the roof 407 selected with origin marker 410 in image 408; marker 421 has been moved to the corner selected with marker 411 in image 408; marker 422 has been moved to the corner selected with marker 412 in image 408; and marker 423 has been moved to the corner selected with marker 413 in image 408. In addition, markers 420-423 have been rotated, by operator rotation of the origin marker 420, to align with the major axes of the roof 407.

[0066] As noted, the operator can utilize the origin marker 420 to specify the vertical axis of the reference grid. In particular, the operator can adjust (e.g., by dragging with a mouse or other pointing device) arm 420c of marker 420 to specify the vertical (Z) axis of the image. In some cases, aerial images may include some amount of lean, due to the orientation of the aircraft during image capture. For example, pitch, yaw, or roll of an aircraft during the course of image capture may result in images that are misaligned with respect to the vertical axis of the building and its roof. Typically, an operator may adjust arm 420c to line up with a feature of a building or roof that is known to be substantially vertical, such as a wall of a house or a chimney. Then, based on the angle of arm 420c with respect to the vertical axis of the image, the roof

estimation system can determine a correction between the reference grid and the image.

[0067] Figure 4F shows an enlarged view of image portion 418 after registration of image 404. Once the operator has placed and adjusted markers 420-423, the operator may direct (e.g., by clicking a button) the roof estimation system to register the image to the reference grid, based on the positions and orientations of markers 420-423. Once the roof estimation system registers the image, it provides the operator with feedback so that the operator may determine the correctness or accuracy of the registration.

[0068] In the example of Figure 4F, the operator has directed the roof estimation system to register image 404, and the roof estimation system has updated image portion 418 with registration indicators 430-433. Registration indicators 430-433 provide the operator with feedback so that the operator may judge the accuracy of the registration of image 404.

[0069] Registration indicator 430 is an origin registration indicator that includes two arms 430a-430b and three reference grid indicators 430c-430e, shown as dashed lines. The reference grid indicators 430c-430e show the vertical axis (430c) and the two horizontal axes (430d and 430e) of the reference grid determined based on the placement and orientation of the markers 420-423. Arms 430a and 430b correspond to the placement of arms 420a-420c of origin marker 420. If the arms 430a and 430b do not substantially align with the corresponding reference grid indicators 430e and 430d, then the determined reference grid is out of alignment with the specified axes of the house. Typically, an operator will return to the view of Figure 4E to make adjustments to origin marker, such as adjusting one or more of the vertical or horizontal axes, in order to refine the registration of the image. Although the arms 430a-430b and the reference grid indicators 430c-430e are here illustrated as solid and dashed lines, in other embodiments they may be color coded. For example, arms 430a-430b may be red, while reference grid indicators 430c-430e may be blue.

[0070] Registration indicators 431-433 provide the operator with information regarding the accuracy of the placement of markers 421-423. In particular, each registration indicator 431-433 includes a solid crosshairs and a reference indicator, shown for example as a dashed line 432a. The crosshair of a registration indicator corresponds to the placement of a marker. For example, the crosshairs of registration indicator 431 corresponds to the placement of marker 421 in Figure 4E. If the reference indicator intersects the center (or substantially near the center) of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is accurate. On the other hand, if the reference indicator does not intersect the center of the crosshairs of a registration indicator, then the operator knows that the placement of the corresponding marker is inaccurate. Typically, such an inaccuracy arises when the placement of markers in the top view of the roof does not agree with (correspond to) the placement of corresponding markers in another view of the roof. In such cases, the operator can return to the view of Figure 4C or 4E to adjust the position of one or more markers.

[0071] After registering image 404, the operator will proceed to register additional images of the building roof 407 utilizing a process similar to that described above. In this example, the operator will register images 403, 405, and 406. Although the operator is here described as registering a total of five images, in other cases more or fewer images may be registered.

B. Roof Model Construction

[0072] Figures 5A-5D and 6A-6C generally illustrate aspects of the process of roof model generation based on multiple registered images. In particular, these figures illustrate the construction of a roof model by an operator. Model generation/construction may include identification of roof features shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. Each identified roof feature is incorporated by the roof estimation system into a 3D model of

the roof, based on a translation between an image in which the feature is identified and the reference grid, as determined by the process described with reference to Figures 4A-4F, above.

[0073] Figures 5A-5D are screen displays illustrating pitch determination in an example embodiment. In particular, Figure 5A shows the user interface screen 400 after images 402-406 have been registered. In this example, the operator is using a pitch determination control (also called a “pitch determination marker” or “pitch determination tool”) to specify the pitch of a planar roof section of the building roof 407 visible in image 406. The pitch determination control will be further described in Figure 5B, below, with respect to an enlargement of image portion 508.

[0074] Figure 5B shows an enlarged view of image portion 508 during the process of pitch determination for image 406, which provides an east perspective view of the building roof 407. As shown in Figure 5B, the image portion 508 includes the building roof 407 and a pitch determination marker 510 (also called a “protractor tool”). The pitch determination marker 510 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407.

[0075] The pitch determination marker 510 includes arms 510a-510d. Arms 510a-510c are axes, which are automatically aligned, based on the registration of image 406, with the major (X, Y, and Z) axes of the building roof. Arm 510d is a “protractor” arm that is adjustable by the operator to specify roof pitch.

[0076] The marker 510 is typically first moved by the operator to a convenient location on the building roof 407, usually corner of a planar section of the roof 407. Next, the operator adjusts arm 510d so that it substantially aligns with the sloped edge of the planar roof section. Then, the roof estimation system determines the pitch of the roof section, based on the configuration of the marker 510 with respect to the image and the reference grid.

[0077] After specifying the pitch of a planar roof section, the operator will typically specify other information about the planar roof section, such as its outline, as will be

described with reference to Figures 6A-6D. Note that as the operator provides additional information about the geometry of the roof 407, the roof estimation system may automatically determine the pitch and/or other features of at least some of the other planar roof sections, based on the provided geometric information and/or assumptions about roof symmetry or other standard architectural practices.

[0078] Figure 5C shows a second type of pitch determination marker being used in the context of image 403 which provides a south perspective view of the building roof 407. The illustrated pitch determination marker may be used in addition to, or instead of, the pitch determination marker 510 described with respect to Figures 5A-5B, above. In particular, Figure 5C shows a pitch determination marker 520 (also called an “envelope tool”) that includes surfaces 520a and 520b. The pitch determination marker 520 is an interactive user interface control that can be directly manipulated by the operator in order to specify the pitch of a section of the building roof 407. In particular, the pitch determination marker 520 may be moved and/or adjusted so that it appears to lie substantially atop two adjacent planar sections of roof 407.

[0079] Figure 5D shows the pitch determination marker 520 after the operator has used it to specify the pitch of two sections of roof 407. Here, the operator has moved the marker 520 to a position in which the spine of the marker 520 is substantially aligned with the ridge line of roof 407. Then, the operator has adjusted the angle of the surfaces 520a and 520b so that they appear to lie substantially atop corresponding sections of roof 407. Then, the roof estimation system determines the pitch of the roof sections, based on the configuration of the marker 520 with respect to the image and the reference grid. Also illustrated are pitch indicators 521 and 522. Pitch indicator 521 corresponds to the measured pitch of surface 520a, and pitch indicator 522 corresponds to the measured pitch of surface 520b. As the operator adjusts the angle of surfaces 520a and/or 520b, the corresponding pitch indicators 521-522 are automatically updated to reflect the determined pitch. In this example, the pitch of both surfaces is given as 4 inches of rise per foot of run.

[0080] The envelope pitch determination marker 520 may be adjusted in other ways, to specify pitches for types of roofs other than the gabled roof shown in image 403. For example, when measuring pitch of roof sections that form a roof hip, point 520c may be manipulated by the operator, such as by dragging it to the left or right, to adjust the shape of the surfaces 520a and 520b, so that the surfaces align with the edges formed by the intersection of the sections that form the roof hip.

[0081] Figures 6A-6D are screen displays illustrating model construction and concurrent display of operator specified roof features in an example embodiment. In particular, Figures 6A-6D illustrate the construction of a three dimensional wire frame model of a building roof, based on the specification of roof features by an operator. In addition, Figures 6A-6D illustrate the concurrent display of operator specified roof features in multiple views of a building roof.

[0082] Figure 6A shows the user interface screen 400 after images 402-406 have been registered, and after roof pitches have been determined. In this example, the operator is specifying sections of roof 407, visible in image 406, that are to be added to a 3D wire frame model of the roof 407 maintained by the roof estimation system. The specification of roof sections will be further described with reference to enlarged portion 608 of image 406 in Figure 6B, below. In addition, as the operator specifies roof sections in image 406, the roof estimation system concurrently displays the specified roof sections in each of the other images 402-405. The concurrent display of operator specified roof features will be further described with reference to enlarged portion 609 of image 402 in Figure 6C, below.

[0083] Figure 6B is an enlarged view of image portion 608 during the process of wire frame model construction in the context of image 406, which provides an east perspective view of the building roof 407. As shown in Figure 6B, the image portion 608 includes the building roof 407, drawing tool 610, and wire frame 611. The drawing tool 610 (also called a “drawing marker” or a “drawing control”) is an interactive user interface control that can be directly manipulated by the operator in order to specify roof features, such as edges, ridges, valleys, corners, etc. In the

illustrated embodiment, the operator uses the drawing tool 610 to trace or outline planar sections of the roof 407, leading to the generation of wire frame 611. The drawing tool 610 may be used to establish a series of connected line segments that result in a closed polygon representing a planar roof section. As the operator specifies a planar roof section in this manner, the roof estimation system determines, based on the image and the reference grid, the geometry of the planar roof section, and includes (adds) the specified planar roof section in a 3D model that corresponds to roof 407.

[0084] Figure 6C is an enlarged view of image portion 609 illustrating the concurrent display of operator specified roof features, in the context of image 402, which provides a top plan view of the building roof 407. As the operator specifies roof sections as described with respect to Figure 6B, the roof estimation system concurrently displays the specified roof features in one or more of the other images displayed by the user interface screen 400. More specifically, image portion 609 includes building roof 407 and wire frame 612. Wire frame 612 corresponds to wire frame 611 constructed by the operator with reference to Figure 6B, except that wire frame 612 is automatically displayed as a projection from the 3D model into the top-down view of image 402. Changes that the operator makes to wire frame 611 are concurrently displayed by the roof estimation system as wire frame 612 in image portion 609. For example, if a new planar roof section is added by the operator to wire frame 611, the new planar roof section is automatically displayed in wire frame 612. By concurrently displaying operator identified features in multiple views of building roof 407, the operator obtains feedback regarding the correctness and/or accuracy of the 3D model or other aspects of the model generation process, such as image registration and pitch determination.

[0085] Generally, the roof estimation system can be configured to concurrently display any operator-identified features, such as corners, ridges, valleys, planar sections, and the like, in multiple views of a building.

[0086] Furthermore, the concurrently displayed wire frame 612 is an interactive user interface element, in that the operator can make changes to the wire frame 612, which

are then concurrently displayed in wire frame 611. Wire frames similar to those described above are also projected by the roof estimation system into images 403, 404, and 405 displayed by the user interface screen 400. In this manner, the operator can switch between various images of the building roof 407, making refinements to the 3D model by adjusting the wire frame in whichever image is more convenient and/or provides a more suitable perspective/view of the model.

[0087] Figure 6D shows the user interface screen 400 during construction of a 3D model of the building roof 407. In particular, the user interface 400 includes a shaded wire frame 613 representation of the 3D model constructed as described above. In this view, the operator can review the wire frame 613 in isolation from any images to determine whether the wire frame 613 accurately represents the building roof 407. The wire frame 613 is an interactive user interface component, in that it can be directly manipulated (e.g., moved, rotated, resized, etc.). In some embodiments, manipulating the wire frame 613, such as by changing its shape, results in corresponding changes in the underlying 3D model.

C. Roof Model Review

[0088] Figures 7A-7C are screen displays illustrating roof model review in an example embodiment. In particular, Figures 7A-7C illustrate various techniques to facilitate the review of a roof model by an operator. Reviewing the roof model may include reviewing roof section pitches (e.g., to determine whether they conform to the building roof and/or standard construction practices), reviewing the shape and/or location of the roof model (e.g., to determine whether it substantially conforms to the building roof), etc.

[0089] Figure 7A shows the user interface screen 400 after the operator has constructed a model of the roof 407 using one or more of the images 402-406. In this example, a wire frame has been projected onto (superimposed upon) image 402 and annotated with roof section pitches, as will be described further with respect to enlarged portion 708 of image 402 in Figure 7B, below.

[0090] Figure 7B is an enlarged view of image portion 708 during the process of roof model review in the context of image 402, which provides a substantially top plan view of the building roof 407. As shown in Figure 7B, the image portion 708 includes a wire frame 710 and labels 711a-711c that indicate pitches of corresponding sections of roof 407. The wire frame 710 and the illustrated pitches are determined by the roof estimation system based on the pitch determination described with respect to Figures 5A-5D, above, and the operator's specification of the wire frame model described with respect to Figures 6A-6D, above.

[0091] The wire frame 710 includes multiple vertexes connected by line segments. Each vertex includes a handle, such as handle 710a. The handles may be directly manipulated (individually or in groups) by the operator to make adjustments/modifications to the wire frame 710. For example, when an operator drags handle 710a to a new location, the ends of the two line segments connected to handle 710a will also move to the new location.

[0092] Figure 7C is an alternative view of the 3D model of roof 407 during the process of roof model review. In Figure 7C, the user interface screen 400 includes a wire frame 720 representation of the 3D model of the roof 407. The wire frame 720 consists of multiple line segments corresponding to edges of planar roof sections. Each line segment is annotated with a label, such as label 723, indicating the determined length of the corresponding roof section edge. Furthermore, some of the line segments indicate that they correspond to a particular roof feature. For example, line segments 721 and 722 may be colored (e.g., red) so as to indicate that they correspond to roof ridges. Other line segments may be differently colored (e.g., blue) so as to indicate a correspondence to roof valleys or other features. In addition, the wire frame 720 may be directly manipulated by the operator in order to make adjustments to the underlying model of the roof 407. For example, the operator could increase or decrease the length of line segment 721, resulting in a change in the corresponding feature of the 3D model of roof 407.

[0093] Note that although the operator is shown, in Figures 5-7 above, operating upon a total of five images, in other cases, fewer images may be used. For example, in some cases fewer images may be available, or some images may provide obstructed views of the building roof, such as due to tree cover, neighboring buildings, etc.

3. Implementation Techniques

[0094] Figure 8 is an example block diagram of a computing system for practicing embodiments of a roof estimation system. Figure 8 shows a computing system 800 that may be utilized to implement a Roof Estimation System (“RES”) 810. One or more general purpose or special purpose computing systems may be used to implement the RES 810. More specifically, the computing system 800 may comprise one or more distinct computing systems present at distributed locations. In addition, each block shown may represent one or more such blocks as appropriate to a specific embodiment or may be combined with other blocks. Moreover, the various blocks of the RES 810 may physically reside on one or more machines, which use standard inter-process communication mechanisms (*e.g.*, TCP/IP) to communicate with each other. Further, the RES 810 may be implemented in software, hardware, firmware, or in some combination to achieve the capabilities described herein.

[0095] In the embodiment shown, computing system 800 comprises a computer memory (“memory”) 801, a display 802, one or more Central Processing Units (“CPU”) 803, Input/Output devices 804 (*e.g.*, keyboard, mouse, joystick, track pad, CRT or LCD display, and the like), other computer-readable media 805, and network connections 806. The RES 810 is shown residing in memory 801. In other embodiments, some portion of the contents, some of, or all of the components of the RES 810 may be stored on and/or transmitted over the other computer-readable media 805. The components of the RES 810 preferably execute on one or more CPUs 803 and generate roof estimate reports, as described herein. Other code or programs 830 (*e.g.*, a Web server, a database management system, and the like) and potentially other data repositories, such as data repository 820, also reside in the

memory 801, and preferably execute on one or more CPUs 803. Not all of the components in Figure 8 are required for each implementation. For example, some embodiments embedded in other software do not provide means for user input, for display, for a customer computing system, or other components.

[0096] In a typical embodiment, the RES 810 includes an image acquisition engine 811, a roof modeling engine 812, a report generation engine 813, an interface engine 814, and a roof estimation system data repository 816. Other and/or different modules may be implemented. In addition, the RES 810 interacts via a network 850 with an image source computing system 855, an operator computing system 865, and/or a customer computing system 860.

[0097] The image acquisition engine 811 performs at least some of the functions of the image acquisition engine 101 described with reference to Figure 1. In particular, the image acquisition engine 811 interacts with the image source computing system 855 to obtain one or more images of a building, and stores those images in the RES data repository 816 for processing by other components of the RES 810. In some embodiments, the image acquisition engine 811 may act as an image cache manager, such that it preferentially provides images to other components of the RES 810 from the RES data repository 816, while obtaining images from the image source computing system 855 when they are not already present in the RES data repository 816. In other embodiments, images may be obtained in an “on demand” manner, such that they are provided, either by the image acquisition engine 811 or the image source computing system 855, directly to modules of the RES 810 and/or the operator computing system 865, without intervening storage in the RES data repository 816.

[0098] The roof modeling engine 812 performs at least some of the functions of the roof modeling engine 102 described with reference to Figure 1. In particular, the roof modeling engine 812 generates a model based on one or more images of a building that are obtained from the RES data repository 816 or directly from the image source computing system 855. As noted, model generation may be performed semi-automatically, based on at least some inputs received from the computing system

865. In addition, at least some aspects of the model generation may be performed automatically, based on image processing and/or image understanding techniques. After the roof modeling engine 812 generates a model, it stores the generated model in the RES data repository 816 for further processing by other components of the RES 810.

[0099] The report generation engine 813 performs at least some of the functions of the report generation engine 103 described with reference to Figure 1. In particular, the report generation engine 813 generates roof reports based on models stored in the RES data repository 816. Generating a roof report may include preparing one or more views of a given 3D model of a roof, annotating those views with indications of various characteristics of the model, such as dimensions of sections or other features (e.g., ridges, valleys, etc.) of the roof, slopes of sections of the roof, areas of sections of the roof, etc. In some embodiments, the report generation engine 813 facilitates transmission of roof measurement information that may or may not be incorporated into a roof estimate report. For example, the roof generation engine 813 may transmit roof measurement information based on, or derived from, models stored in the RES data repository 816. Such roof measurement information may be provided to, for example, third-party systems that generate roof estimate reports based on the provided information.

[00100] The interface engine 814 provides a view and a controller that facilitate user interaction with the RES 810 and its various components. For example, the interface engine 814 implements a user interface engine 104 described with reference to Figure 1. Thus, the interface engine 814 provides an interactive graphical user interface that can be used by a human user operating the operator computing system 865 to interact with, for example, the roof modeling engine 812, to perform functions related to the generation of models, such as point registration, feature indication, pitch estimation, etc. In other embodiments, the interface engine 814 provides access directly to a customer operating the customer computing system 860, such that the customer may place an order for a roof estimate report for an indicated building

location. In at least some embodiments, access to the functionality of the interface engine 814 is provided via a Web server, possibly executing as one of the other programs 830.

[00101] In some embodiments, the interface engine 814 provides programmatic access to one or more functions of the RES 810. For example, the interface engine 814 provides a programmatic interface (e.g., as a Web service, static or dynamic library, etc.) to one or more roof estimation functions of the RES 810 that may be invoked by one of the other programs 830 or some other module. In this manner, the interface engine 814 facilitates the development of third-party software, such as user interfaces, plug-ins, adapters (e.g., for integrating functions of the RES 810 into desktop applications, Web-based applications, embedded applications, etc.), and the like. In addition, the interface engine 814 may be in at least some embodiments invoked or otherwise accessed via remote entities, such as the operator computing system 865, the image source computing system 855, and/or the customer computing system 860, to access various roof estimation functionality of the RES 810.

[00102] The RES data repository 816 stores information related the roof estimation functions performed by the RES 810. Such information may include image data 105, model data 106, and/or report data 107 described with reference to Figure 1. In addition, the RES data repository 816 may include information about customers, operators, or other individuals or entities associated with the RES 810.

[00103] In an example embodiment, components/modules of the RES 810 are implemented using standard programming techniques. For example, the RES 810 may be implemented as a “native” executable running on the CPU 803, along with one or more static or dynamic libraries. In other embodiments, the RES 810 is implemented as instructions processed by virtual machine that executes as one of the other programs 830. In general, a range of programming languages known in the art may be employed for implementing such example embodiments, including representative implementations of various programming language paradigms, including but not limited to, object-oriented (e.g., Java, C++, C#, Matlab, Visual

Basic.NET, Smalltalk, and the like), functional (e.g., ML, Lisp, Scheme, and the like), procedural (e.g., C, Pascal, Ada, Modula, and the like), scripting (e.g., Perl, Ruby, Python, JavaScript, VBScript, and the like), declarative (e.g., SQL, Prolog, and the like).

[00104] The embodiments described above may also use well-known synchronous or asynchronous client-server computing techniques. However, the various components may be implemented using more monolithic programming techniques as well, for example, as an executable running on a single CPU computer system, or alternatively decomposed using a variety of structuring techniques known in the art, including but not limited to, multiprogramming, multithreading, client-server, or peer-to-peer, running on one or more computer systems each having one or more CPUs. Some embodiments execute concurrently and asynchronously, and communicate using message passing techniques. Equivalent synchronous embodiments are also supported by an RES implementation. Also, other functions could be implemented and/or performed by each component/module, and in different orders, and by different components/modules, yet still achieve the functions of the RES.

[00105] In addition, programming interfaces to the data stored as part of the RES 810, such as in the RES data repository 816, can be available by standard mechanisms such as through C, C++, C#, and Java APIs; libraries for accessing files, databases, or other data repositories; through scripting languages such as XML; or through Web servers, FTP servers, or other types of servers providing access to stored data. For example, the RES data repository 816 may be implemented as one or more database systems, file systems, memory buffers, or any other technique for storing such information, or any combination of the above, including implementations using distributed computing techniques.

[00106] Also, the example RES 810 can be implemented in a distributed environment comprising multiple, even heterogeneous, computer systems and networks. For example, in one embodiment, the image acquisition engine 811, the roof modeling engine 812, the report generation engine 813, the interface engine 814, and the data

repository 816 are all located in physically different computer systems. In another embodiment, various modules of the RES 810 are hosted each on a separate server machine and are remotely located from the tables which are stored in the data repository 816. Also, one or more of the modules may themselves be distributed, pooled or otherwise grouped, such as for load balancing, reliability or security reasons. Different configurations and locations of programs and data are contemplated for use with techniques of described herein. A variety of distributed computing techniques are appropriate for implementing the components of the illustrated embodiments in a distributed manner including but not limited to TCP/IP sockets, RPC, RMI, HTTP, Web Services (XML-RPC, JAX-RPC, SOAP, and the like).

[00107] Furthermore, in some embodiments, some or all of the components of the RES are implemented or provided in other manners, such as at least partially in firmware and/or hardware, including, but not limited to one or more application-specific integrated circuits (ASICs), standard integrated circuits, controllers (*e.g.*, by executing appropriate instructions, and including microcontrollers and/or embedded controllers), field-programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), and the like. Some or all of the system components and/or data structures may also be stored (*e.g.*, as software instructions or structured data) on a computer-readable medium, such as a hard disk, a memory, a network, or a portable media article to be read by an appropriate drive or via an appropriate connection. The system components and data structures may also be stored as data signals (*e.g.*, by being encoded as part of a carrier wave or included as part of an analog or digital propagated signal) on a variety of computer-readable transmission mediums, which are then transmitted, including across wireless-based and wired/cable-based mediums, and may take a variety of forms (*e.g.*, as part of a single or multiplexed analog signal, or as multiple discrete digital packets or frames). Such computer program products may also take other forms in other embodiments. Accordingly, embodiments of this disclosure may be practiced with other computer system configurations.

[00108] Figure 9 is an example flow diagram of an image registration routine provided by an example embodiment. The illustrated routine 900 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 900 facilitates image registration based upon operator indicated registration points and/or image lean corrections.

[00109] More specifically, the routine begins in step 901, where it displays, on a user interface screen, an aerial image of a building having a roof. As part of the user interface screen, the routine also displays user interface controls such as markers that may be used by an operator for purposes of image registration and/or lean correction, as described with reference to Figure 4A, above.

[00110] In step 902, the routine receives, via one or more registration markers, indications of one or more points on the aerial image. The registration markers are manipulated by the operator to specify points on the aerial image, as described with reference to Figures 4A-4E. Typically, the points are visually identifiable features, such as corners of the roof of the building. For example, if the roof has four corners (e.g., a northwest, southwest, northeast, and southwest corner) the operator may place one registration marker on each of the four corners as shown in the aerial image. Then, the positions (e.g., coordinates on the aerial image) of the markers are transmitted to the routine for use in registering the aerial image, as described below.

[00111] In step 903, the routine receives, via a lean correction marker, an indication of the vertical axis of the building roof. In at least some cases, the aerial image of the building is out of alignment with respect to the vertical axis of the building. This may be caused, for example, by pitch, roll, and/or yaw experienced by the aircraft during the process of photographing the building. To correct for such misalignment, the lean correction marker is manipulated by the operator to indicate a vertical axis of the building. Typically, the operator aligns the lean correction marker with known, substantially vertical feature of the building, such as a chimney, wall corner, etc., as described with reference to Figure 4E, above. After the operator has aligned the lean correction marker, the position (e.g., angle of the marker, coordinates of the endpoints

of the marker, etc.) of the lean correction marker is transmitted to the routine for use in registering the aerial image, as described below.

[00112] Particular benefits may be obtained from lean correction performed in the context of an overhead, or “top down,” view. An “overhead lean” occurs when the camera is not directly overhead with respect to the building when the photo is taken. In some cases, leans in excess of 5 degrees have been observed in “top down” photos. Furthermore, unlike oblique, perspective views, a top-down lean is typically less likely to include a convenient visual marker that provides sufficient angle to assess the lean direction and magnitude, such as the edge of the building or a tall chimney. An overhead lean affects the perceived location of the roof lines in a top down view. This effect is amplified as the pitch of the roof increases and/or as the vertical separation between disconnected roof sections increases. Without lean correction, superimposing a wire frame over the visible ridgelines (and other features of a building that reside at different elevations) may produce asymmetries in otherwise symmetric structures. Further, an absence of lean correction may introduce errors in pitch estimation, as the wire frame may not appear consistent between top and oblique view points. More specifically, without top view lean correction, the positions for the roof lines in an otherwise correct (*i.e.*, accurate with respect to the actual geometry of the roof) wire frame will typically not line up on the visible roof lines in the overhead reference photo. This often leads the user (or software) to either introduce errors by incorrectly drawing the wire frame to the image lines or perform a subjective determination of where and how to shift the wire frame lines off the image lines to produce a correct model. Top view lean correction allows the roof estimation system to trace to, or substantially to, the actual roof lines seen in the top image while still producing an accurate wire frame model.

[00113] Image misalignment may be specified in other ways. For example, in other embodiments, the operator may instead rotate the image to a position in which the building appears to be in a substantially vertical position. Then, the angle of rotation of the image may be transmitted to the routine for use in registering the aerial image.

[00114] In step 904, the routine registers, based on the received indications of the points and/or the received indication of the vertical axis, the aerial image to a reference grid. Registering the image to a reference grid may include determining a transformation between the reference grid and the image, based on the indicated points and/or the indicated vertical axis. Determining such a transformation may be based on other information as well, such as meta-information associated with the aerial image. In some embodiments, the aerial image has corresponding meta-information that includes image capture conditions, such as camera type, focal length, time of day, camera position (e.g., latitude, longitude, and/or elevation), etc.

[00115] In step 905, the routine determines whether there are additional aerial images to be registered, and if so, returns to step 901, else proceeds to step 906. During execution of the loop of steps 901-905, the operator typically indicates, for each registration marker, the same feature (e.g., corner) of the roof as shown in each of multiple images, such that the routine can register the multiple images to a single, uniform reference grid. Upon completion of the registration process, the routine has determined a uniform coordinate system for the multiple aerial images, for use during other phases of model construction, such as pitch determination or feature identification.

[00116] In step 906, the routine generates a three-dimensional model based at least in part on the aerial image(s) and the reference grid. As discussed above with reference to Figures 5A-5D and 6A-6D, model generation includes identification of roof features shown in various images of the roof, such as edges, planar sections, vertexes, and the like, as well as determination of roof pitch and other dimensional attributes of the roof. In other embodiments, the routine performs other functions with the registered images, such as storing them for later use (e.g., by an automated model generation module), transmitting them to another computing (e.g., for use in a third-party design application), etc. After step 906, the routine ends.

[00117] Note that in at least some embodiments, aspects of the routine 900 may be performed in an automated manner. For example, operations discussed above as

being performed by an operator, such as the determination of the location of image registration points of step 902 and/or the indication of lean of step 903, may be performed by automated image processing techniques.

[00118] Figure 10 is an example flow diagram of a pitch determination routine provided by an example embodiment. The illustrated routine 1000 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1000 facilitates the determination of the pitch of a section of a roof, by displaying a pitch determination marker and modifying a 3D model of a roof based on an indication of roof pitch received via the pitch determination marker.

[00119] More specifically, the routine begins at step 1001 where it displays an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch. The aerial image is displayed in the context of a user interface screen, such as is described with reference to Figures 4A-6C, above. The aerial images may be received from, for example, the image source computing system 855 and/or from the RES data repository 816 described with reference to Figure 8. As discussed above, aerial images may be originally created by cameras mounted on airplanes, balloons, satellites, etc. In some embodiments, images obtained from ground-based platforms (*e.g.*, vehicle-mounted cameras) may be used instead or in addition.

[00120] In step 1002, the routine displays a pitch determination marker operable to indicate pitch of a planar roof section. The pitch determination marker may be, for example, a pitch determination marker 510 (“protractor tool”) or 520 (“envelope tool”), such as are respectively described with respect to Figures 5B and 5C, above. The routine displays the pitch determination marker by, for example, presenting it on a user interface screen displayed on a computer monitor or other display device. The pitch determination marker is a direct manipulation user interface control, in that an operator may manipulate it (*e.g.*, adjust an angle, change its shape, alter its position, etc.) in order to indicate pitch of a planar roof section. Additional details regarding pitch determination controls are provided with respect to Figures 5A-5D, above.

[00121] In step 1003, the routine receives, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building. Receiving an indication of the pitch includes receiving an indication (*e.g.*, via an event, callback, etc.) that the marker has been manipulated by the operator, and then determining an angle based on the shape and/or position of the marker. In some embodiments, such an indication may be received on an event driven basis, such as every time the marker is manipulated in some manner. In other embodiments, the routine may poll the marker from time to time to determine its current state. In addition, the operator may explicitly indicate that the current state of the marker is to be transmitted to the routine, such as by pressing a button or other indication.

[00122] In step 1004, the routine modifies a three-dimensional model of the roof based on the received indication of the pitch of the one planar roof section. Modifying the 3D model of the roof includes associating the indicated pitch with a portion of the model corresponding to the one planar roof section. For example, the 3D model may include one or more data structures representing planar roof sections, and the indicated pitch may be included as part of the data structure representing the one planar roof section. In some embodiments, the 3D model may not at this point include representations of the planar roof sections, such as because the operator has not yet specified them. In such a case, the routine may store the indicated pitch in association with the location and orientation at which the pitch was specified by the operator, as determined from the aerial image. Then, at a later time, when the operator specifies a roof section that has the same orientation as the stored pitch and that includes or is near the stored location, the roof estimation system can store the indicated pitch in association with the specified roof section.

[00123] After step 1004, the routine ends. In other embodiments, the routine may instead return to step 1001, to determine the pitch for another planar roof section (of the same or different roof).

[00124] Figure 11 is an example flow diagram of concurrent feature display routine provided by an example embodiment. The illustrated routine 1100 may be provided by, for example, execution of the roof estimation system 810 described with respect to Figure 8. The illustrated routine 1100 concurrently displays operator indicated features in multiple aerial images of a building roof.

[00125] More specifically, the routine begins in step 1101, where it displays a first and a second aerial image of a building having a roof, each of the aerial images providing a different view of the roof of the building. The aerial images are displayed in the context of a user interface screen, such as is described with reference to Figures 6A-6C, above.

[00126] In step 1102, the routine receives an indication of a feature of the building shown in the first aerial image. The indication is typically received via a user interface control, such as a drawing tool or marker, upon its manipulation by an operator. For example, the operator may manipulate a drawing tool in order to specify one or more features of the building roof, such as a corner on the roof, an edge of the roof, an outline of a section of the roof, etc. In one embodiment, the operator utilizes a drawing tool to indicate roof section corner points and roof section edges connecting those corner points. Additional details regarding feature indication are provided with respect to Figures 6A-6C, above.

[00127] In step 1103, the routine modifies a three-dimensional model of the roof based on the received indication of the feature of the building. Modifying the 3D model may include adding or updating the indicated feature to a wire frame model of the roof. For example, if the indicated feature is a roof section corner point, the corner point will be added to the 3D model, along with the location (e.g., the X, Y, and Z position of the point) of the point. The location of the point is automatically determined based on a translation of the position of the point in the image to a point in the uniform reference grid associated with the image. If the indicated feature is a roof section edge, the edge will be added to the 3D model, such as by associating the edge with two points corresponding to the end points of the edge. Higher-level features can also be

indicated. For example, a planar roof section may be indicated by “closing” a sequence of two or more connected line segments, to create a closed polygon that represents the outline or perimeter of the planar roof section.

[00128] In step 1104, the routine concurrently displays a projection of the feature from the modified three-dimensional model onto the first and second aerial images. In one embodiment, displaying the feature from the modified three-dimensional model includes projecting the three-dimensional model onto both the first and second aerial images. For example, if the first image (for which the indicated feature was received) provides a west view of the building, and the second image provides an east view of the building, the routine will concurrently display a projection of the indicated feature from the 3D model onto both the first and second images. The projection of the indicated feature into the second image is based at least in part on a translation from the position of the feature in the reference grid to a position in the second image. In addition, the concurrent display onto two or more images occurs at substantially the same time (within a short time interval, at times that are substantially coincident) as the indication of the feature of the building in step 1102, giving the operator the illusion that as they are indicating a feature in the first image, the feature is being simultaneously projected into the second image.

[00129] After step 1104, the routine ends. In other embodiments, the routine may instead return to step 1101, to perform an interactive loop of steps 1101-1104 with the operator, so that the routine can concurrently display multiple features as they are indicated by the operator. Note that in such an embodiment, each iteration of the loop of steps 1101-1104 may be performed at near real-time speeds, so as to provide a fluid, interactive model generation experience for the operator enabling the operator to drag, draw, or otherwise indicate/manipulate features in a first image and view the results of their work concurrently projected into a second image.

[00130] All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications

referred to in this specification and/or listed in the Application Data Sheet, including but not limited to U.S. Provisional Patent Application No. 61/197,904, entitled "USER INTERFACE SYSTEMS AND METHODS FOR ROOF ESTIMATION," filed October 31, 2008, are incorporated herein by reference, in their entireties.

[00131] From the foregoing it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the present disclosure. For example, the methods, systems, and techniques for generating and providing roof estimate reports discussed herein are applicable to other architectures other than the illustrated architecture or a particular roof estimation system implementation. Also, the methods and systems discussed herein are applicable to differing network protocols, communication media (optical, wireless, cable, etc.) and devices (such as wireless handsets, electronic organizers, personal digital assistants, portable email machines, game machines, pagers, navigation devices such as GPS receivers, etc.). Further, the methods and systems discussed herein may be utilized by and/or applied to other contexts or purposes, such as by or for solar panel installers, roof gutter installers, awning companies, HVAC contractors, general contractors, and/or insurance companies.

CLAIMS

1. A computer-implemented method for generating a roof estimate report, the method comprising:
 - displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch;
 - displaying a pitch determination marker operable to indicate pitch of a planar roof section;
 - receiving, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building; and
 - modifying a model of the roof based on the received indication of the pitch of the one planar roof section.
2. The method of claim 1 wherein the pitch determination marker is adjustable to specify pitch of a planar roof section.
3. The method of claim 1 further comprising:
 - transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section.
4. The method of claim 1 wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building.
5. The method of claim 1 further comprising:
 - displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

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

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

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

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

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

a memory;

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

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

display a pitch determination marker operable to indicate pitch of a planar roof section;

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

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

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

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

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

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

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

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

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

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

displaying a pitch determination marker operable to indicate pitch of the planar roof section;

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

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

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

18. The computer-readable storage medium of claim 16 wherein the method further comprises:

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

and

transmitting the generated roof estimate report.

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

20. The computer-readable storage medium of claim 16 wherein the method further comprises:

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

transmitting the determined roof measurement information.

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

22. The computer-readable storage medium of claim 16 wherein the method further comprises:

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

23. The computer-readable storage medium of claim 16 wherein the method further comprises:

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

24. The computer-readable storage medium of claim 23 wherein registering multiple images includes:

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

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

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

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

26. The computer-readable storage medium of claim 16 wherein the method further comprises:

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

27. The computer-readable storage medium of claim 26 wherein correcting misalignment of the aerial image includes:

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

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

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

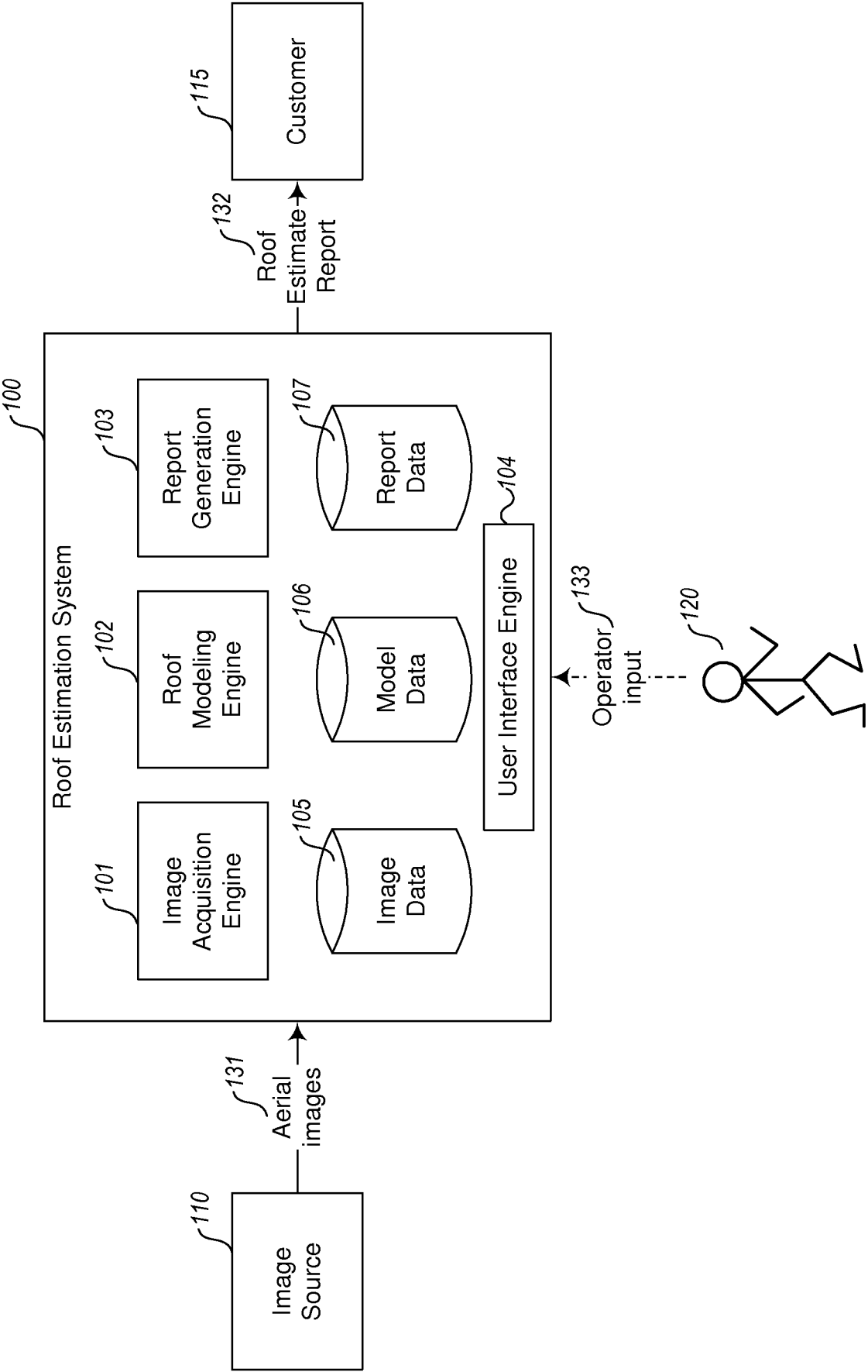
28. The computer-readable storage medium of claim 16 wherein modifying the model of the roof includes modifying a three-dimensional model of the roof.

ABSTRACT OF THE DISCLOSURE

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

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Fig. 1



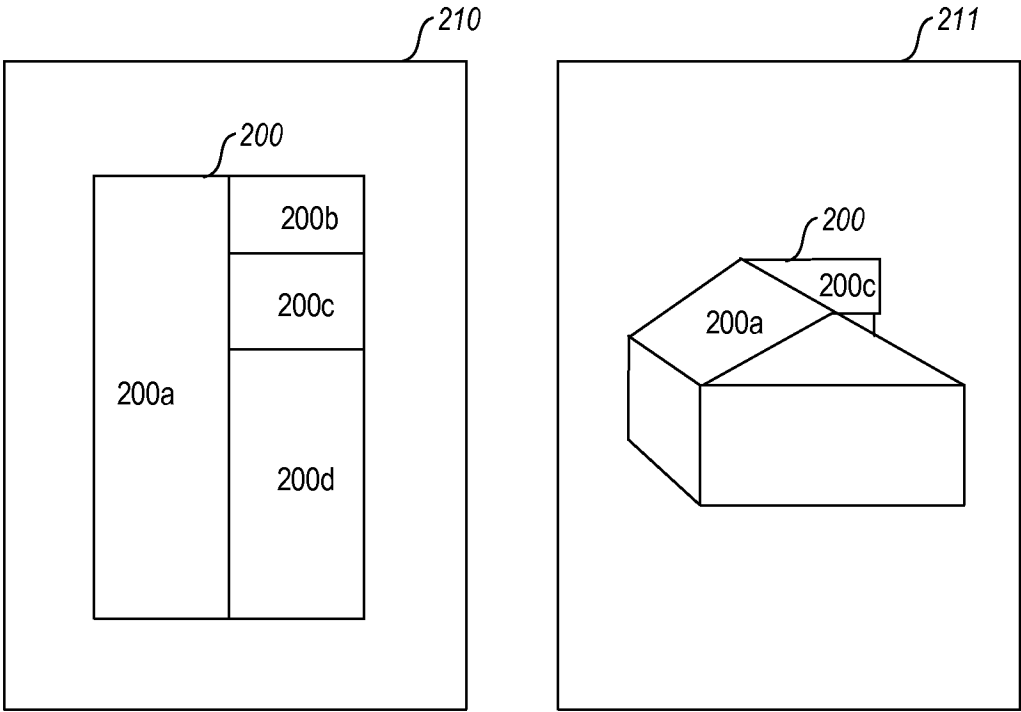


Fig. 2A

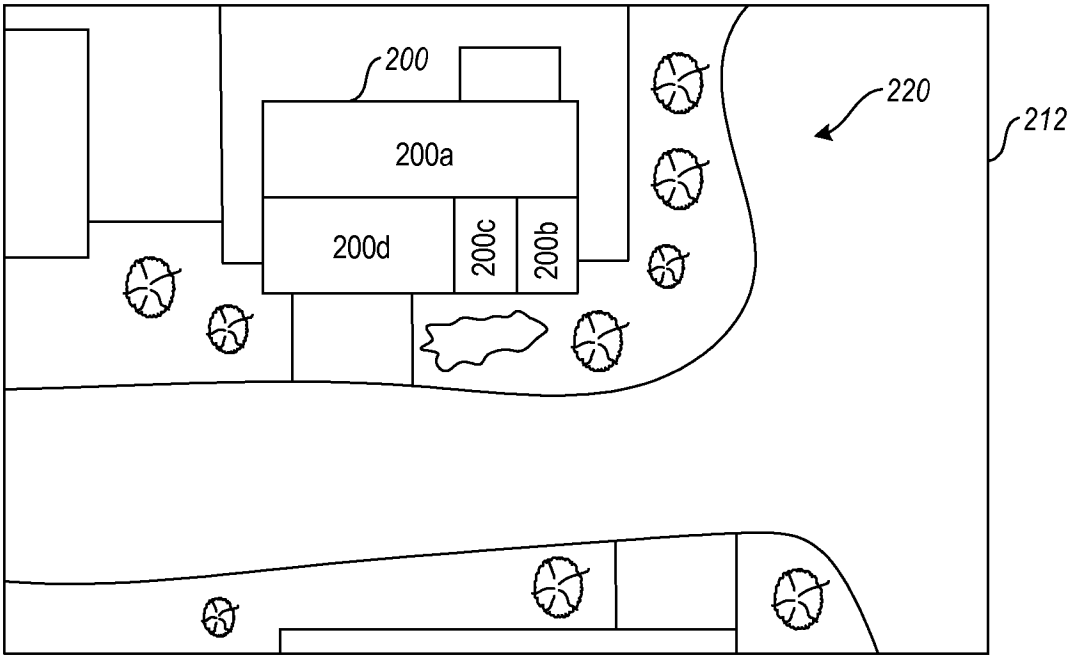


Fig. 2B

1234 Main Street, Redmond, WA

Order: 2468

<Customer Name Here>

4/16/2008

1234 Main Street, Redmond, WA



Order: 2468

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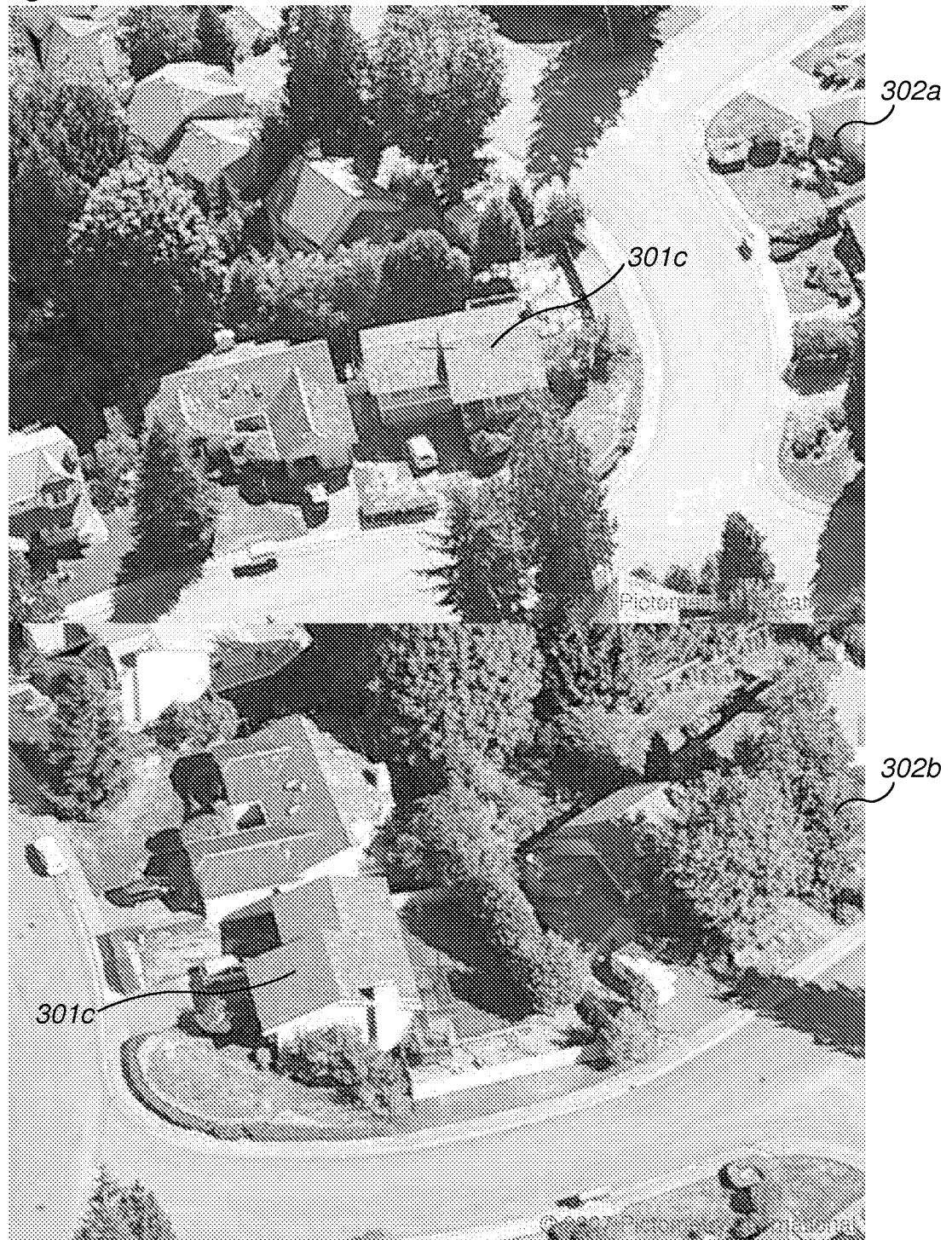
Page 1 of 6

301

Fig. 3A

1234 Main Street, Redmond, WA

Images:



302

Fig. 3B

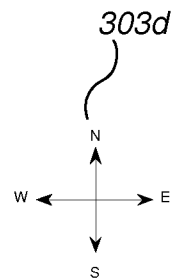
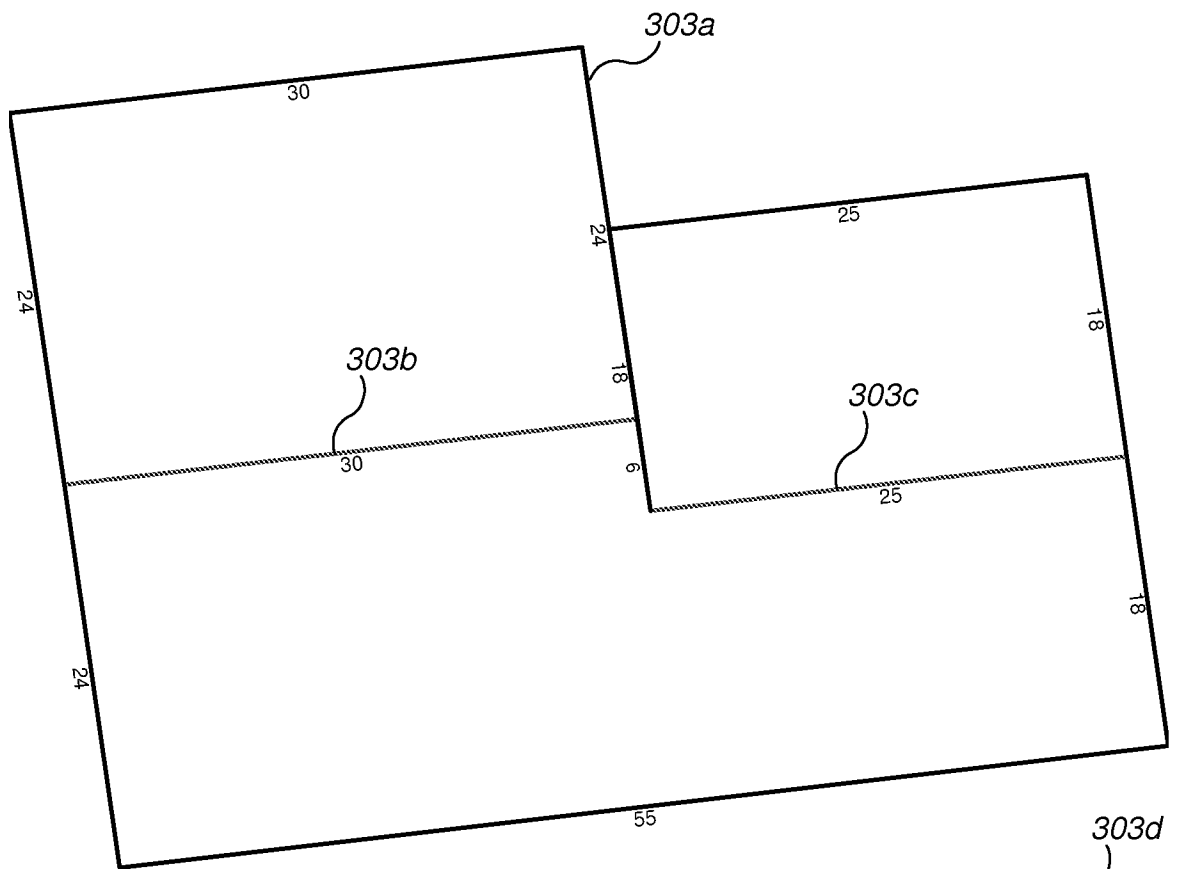
1234 Main Street, Redmond, WA

Length Diagram:

All measurements are rounded to the nearest foot

Ridge Length = 55 ft [Red Lines]

Valley Length = 0 ft [Blue lines]



Order: 2468

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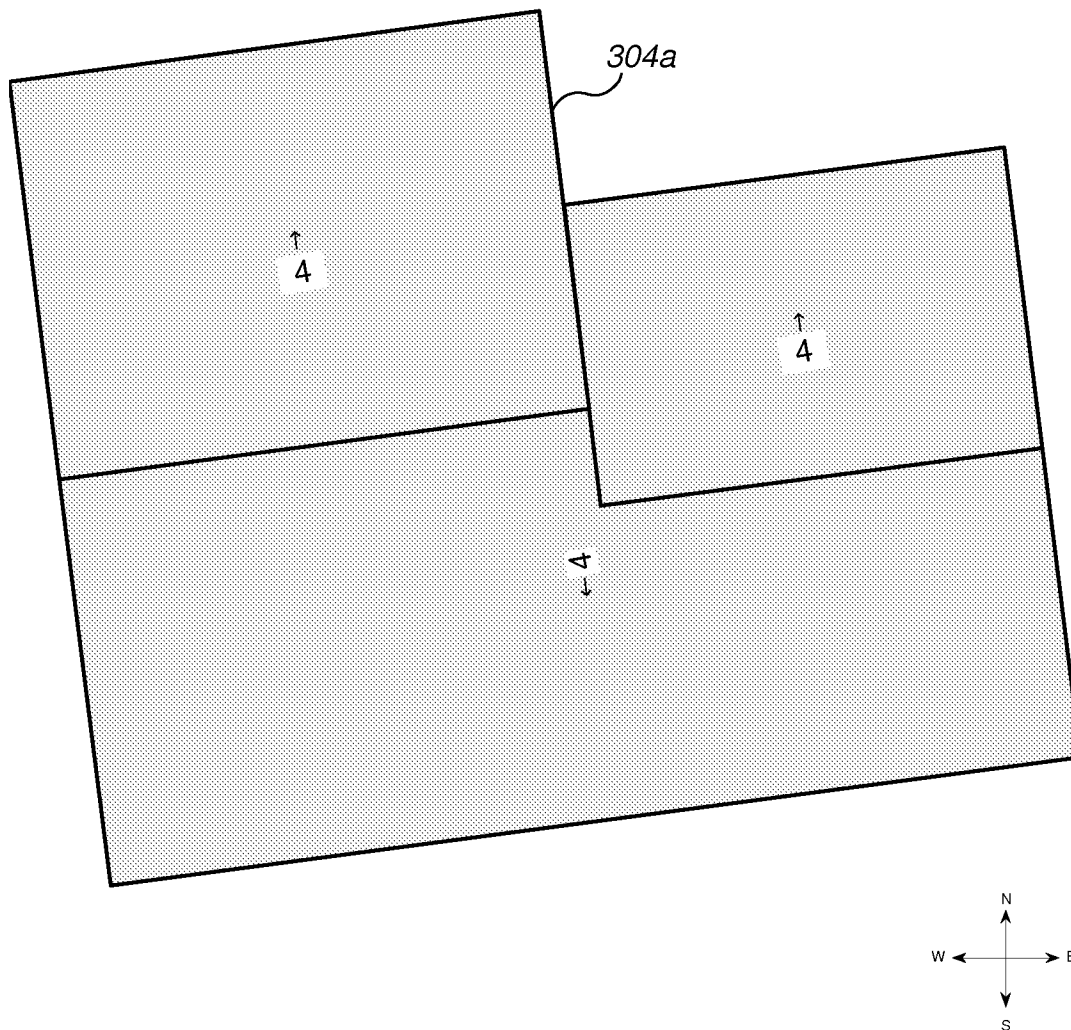
303

Fig. 3C

1234 Main Street, Redmond, WA

Pitch Diagram:

Pitch units are inches per foot.



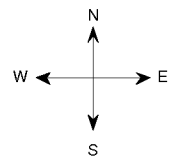
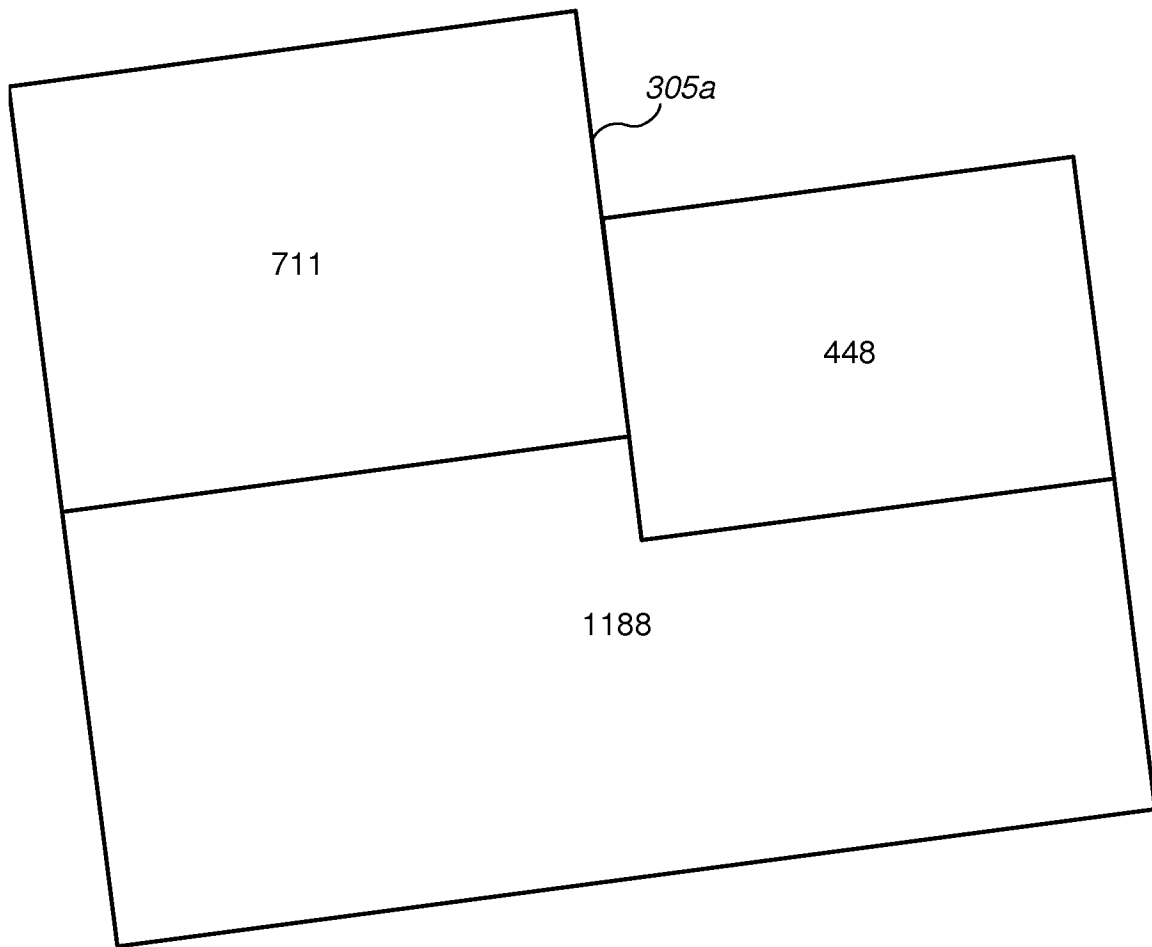
304

Fig. 3D

1234 Main Street, Redmond, WA

Area Diagram:

Total Area = 2347 sqft

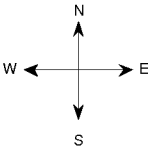
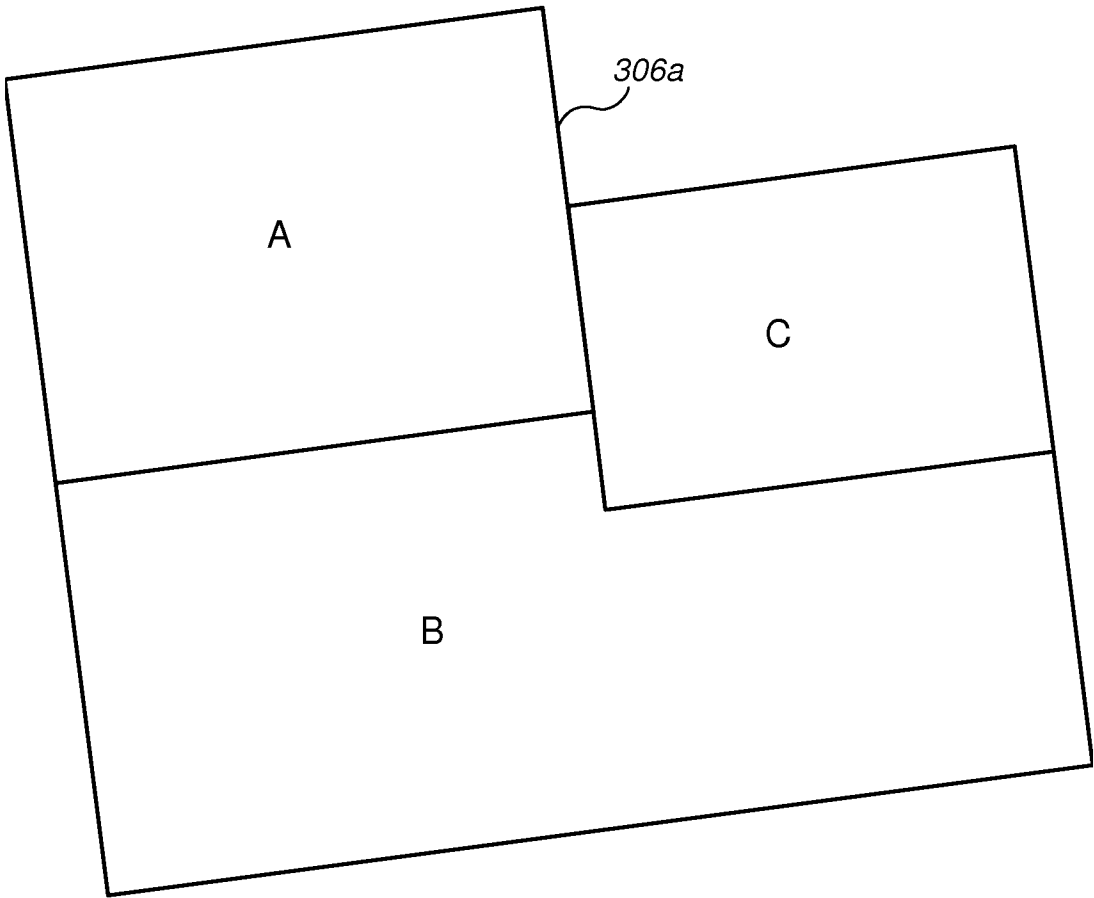


305

Fig. 3E

1234 Main Street, Redmond, WA

Notes:



306

Fig. 3F

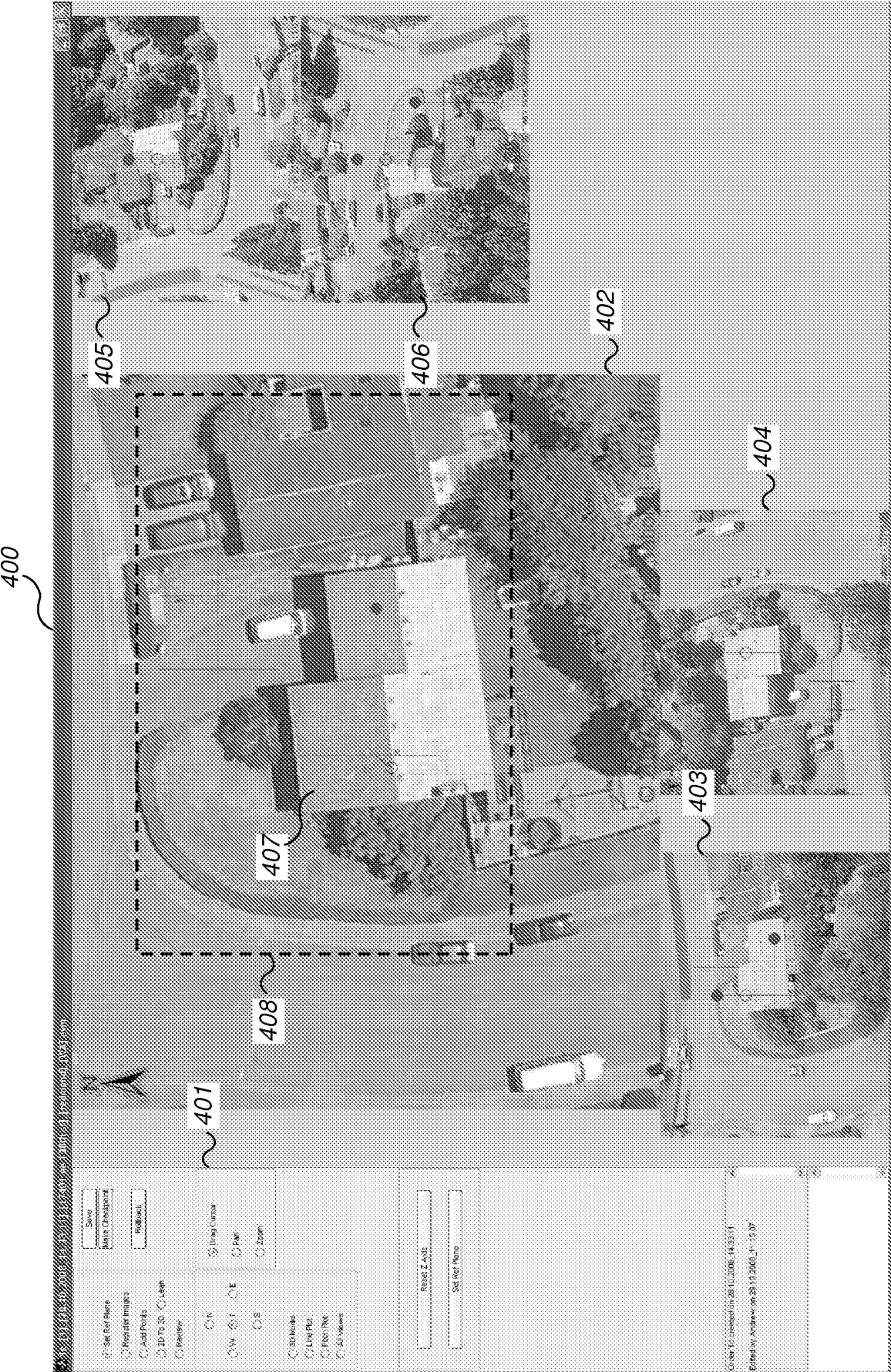


Fig. 4A

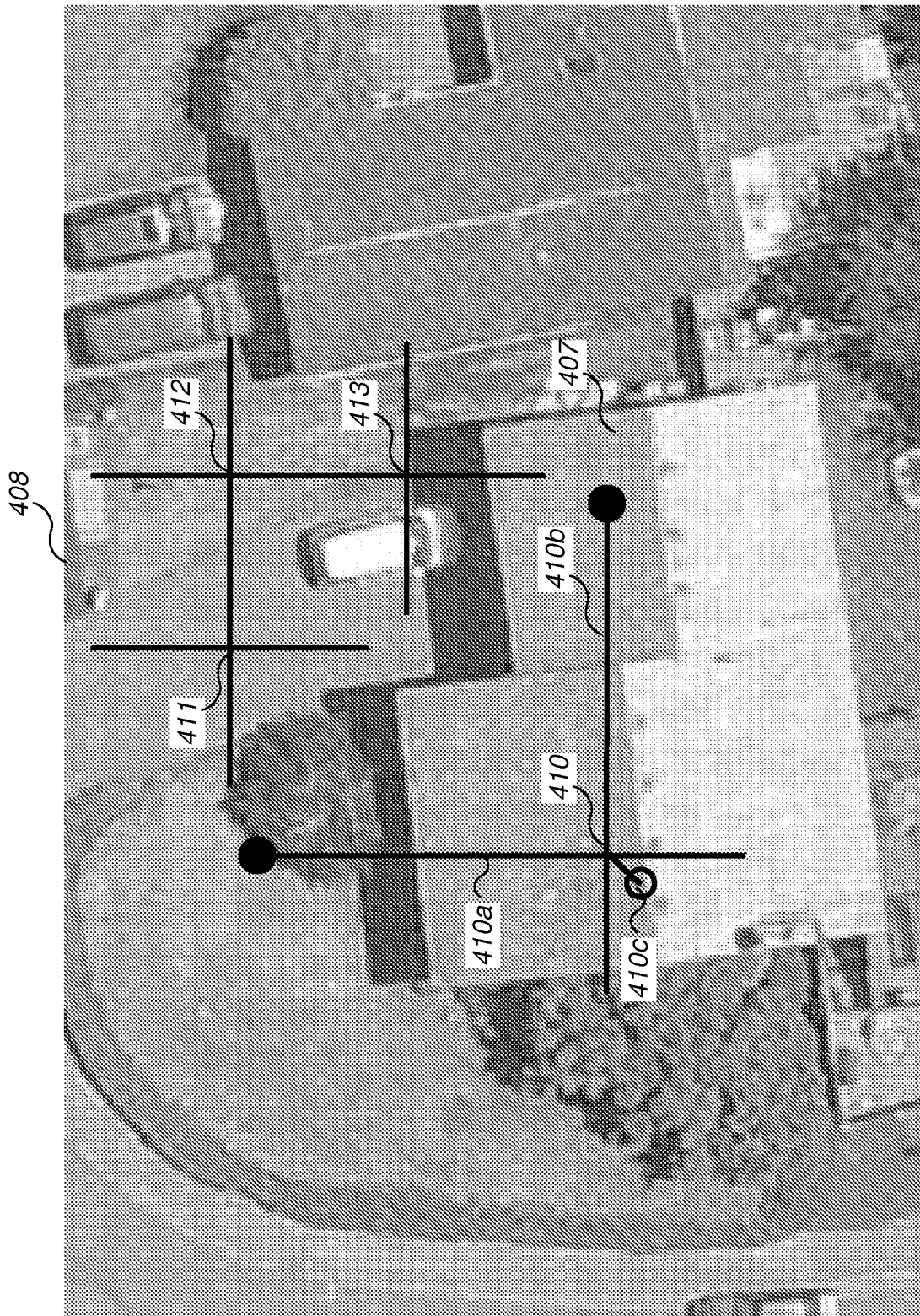


Fig. 4B

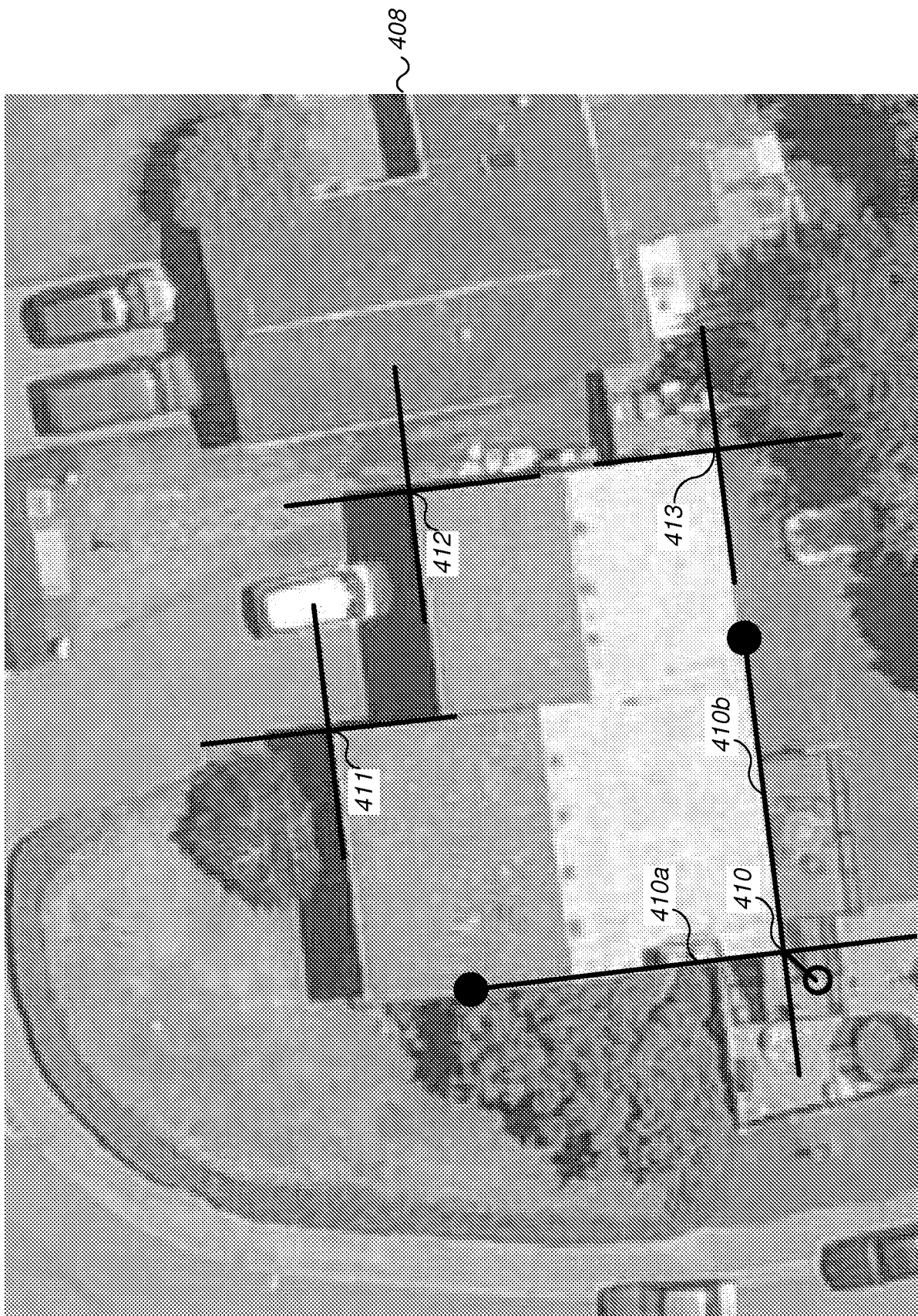


Fig. 4C

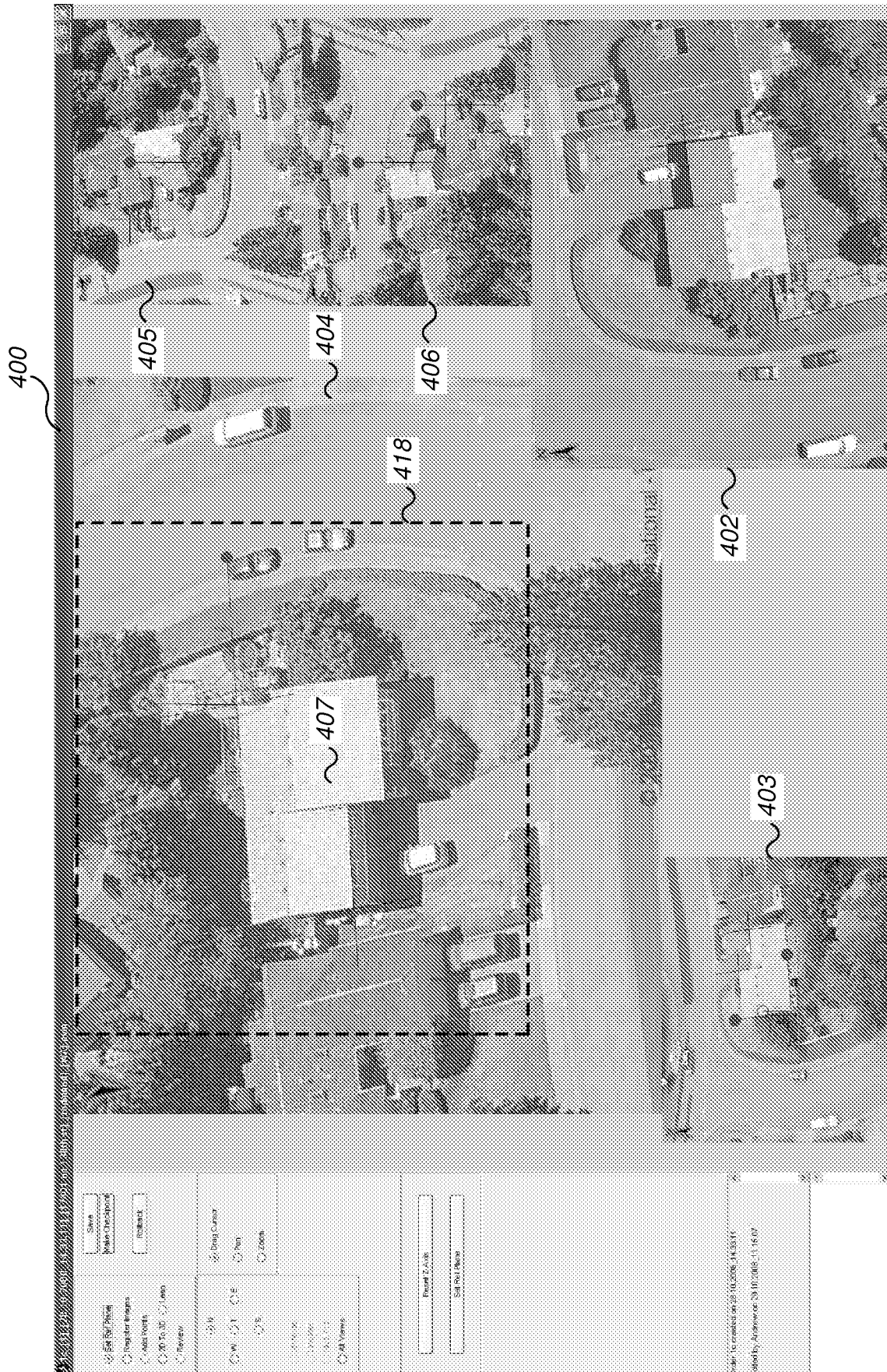


Fig. 4D

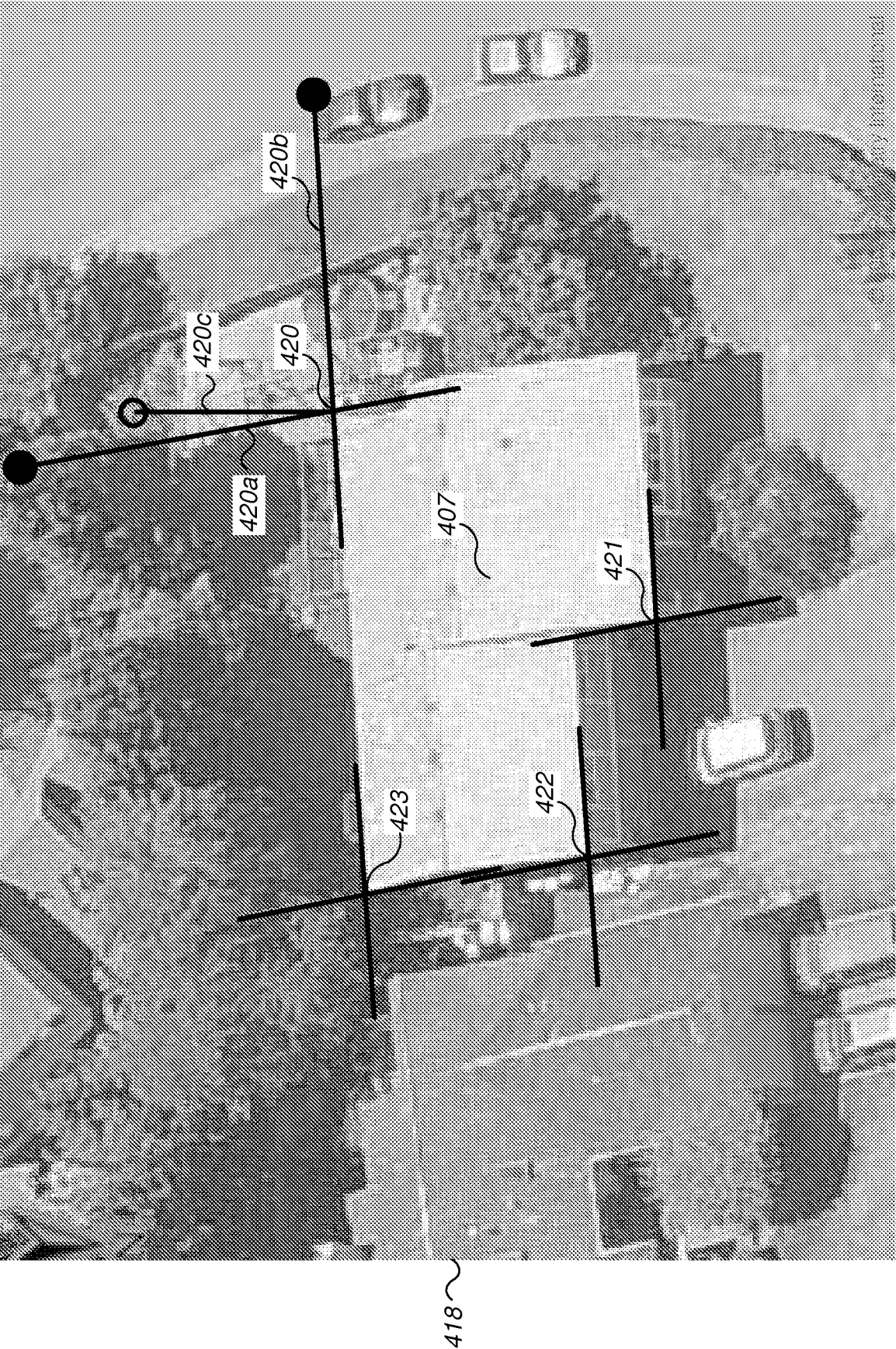


Fig. 4E



Fig. 4F

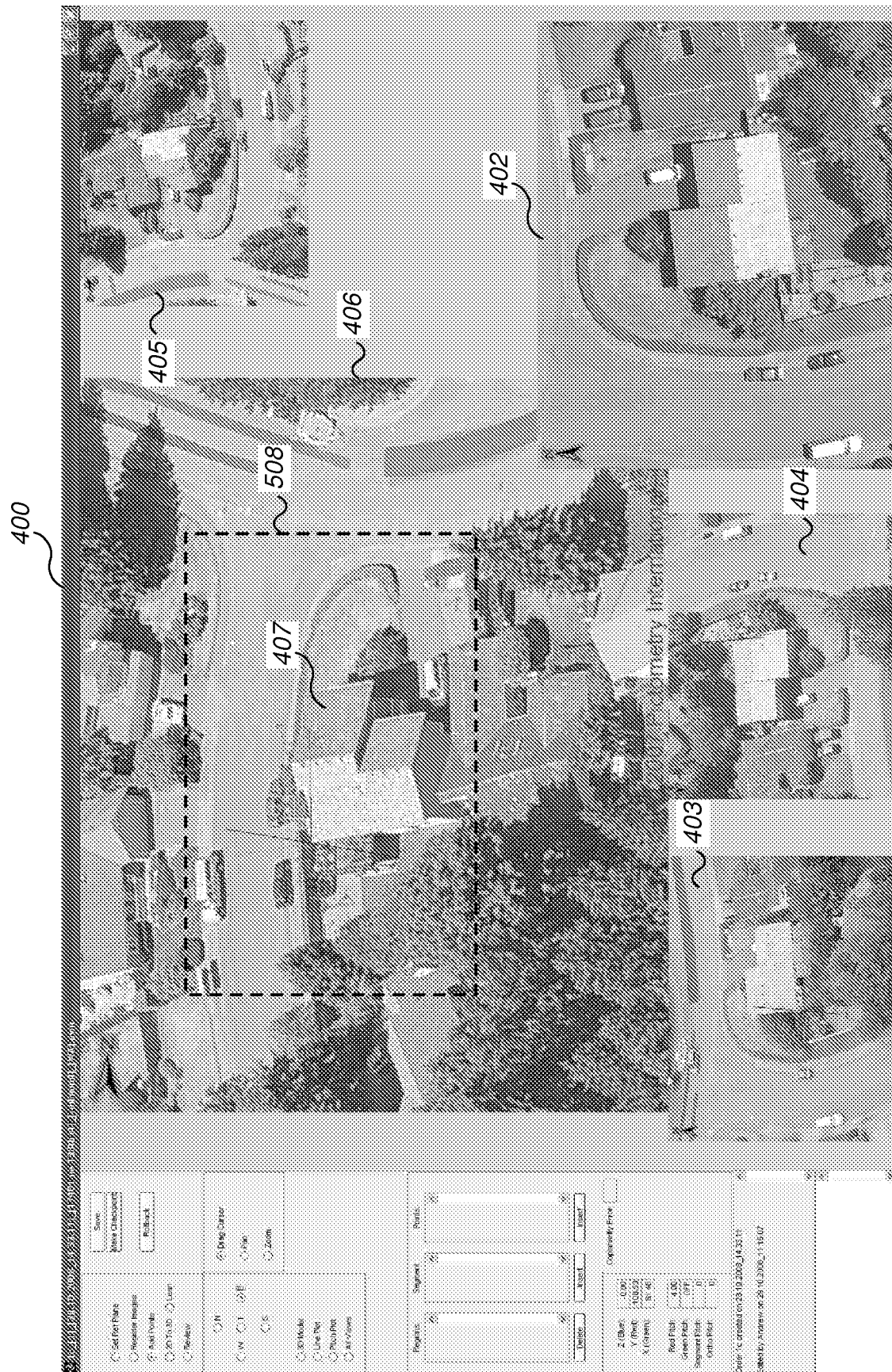


Fig. 5A

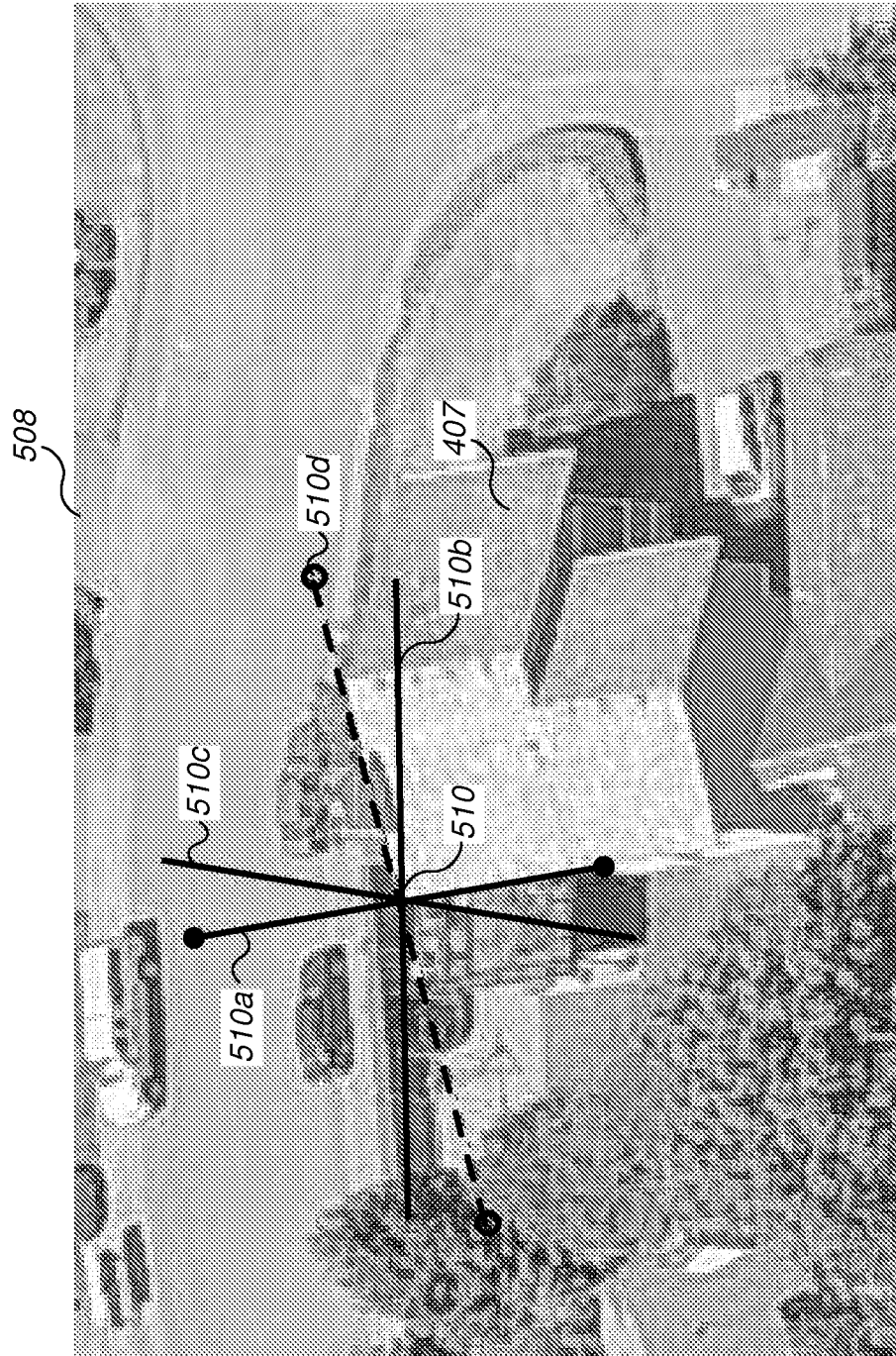


Fig. 5B

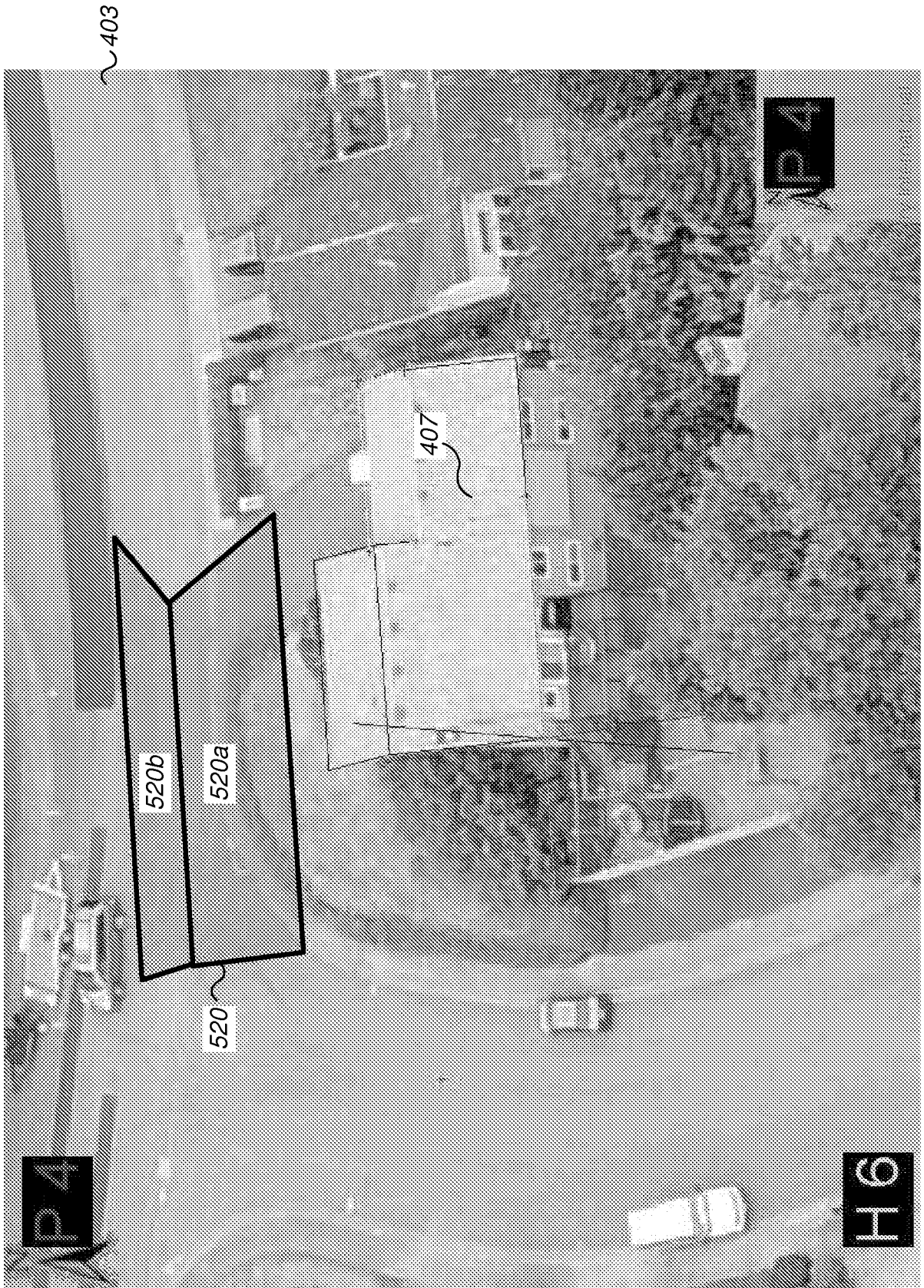


Fig. 5C

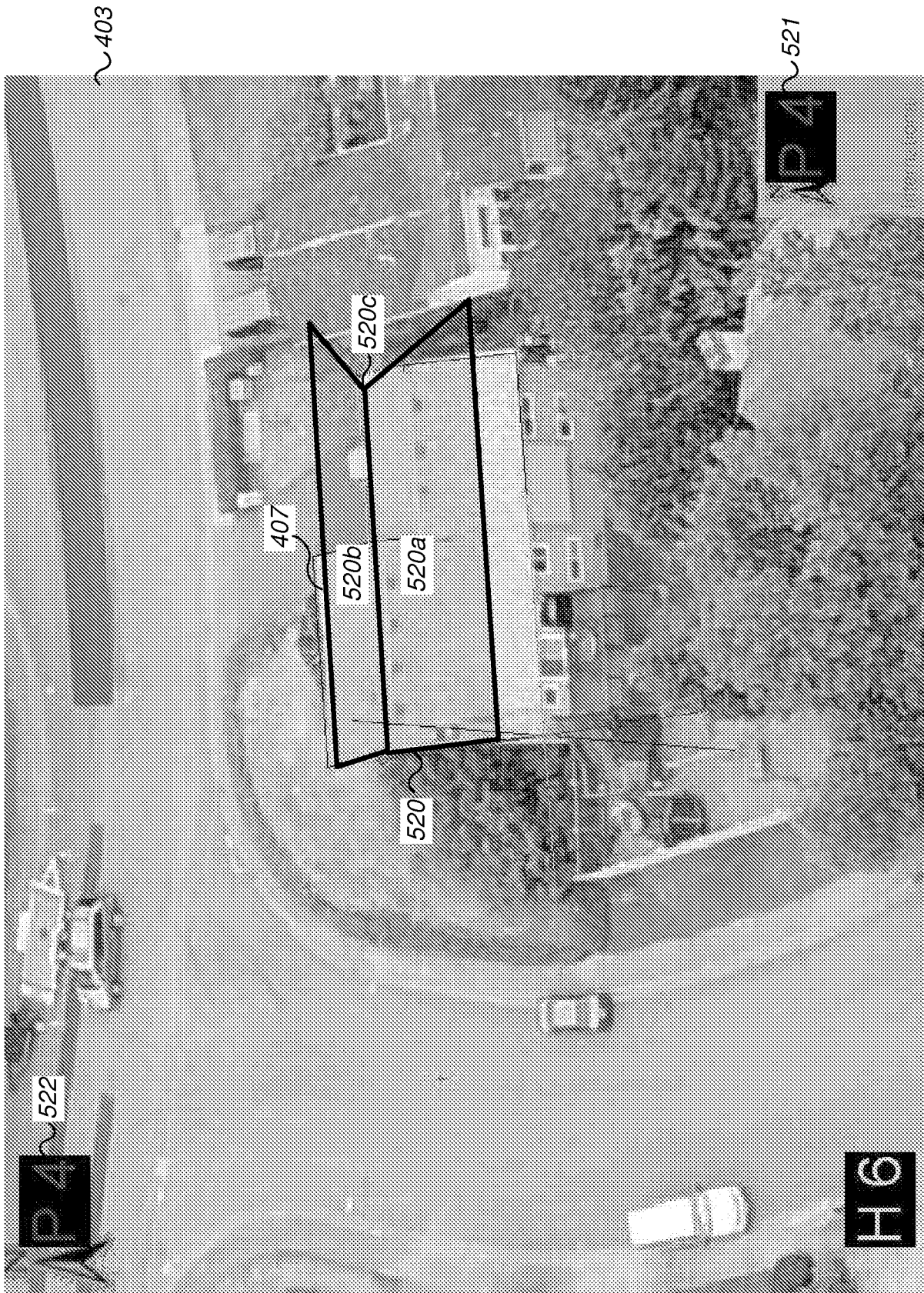


Fig. 5D



Fig. 6A

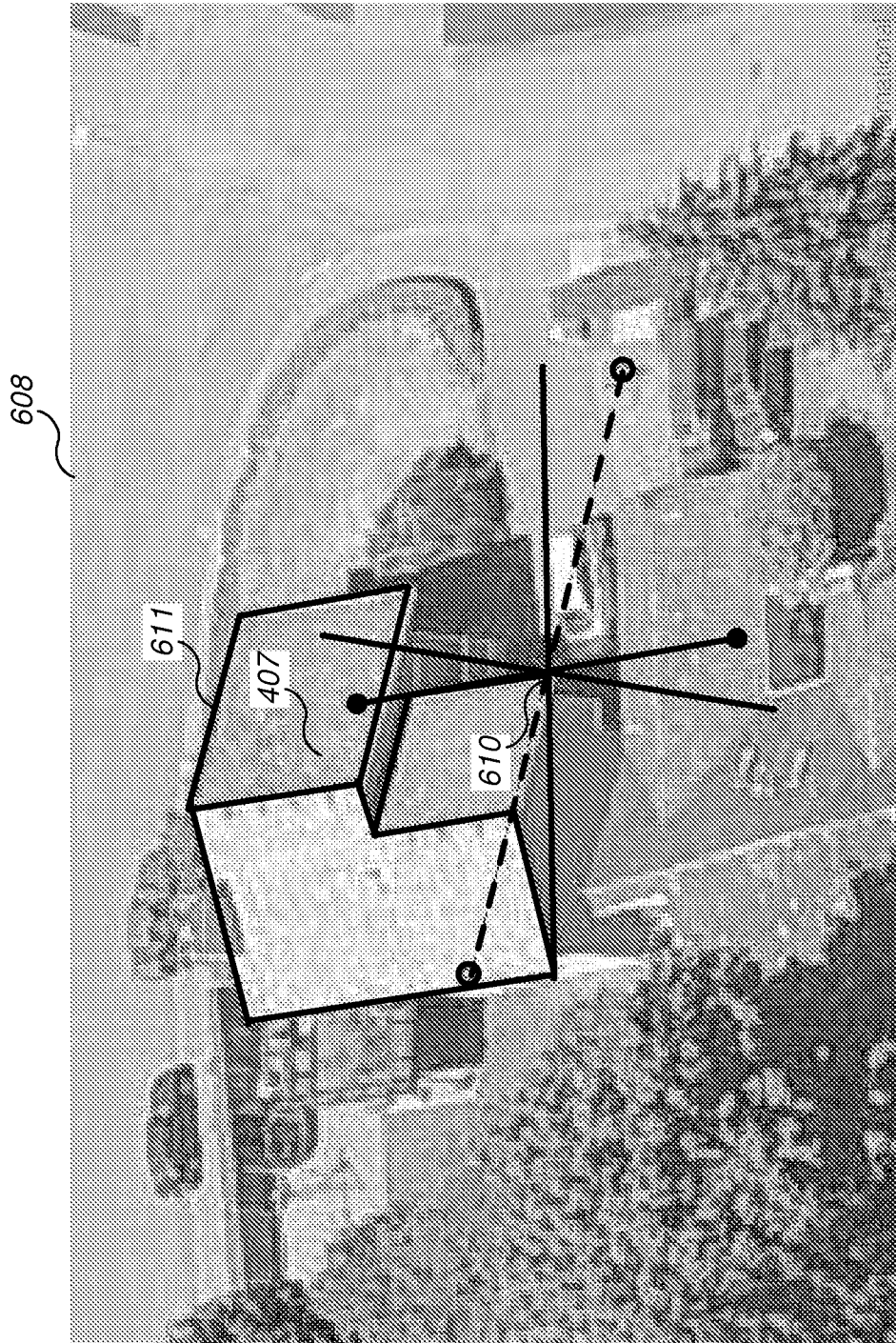


Fig. 6B



Fig. 6C



Fig. 6D

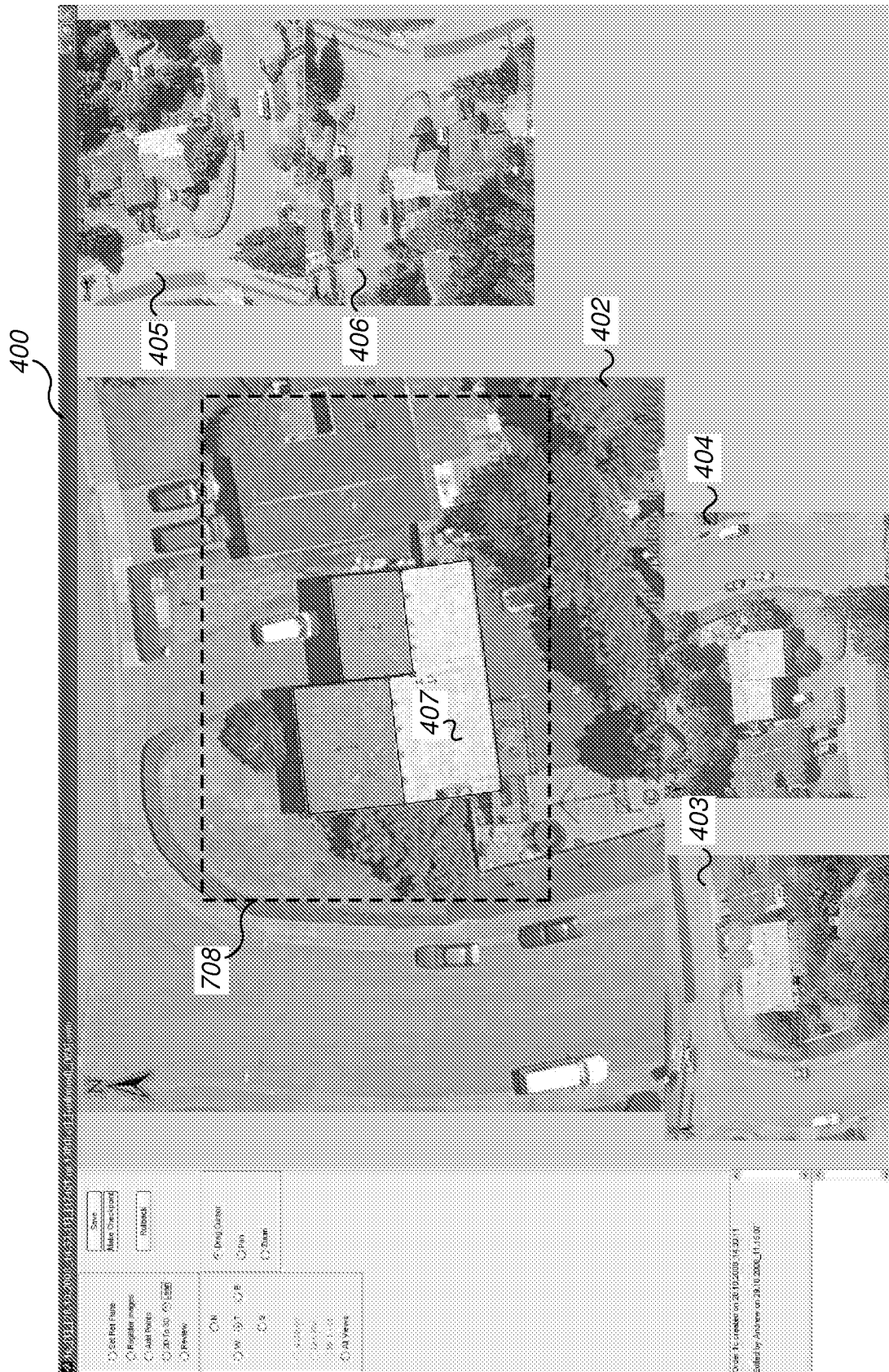
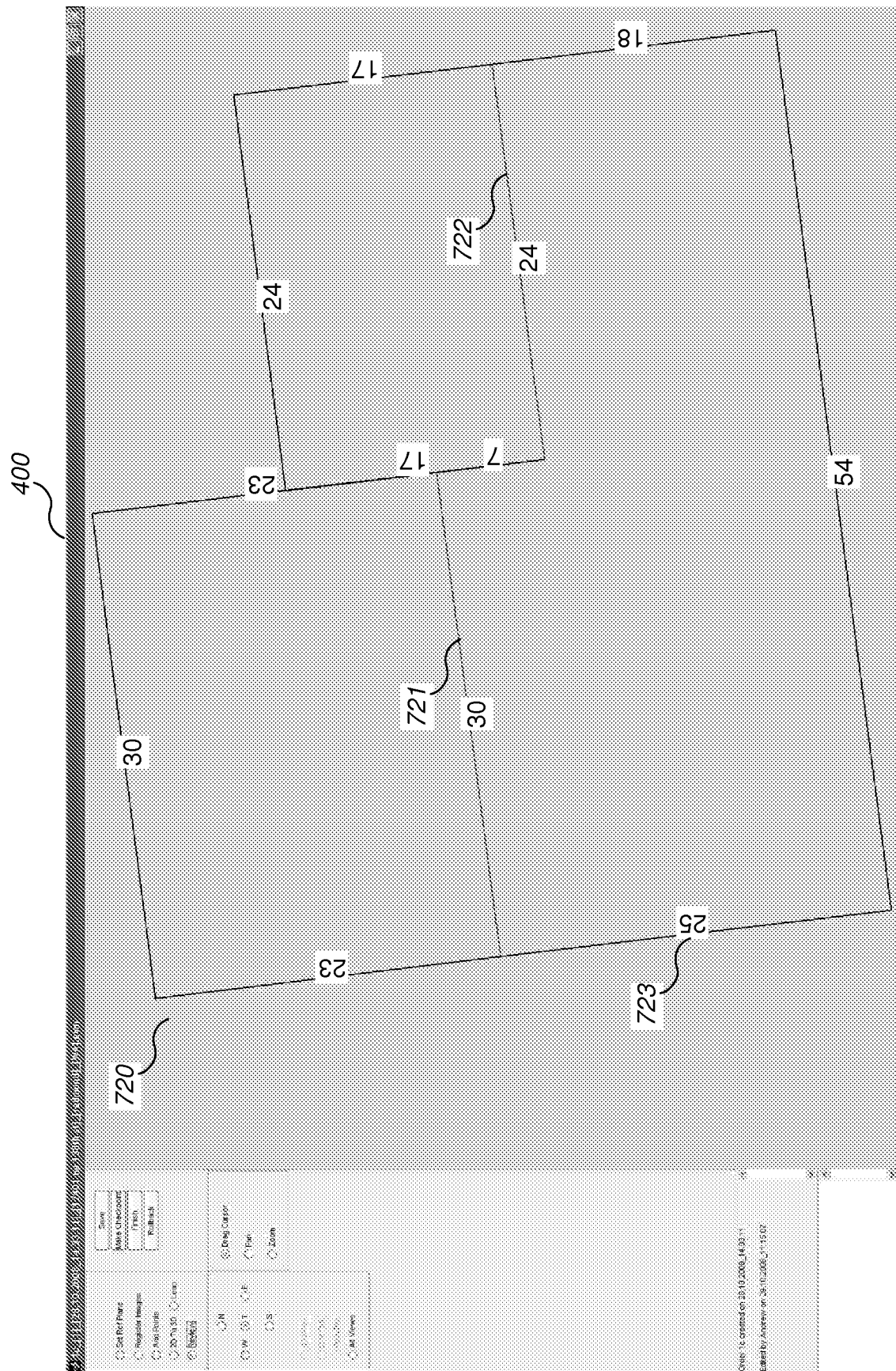


Fig. 7A



Fig. 7B



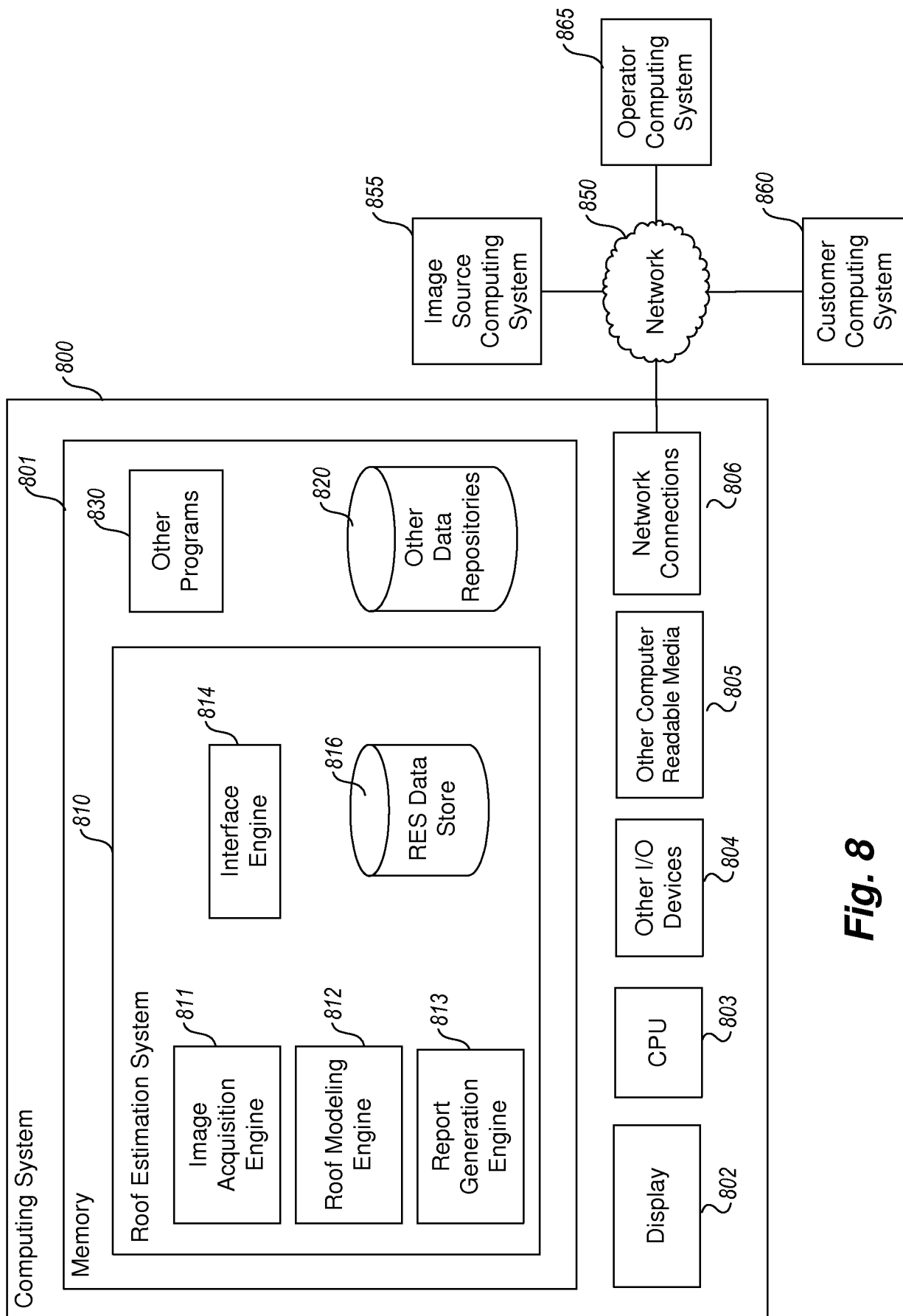


Fig. 8

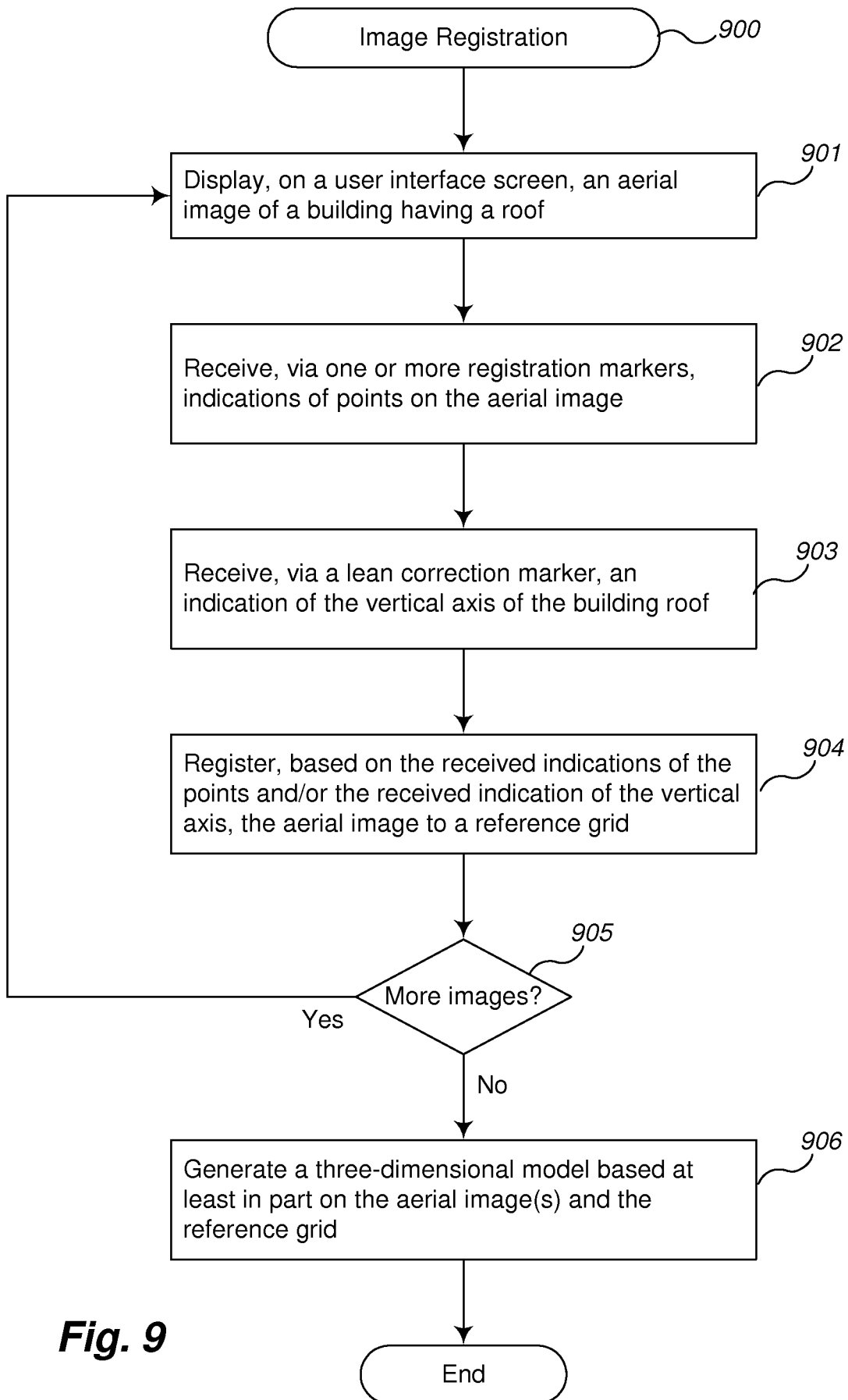


Fig. 9

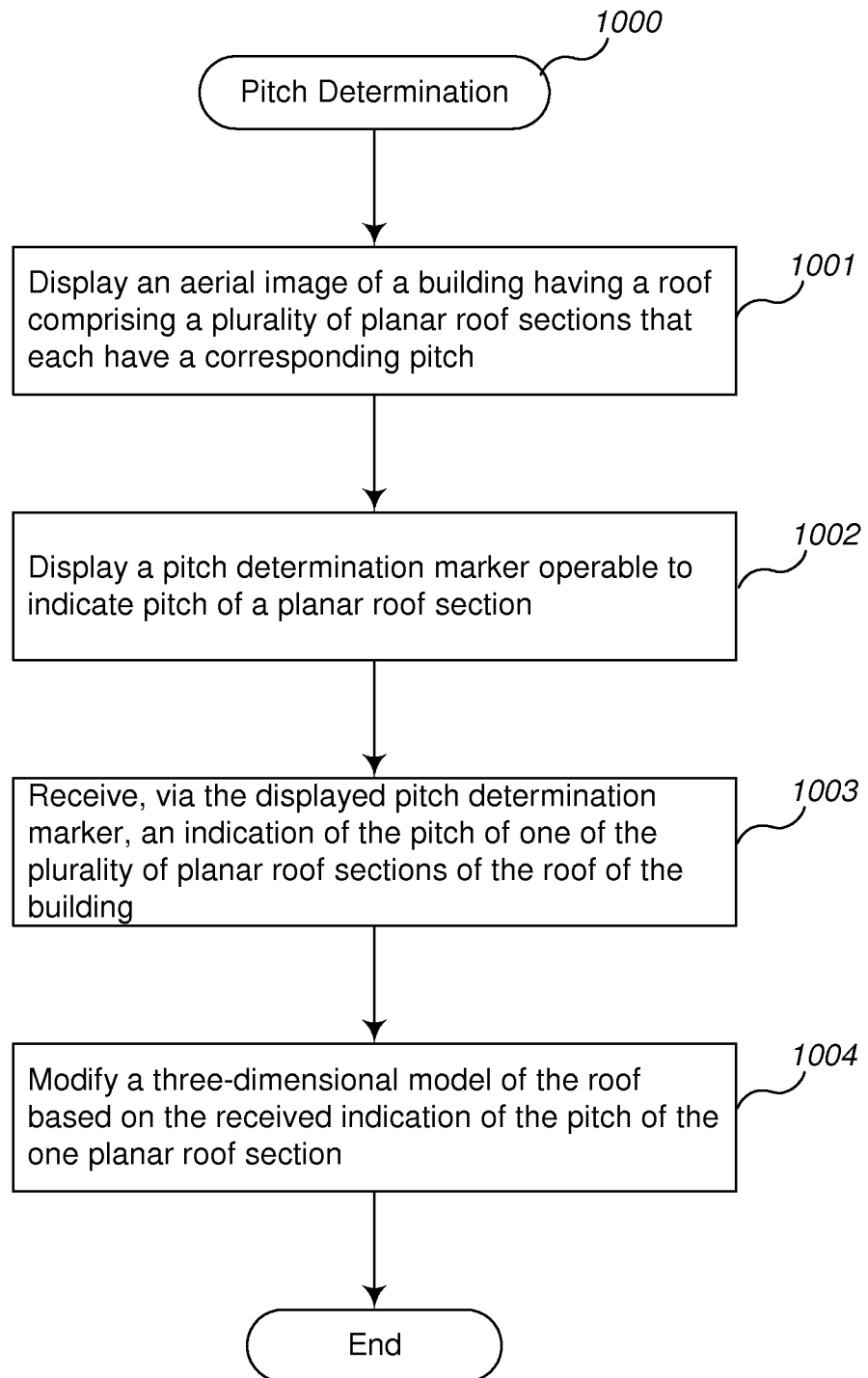


Fig. 10

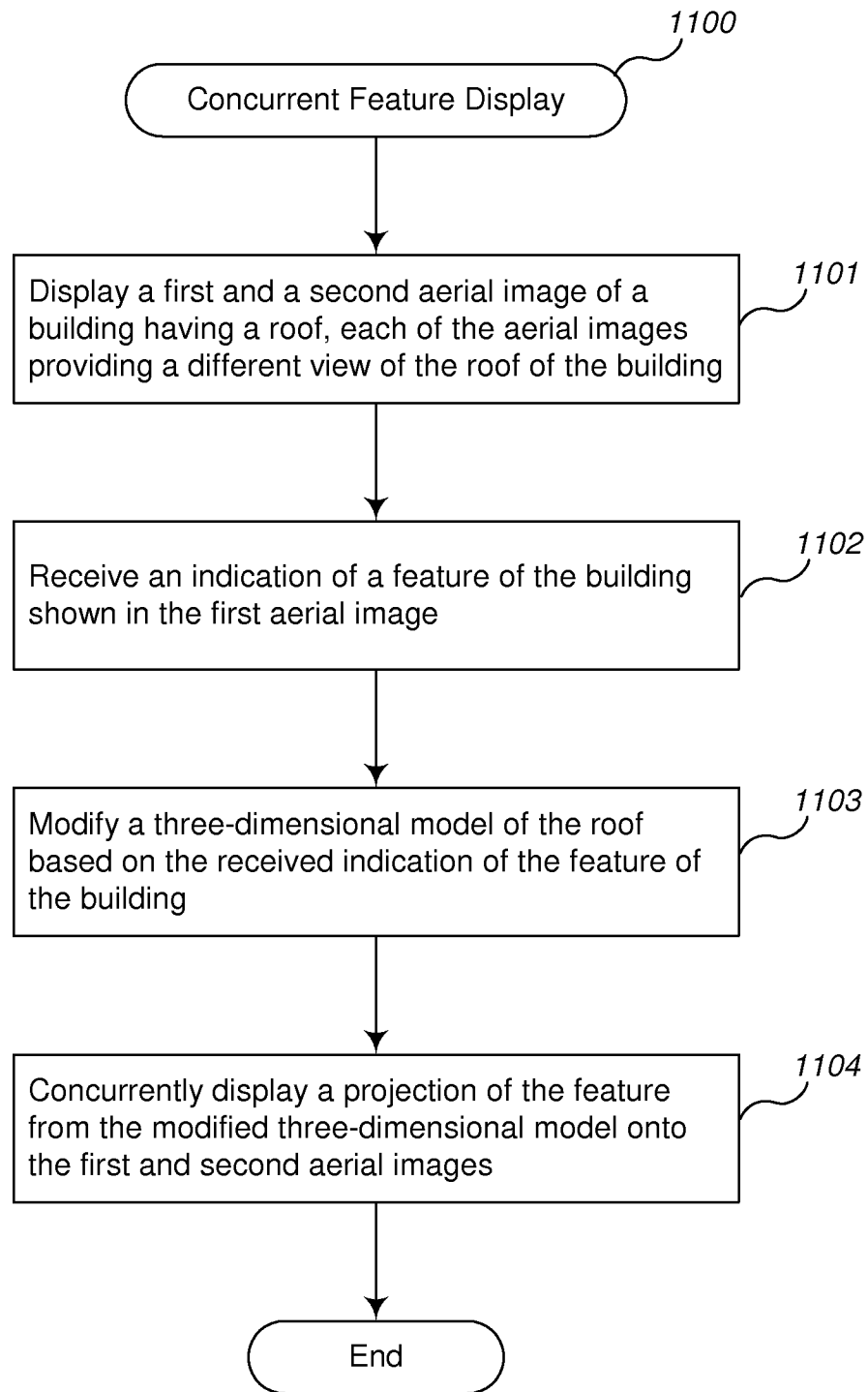


Fig. 11

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION
USING AN APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
---------------------------	---

As the below named inventor(s), I/we declare that:

This declaration is directed to:

- ☒ The attached application, or
☐ Application No. _____, filed on _____,
☐ as amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

All statements made herein of my/our own knowledge are true, all statements made herein on information and belief are believed to be true, and further that these statements were made with the knowledge that wilful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one:	<u>Chris Pershing</u>	Citizen of:	<u>US</u>
Signature:		Date:	<u>3/15/2009</u>

Inventor two:	_____	Citizen of:	_____
Signature:	_____	Date:	_____

Inventor three:	_____	Citizen of:	_____
Signature:	_____	Date:	_____

Inventor four:	_____	Citizen of:	_____
Signature:	_____	Date:	_____

Inventor five:	_____	Citizen of:	_____
Signature:	_____	Date:	_____

☐ Additional inventors or a legal representative are being named on _____ additional form(s) attached hereto.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
Docket No. 290115.403
1390348_1.DOC

ELECTION AND POWER OF ATTORNEY and CORRESPONDENCE ADDRESS INDICATION FORM	Application Number	
	Filing Date	
	First Named Inventor	Chris Pershing
	Title	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
	Art Unit	
	Examiner Name	
	Attorney Docket Number	290115.403

I hereby revoke all previous powers of attorney given in the above-identified application.

I hereby appoint:

☒ Practitioners at Seed IP Law Group PLLC, Customer Number: **00500**

OR

☐ Practitioner(s) named below:

Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above (and any continuation/divisional applications therefrom), and to transact all business in the United States Patent and Trademark Office connected therewith.

Please recognize or change the correspondence address for the above-identified application to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number:

OR

☐ Firm or
Individual Name

Address

Address

City

State

ZIP

Country

Telephone

Email

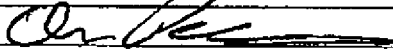
I am the:

☐ Applicant/Inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

☒ As assignee of record of the entire interest I/we hereby elect, under 37 CFR 3.71, to prosecute the application to the exclusion of the inventor(s).

SIGNATURE of Applicant or Assignee of Record

Signature		Date	3/15/2009
Name	Chris Pershing		
Title and Company (Assignee)	CTO Eagle View Technologies, Inc.		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☒ *Total of one form is submitted.

SEND TO: Commissioner for Patents, P.O. Box 1460, Alexandria, VA 22313-1460.

1390350_1.DOC

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Chris Pershing

Application No./Patent No.: _____ Filed/Issue Date: _____

Entitled: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF
ESTIMATION

Eagle View Technologies, Inc. a corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. ☒ the assignee of the entire right, title, and interest; or
2. ☐ an assignee of less than the entire right, title and interest.
(The extent (by percentage) of its ownership interest is _____ %)

in the patent application/patent identified above by virtue of either:

- A. ☒ An assignment from the inventor(s) of the patent application/patent identified above.
The assignment was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

OR

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

1. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet.

- ☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the
original owner to the assignee was, or concurrently is being, submitted for recordation
pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment
Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP
302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Chris Pershing
Signature

3/15/2009
Date

Chris Pershing
Typed or printed name

CTO
Title

ASSIGNMENT

WHEREAS, I, Chris Pershing (hereinafter referred to as ASSIGNOR), having a mailing address of 17401 Northeast 138th Street, Redmond, Washington 98052, am the sole inventor of an invention entitled "PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION," as described and claimed in the specification forming part of an application for United States letters patent executed herewith. This application claims the benefit of U.S. Provisional Application No. 61/197,904, filed on October 31, 2008;

WHEREAS, Eagle View Technologies, Inc. (hereinafter referred to as ASSIGNEE), a corporation of the State of Washington having a business address at 17401 Northeast 138th Street, Redmond, Washington 98052, is desirous of acquiring the entire right, title and interest in and to the invention and in and to any letters patent that may be granted therefor in the United States and in any and all foreign countries;

NOW, THEREFORE, in exchange for good and valuable consideration, the receipt of which is hereby acknowledged, ASSIGNOR hereby sells, assigns and transfers unto said ASSIGNEE, the entire right, title and interest in and to said invention, said application and any and all letters patent which may be granted for said invention in the United States of America and its territorial possessions and in any and all foreign countries, and in any and all divisions, reissues and continuations thereof, including the right to file foreign applications directly in the name of ASSIGNEE and to claim priority rights deriving from said United States application to which said foreign applications are entitled by virtue of international convention, treaty or otherwise, said invention, application and all letters patent on said invention to be held and enjoyed by ASSIGNEE and its successors and assigns for their use and benefit and of its successors and assigns as fully and entirely as the same would have been held and enjoyed by ASSIGNOR had this assignment, transfer and sale not been made. ASSIGNOR hereby authorizes and requests the Commissioner of Patents and Trademarks to issue all letters patent on said invention to ASSIGNEE. ASSIGNOR agrees to execute all instruments and documents required for the making and prosecution of applications for United States and foreign letters patent on said invention, for litigation regarding said letters patent, or for the purpose of protecting title to said invention or letters patent therefor.

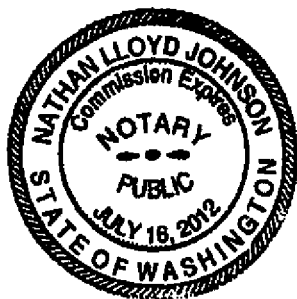
3/15/2009
Date

Chris Pershing
Chris Pershing

State of Washington
County of King

ss.

I certify that I know or have satisfactory evidence that Chris Pershing is the person who appeared before me, and said person acknowledged that he signed this instrument and acknowledged it to be his free and voluntary act for the uses and purposes mentioned in the instrument.



Dated May 15, 2009
Signature of Nathan Lloyd Johnson
Notary Public
Printed Name Nathan Lloyd Johnson
My appointment expires July 16, 2012

1390353_1.DOC
(290115.403)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Chris Pershing
Filed : May 15, 2009
For : PITCH DETERMINATION SYSTEMS AND METHODS FOR
AERIAL ROOF ESTIMATION

Docket No. : 290115.403
Date : May 15, 2009

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

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

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

Respectfully submitted,
SEED Intellectual Property Law Group PLLC

/David V. Carlson/
David V. Carlson
Registration No. 31,153

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

1390423_1.DOC

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Chris Pershing
Filed : May 15, 2009
For : PITCH DETERMINATION SYSTEMS AND
METHODS FOR AERIAL ROOF ESTIMATION

Docket No. : 290115.403
Date : May 15, 2009

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

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

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

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

Applicant believes this Information Disclosure Statement has been timely filed, however, the Director is authorized to charge any fee due by way of this Information Disclosure Statement to our Deposit Account No. 19-1090.

Respectfully submitted,
Seed Intellectual Property Law Group PLLC

/David V. Carlson/
David V. Carlson
Registration No. 31,153

DVC:jrh

Enclosures:
Information Disclosure Statement
Cited References (9)

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

1390425_1.DOC

SCORE Placeholder Sheet for IFW Content

Application Number: 12467244 Document Date: 5/15/2009

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

- Drawings – Other than Black and White Line Drawings

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

To access the documents in the SCORE database, refer to instructions developed by SIRA.

At the time of document entry (noted above):

- Examiners may access SCORE content via the eDAN interface.
- Other USPTO employees can bookmark the current SCORE URL (<http://es/ScoreAccessWeb/>).
- External customers may access SCORE content via the Public and Private PAIR interfaces.

Form Revision Date: February 8, 2006



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UNITED STATES DEPARTMENT OF COMMERCE
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www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
12/467,244	05/15/2009	3633	670	290115.403	28	3

CONFIRMATION NO. 7599

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

FILING RECEIPT



OC000000036177892

Date Mailed: 06/03/2009

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Chris Pershing, Residence Not Provided;

Power of Attorney: The patent practitioners associated with Customer Number 00500

Domestic Priority data as claimed by applicant

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

Foreign Applications

If Required, Foreign Filing License Granted: 05/26/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/467,244**

Projected Publication Date: 05/06/2010

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Preliminary Class

052

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER**Title 35, United States Code, Section 184****Title 37, Code of Federal Regulations, 5.11 & 5.15****GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).



UNITED STATES PATENT AND TRADEMARK OFFICE

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

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

CONFIRMATION NO. 7599

POA ACCEPTANCE LETTER

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



Date Mailed: 06/03/2009

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 05/15/2009.

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

/hkquach/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



UNITED STATES PATENT AND TRADEMARK OFFICE

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

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

CONFIRMATION NO. 7599

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

NOTICE



Date Mailed: 06/03/2009

NOTICE OF INFORMAL APPLICATION

This application is considered to be informal since it does not comply with the regulations for the reason(s) indicated below. The period within to correct the informalities noted below and avoid abandonment is set in the accompanying Office action.

Items Required To Avoid Processing Delays:

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

A new oath or declaration, identifying this application number, or, if appropriate, an application data sheet (37 CFR 1.76), is required. The oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not identify the residence (e.g., city and either state or foreign country) of each inventor.
- does not identify the complete mailing or post office address of each inventor.

Filing Date: 05/15/09

Approved for use through 7/31/2006. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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

PATENT APPLICATION FEE DETERMINATION RECORD					Application or Docket Number 12/467,244	
Substitute for Form PTO-875						
APPLICATION AS FILED – PART I						
(Column 1)		(Column 2)		SMALL ENTITY		OR
FOR	NUMBER FILED	NUMBER EXTRA	RATE (\$)	FEE (\$)	RATE (\$)	FEE (\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	82	N/A	
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	270	N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	110	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	28	minus 20 =	8	x\$26	208	x\$52
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 =	*	x\$110		x\$220
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$270 (\$135 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR					
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))						
			195		390	
			TOTAL	670	TOTAL	
* If the difference in column 1 is less than zero, enter "0" in column 2.						
APPLICATION AS AMENDED – PART II						
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	OTHER THAN SMALL ENTITY
	Total (37 CFR 1.16(i))	Minus **	=	X =		X =
	Independent (37 CFR 1.16(h))	Minus ***	=	X =		X =
	Application Size Fee (37 CFR 1.16(s))					
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
			TOTAL		TOTAL	
			ADD'T FEE		ADD'T FEE	
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)	OTHER THAN SMALL ENTITY
	Total (37 CFR 1.16(i))	Minus **	=	X =		X =
	Independent (37 CFR 1.16(h))	Minus ***	=	X =		X =
	Application Size Fee (37 CFR 1.16(s))					
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
			TOTAL		TOTAL	
			ADD'T FEE		ADD'T FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.						

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

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

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

Art Unit : 3633
Docket No. : 290115.403
Date : July 8, 2009

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

RESPONSE TO NOTICE OF INFORMAL APPLICATION

Commissioner for Patents:

In response to the Notice of Informal Application dated June 3, 2009, please find enclosed the following documents:

X Copy of Notice of Informal Application
X Application Data Sheet

Respectfully submitted,
SEED Intellectual Property Law Group PLLC

/David V. Carlson/
David V. Carlson
Registration No. 31,153



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
12/467,244	05/15/2009	Chris Pershing	290115.403

CONFIRMATION NO. 7599

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

NOTICE



Date Mailed: 06/03/2009

NOTICE OF INFORMAL APPLICATION

This application is considered to be informal since it does not comply with the regulations for the reason(s) indicated below. The period within to correct the informalities noted below and avoid abandonment is set in the accompanying Office action.

Items Required To Avoid Processing Delays:

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

A new oath or declaration, identifying this application number, or, if appropriate, an application data sheet (37 CFR 1.76), is required. The oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not identify the residence (e.g., city and either state or foreign country) of each inventor.
- does not identify the complete mailing or post office address of each inventor.

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	290115.403
		Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1					Remove
Applicant Authority		☒ Inventor		☐ Legal Representative under 35 U.S.C. 117	☐ Party of Interest under 35 U.S.C. 118
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Chris		Pershing		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Redmond	State/Province	WA	Country of Residence i	US
Citizenship under 37 CFR 1.41(b) i		US			
Mailing Address of Applicant:					
Address 1	17401 Northeast 138th Street				
Address 2					
City	Redmond	State/Province	WA		
Postal Code	98052	Countryⁱ	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					
Add					

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	00500		
Email Address	DaveC.Docketing@SeedIP.com	Add Email	Remove Email

Application Information:

Title of the Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		
Attorney Docket Number	290115.403	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	29	Suggested Figure for Publication (if any)	

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	290115.403
		Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		

Publication Information:

☐	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐	Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	00500		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.			
Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61197904	2008-10-31
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).			
			Remove
Application Number	Country i	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			☐ Yes ☒ No
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.	
Assignee 1	Remove

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	290115.403
		Application Number	
Title of Invention	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		

If the Assignee is an Organization check here. ☒			
Organization Name	Eagle View Technologies, Inc.		
Mailing Address Information:			
Address 1	17401 Northeast 138th Street		
Address 2			
City	Redmond	State/Province	WA
Country i	US	Postal Code	98052
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the Add button. Add			

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.					
Signature	/David V. Carlson/			Date (YYYY-MM-DD)	2009-07-08
First Name	David	Last Name	Carlson	Registration Number	31153

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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

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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.

Electronic Acknowledgement Receipt

EFS ID:	5664553
Application Number:	12467244
International Application Number:	
Confirmation Number:	7599
Title of Invention:	PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION
First Named Inventor/Applicant Name:	Chris Pershing
Customer Number:	00500
Filer:	David V. Carlson/Jamie Horner
Filer Authorized By:	David V. Carlson
Attorney Docket Number:	290115.403
Receipt Date:	08-JUL-2009
Filing Date:	15-MAY-2009
Time Stamp:	16:18:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	290115_403_Resp_Inf_App.pdf	50549 ba612092dafd351fff518fcfda60260e8719af64	no	1

Warnings:

Information:

2	Applicant Response to Pre-Exam Formalities Notice	290115_403_Notice_of_Informal_Application.PDF	30627 731d5a0813c31c5893842f037e575feeb8b73564	no	1
Warnings:					
Information:					
3	Application Data Sheet	290115_403_ADS.pdf	938404 060bf3ba16c478eec43b888ca53084949f1c3a08	no	4
Warnings:					
Information:					
Total Files Size (in bytes):			1019580		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
12/467,244	05/15/2009	2628	670	290115.403	28	3

CONFIRMATION NO. 7599

CORRECTED FILING RECEIPT



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

Date Mailed: 07/15/2009

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Chris Pershing, Redmond, WA;

Assignment For Published Patent Application

Eagle View Technologies, Inc., Redmond, WA

Power of Attorney: The patent practitioners associated with Customer Number 00500

Domestic Priority data as claimed by applicant

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

Foreign Applications

If Required, Foreign Filing License Granted: 05/26/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/467,244**

Projected Publication Date: 05/06/2010

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Preliminary Class

345

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

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

CONFIRMATION NO. 7599

PUBLICATION NOTICE



OC000000041486162

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

Title:PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

Publication No.US-2010-0110074-A1

Publication Date:05/06/2010

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <http://pair.uspto.gov/>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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12/467,244

05/15/2009

Chris Pershing

290115.403

7599

500

7590

08/26/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC

701 FIFTH AVE

SUITE 5400

SEATTLE, WA 98104

EXAMINER

PIERRE LOUIS, ANDRE

ART UNIT

PAPER NUMBER

2123

MAIL DATE

DELIVERY MODE

08/26/2011

PAPER

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

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

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

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ____; the restriction requirement and election have been incorporated into this action.
- 4) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 5) ☒ Claim(s) 1-28 is/are pending in the application.
- 5a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 6) ☐ Claim(s) ____ is/are allowed.
- 7) ☒ Claim(s) 1-28 is/are rejected.
- 8) ☐ Claim(s) ____ is/are objected to.
- 9) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 10) ☒ The specification is objected to by the Examiner.
- 11) ☒ The drawing(s) filed on 15 May 2009 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 12) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

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

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) ☒ Notice of References Cited (PTO-892) | 4) ☐ Interview Summary (PTO-413) |
| 2) ☐ Notice of Draftperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. ____. |
| 3) ☒ Information Disclosure Statement(s) (PTO/SB/08) | 5) ☐ Notice of Informal Patent Application |
| Paper No(s)/Mail Date <u>5/15/2009</u> . | 6) ☐ Other: ____. |

DETAILED ACTION

1. Claim 1-28 have been presented for examination.

Drawings

2. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference character(s) not mentioned in the description: see for example reference number 448, 711, 1188 of figure 3E. Corrected drawing sheets in compliance with 37 CFR 1.121(d), or amendment to the specification to add the reference character(s) in the description in compliance with 37 CFR 1.121(b) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Double Patenting

3. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined

application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

3.1 Claims 1-28 are provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-25 of copending Application No. 12/467,250. Although the conflicting claims are not identical, they are not patentably distinct from each other because the claims of application No. 12/467,250 contain every elements of the instant application No. 12/467,244.

This is a provisional obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claim Rejections - 35 USC § 101

4. 35 U.S.C. 101 reads as follows:

Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

- 4.1 Claims 16-28 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. While the claims are directed to a computer-readable medium, para 107 of the original specification describes to include carrier wave/signal bearing medium which does not fit into one of the statutory categories and therefore are not statutory.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

- 5.0 Claims 1-28 are rejected under 35 U.S.C. 102 (e) as being anticipated by Pershing ET al. (USPG_PUB No. 2008/0262789 A1).

The applied reference has a common inventor with the instant application. Based upon the earlier effective U.S. filing date of the reference, it constitutes prior art under 35 U.S.C. 102(e). This rejection under 35 U.S.C. 102(e) might be overcome either by a showing under 37 CFR 1.132 that any invention disclosed but not claimed in the reference was derived from the inventor of this application and is thus not the invention “by another,” or by an appropriate showing under 37 CFR 1.131.

5.1 In considering claims 1, 10, and 16, Pershing et al. discloses a computer-implemented method for generating a roof estimate report, the method comprising: displaying an aerial image of a building having a roof comprising a plurality of planar roof sections that each have a corresponding pitch (see fig.1-2, 5, para 11-13, 22, 28); displaying a pitch determination marker operable to indicate pitch of a planar roof section (see fig.5, para 11-13, 28-31); receiving, via the displayed pitch determination marker, an indication of the pitch of one of the plurality of planar roof sections of the roof of the building (see fig.1-2, 5, para 28-31); and modifying a model of the roof based on the received indication of the pitch of the one planar roof section (para 34-37); and further teaches the step of providing roof measurement information based on the model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section (see para 34-37), shown in claim 10.

5.2 As per claims 2 and 17, Pershing et al. discloses that wherein the pitch determination marker is adjustable to specify pitch of a planar roof section (fig.2, para 27-28, 32).

5.3 With regards to claims 3, 11, 18, and 20 Pershing et al. discloses the step of transmitting roof measurement information based on the modified model of the roof, the roof measurement information including a measure of the pitch of the one planar roof section (fig.1-2, para 22, 25-28, 34-37).

5.4 With regards to claims 4 and 21, Pershing et al. teaches that wherein modifying the model of the roof includes associating the indicated pitch with a portion of the model of the roof that corresponds to the one planar roof section of the roof of the building (see para 34-37).

5.5 As per claims 5-6 and 22, Pershing et al. teaches the step of displaying a wireframe rendering of the modified model superimposed on the aerial image of the building in response to the receiving of the indicated pitch (fig.1-2, 5, para 22-24).

5.6 With regards to claims 7-8 and 12, Pershing et al. teaches that wherein the pitch determination marker includes an adjustable protractor tool having a member that is adjustable to indicate an angle and wherein the pitch determination marker includes an envelope tool having two surfaces that are adjustable to indicate an angle (para 25-28).

5.7 As per claims 9, 15, and 28, Pershing et al. teaches that wherein modifying the model of the roof includes modifying a three-dimensional model of the roof (para 34-37).

5.8 Regarding claim 13, Pershing et al. teaches that wherein the roof estimation module includes an interactive roof modeling user interface (para 22-24).

5.9 With regards to claim 14, Pershing et al. teaches that wherein the roof estimation module is further configured to display the pitch determination marker as part of an interactive user interface (para 22-24, 28-32).

5.10 Regarding claim 19, Pershing et al. teaches that wherein the transmitted roof estimate report includes a line drawing of the roof of the house labeled with a measure of the pitch of the planar roof section (para 22-26, 28).

5.11 With regards to claim 23, Pershing et al. teaches wherein the method further comprises: registering, based on operator indicated features, multiple aerial images to a reference grid corresponding to the model (fig.1-2, para 22-24).

5.12 Regarding claims 24 and 27, Pershing et al. teaches that wherein registering multiple images includes: displaying a marker operable to specify a point on the aerial image,

receiving, via the marker, an indication of a point on the aerial image, and registering, based on the received indication of the point, the aerial image to the reference grid (fig.1-2, para 22-24, 32-34).

5.13 As per claim 25, Pershing et al. teaches that wherein registering the aerial image to the reference grid includes determining a transformation between the aerial image and the reference grid (para 28-30).

5.14 With regards to claim 26, Pershing et al. teaches wherein the method further comprises: correcting lean of the aerial image with respect to a vertical axis of a reference grid corresponding to the model (para 34-37).

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

6.1 Kennedy et al. (USPG_PUB No. 2009/0304227) teaches a method for provisioning energy systems.

6.2 Neumann (USPG_PUB No. 2004/0105573) teaches an augmented virtual environment.

7. Claims 1-28 are rejected and this action is non-final. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ANDRE PIERRE LOUIS whose telephone number is (571)272-8636. The examiner can normally be reached on Mon-Fri, 8:00AM-4:30PM.

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

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

/A. P./
Examiner, Art Unit 2123

August 23, 2011

/Paul L Rodriguez/
Supervisory Patent Examiner, Art Unit 2123

Notice of References Cited	Application/Control No. 12/467,244		Applicant(s)/Patent Under Reexamination PERSHING, CHRIS	
	Examiner ANDRE PIERRE LOUIS		Art Unit 2123	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2008/0262789	10-2008	Pershing et al.	702/156
*	B	US-2009/0304227	12-2009	Kennedy et al.	382/100
*	C	US-2004/0105573	06-2004	Neumann et al.	382/103
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		2009-05-15
	First Named Inventor	Chris Pershing	
	Art Unit		
	Examiner Name		
	Attorney Docket Number	290115.403	

U.S.PATENTS						Remove
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6446053	B1	2002-09-03	Elliott	
	2	6636803	B1	2003-10-21	Hartz, Jr. et al.	
	3	6836270	B2	2004-12-28	Du	
	4	7003400	B2	2006-02-21	Bryant	
	5	7006977	B1	2006-02-28	Attra et al.	
	6	7133551	B2	2006-11-07	Chen et al.	
	7	7324666	B2	2008-01-29	Zoken et al.	
	8	6385541	B1	2002-05-07	Blumberg et al.	
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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2009-05-15
First Named Inventor	Chris Pershing
Art Unit	
Examiner Name	
Attorney Docket Number	290115.403

U.S.PATENT APPLICATION PUBLICATIONS							Remove	
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear		
	1	20020154174	A1	2002-10-24	Redlich et al.			
	2	20050288959	A1	2005-12-29	Eraker et al.			
	3	20060200311	A1	2006-09-07	Aruntunian et al.			
If you wish to add additional U.S. Published Application citation information please click the Add button.							Add	
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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
	1							☐
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.						T ⁵
	1	Gulch E., et al., "On the Performance of Semi-Automatic Building Extraction," In the International Archives of Photogrammetry and Remote Sensing, Vol. 23, 8 pages, 1998.						☐
	2	"How precigeo Roof Works," http://web.archive.org/web/20070107012311/roof.precigeo.com/how-precigeo-roof-works.htm , retrieved April 30, 2009, 1 page.						☐

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

Application Number		
Filing Date		2009-05-15
First Named Inventor	Chris Pershing	
Art Unit		
Examiner Name		
Attorney Docket Number	290115.403	

3	"Microsoft's MSN Virtual Earth: The Map is the Search Platform," Directions Magazine, http://www.directionsmag.com/article.php?article_id=873&trv=1 , retrieved February 6, 2009, 10 pages.	☐
4	Miller, M., et al., "Miller's Guide to Framing and Roofing," 2005, pages 131-136 and 162-163, McGraw Hill.	☐
5	"Pictometry - In the News," http://204.8.121.114/pressrelease%20archived/pressrelease_aec.asp , retrieved February 6, 2009, 3 pages.	☐
6	"Welcome to precigeo," http://web.archive.org/web/20080110074814/http://www.precigeo.com ", February 17, 2009, 1 page.	☐
7	"Welcome to precigeoRoof," http://web.archive.org/web/20070106063144/roof.precigeo.com , retrieved April 30, 2009, 1 page.	☐
8	"YouTube - Pictometry Online Demo," http://www.youtube.com/watch?v=jURSK7o0OD0 , retrieved February 6, 2009, 1 page	☐
9	Ziegler, R, et al. "3D Reconstruction Using Labeled Image Regions," Mitsubishi Electric Research Laboratories, http://www.merl.com , 2003, 14 pages.	☐

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

EXAMINER SIGNATURE

Examiner Signature	/Andre Pierre Louis/ (08/18/2011)	Date Considered	(08/18/2011)
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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.

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

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

☐ Claims renumbered in the same order as presented by applicant		☐ CPA		☐ T.D.		☐ R.1.47			
CLAIM		DATE							
Final	Original	08/23/2011							
	1	✓							
	2	✓							
	3	✓							
	4	✓							
	5	✓							
	6	✓							
	7	✓							
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	24	✓							
	25	✓							
	26	✓							
	27	✓							
	28	✓							

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	77	(roof\$3 with model\$4) and pitch\$3 and building\$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:57
L2	12	1 and aerial and (roof with estimat\$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:58
L3	11	2 and display\$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:58
L4	8	3 and modif\$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 21:59
L6	11	1 and (aerial with image\$2) and measur\$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:23
L7	8	6 and (modif\$4 or adjust\$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
L8	8	6 and (modif\$4 or adjust\$4 or edit\$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
L9	11	6 and pitch\$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 22:24
S1	2298	(703/1).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:19
S2	8	(roof\$3 with model\$4) and pitch\$3 and building\$2 and marker\$2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S3	8	S2 and display\$4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S4	4	S3 and (aerial with display\$4)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:32
S5	2	("20060265287").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:56
S6	2	("20080262789").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2011/08/23 17:56
S7	8	S3 and aerial	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	OFF	2011/08/23 18:40

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BIB DATA SHEET

CONFIRMATION NO. 7599

SERIAL NUMBER 12/467,244	FILING or 371(c) DATE 05/15/2009 RULE	CLASS 703	GROUP ART UNIT 2123	ATTORNEY DOCKET NO. 290115.403	
APPLICANTS Chris Pershing, Redmond, WA; ** CONTINUING DATA ***** This appln claims benefit of 61/197,904 10/31/2008 ** FOREIGN APPLICATIONS ***** ** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** ** SMALL ENTITY ** 05/26/2009					
Foreign Priority claimed ☐ Yes ☒ No 35 USC 119(a-d) conditions met ☐ Yes ☒ No Verified and /ANDRE PIERRE LOUIS/ Acknowledged Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY WA	SHEETS DRAWINGS 29	TOTAL CLAIMS 28	INDEPENDENT CLAIMS 3
ADDRESS SEED INTELLECTUAL PROPERTY LAW GROUP PLLC 701 FIFTH AVE SUITE 5400 SEATTLE, WA 98104 UNITED STATES					
TITLE PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION					
FILING FEE RECEIVED 670	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:		☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit		

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

SEARCHED			
Class	Subclass	Date	Examiner
703	1	8/23/2011	AP

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

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

/A.P./ Examiner.Art Unit 2123	
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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12/467,244

05/15/2009

Chris Pershing

290115.403

7599

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7590

11/28/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC

701 FIFTH AVE

SUITE 5400

SEATTLE, WA 98104

EXAMINER

PIERRE LOUIS, ANDRE

ART UNIT

PAPER NUMBER

2123

MAIL DATE

DELIVERY MODE

11/28/2011

PAPER

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

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

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

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

(1) ANDRE PIERRE LOUIS. (3) David V. Carlson (Reg.31,153).

(2) Jeremiah J. Baunach (Reg.44,527). (4) Chris Pershing (Inventor).

Date of Interview: 22 November 2011.

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

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

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

Claim(s) discussed: 1-25.

Identification of prior art discussed: Chris Pershing.

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

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

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

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

☐ Attachment

/Andre Pierre-Louis/ Examiner, Art Unit 2123	/plr/
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Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record

A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

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

Paragraph (b)

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

37 CFR §1.2 Business to be transacted in writing.

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

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

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

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

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

The Form provides for recordation of the following information:

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

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

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

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

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

Examiner to Check for Accuracy

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

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

Examiner : Andre Pierre Louis
Art Unit : 2123
Docket No. : 290115.403
Date : November 28, 2011

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

AMENDMENT

Commissioner for Patents:

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

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

Remarks begin on page 8 of this paper.

Amendments to the Claims:

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

Listing of Claims:

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

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

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

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

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

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

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

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

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

5. (Original) The method of claim 1 further comprising:
displaying a wireframe rendering of the modified model superimposed on the aerial image of the building.

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

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

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

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

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

a memory;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

transmitting the determined roof measurement information.

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

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

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

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

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

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

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

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

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

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

26. (Currently Amended) The non-transitory computer-readable storage medium of claim 16 wherein the method further comprises:
correcting lean of the aerial image with respect to a vertical axis of a reference grid corresponding to the model.

27. (Currently Amended) The non-transitory computer-readable storage medium of claim 26 wherein correcting misalignment of the aerial image includes:
displaying a lean correction marker operable to indicate a vertical axis of the aerial image;
receiving, via the lean correction marker, an indication of the vertical axis of the aerial image; and
registering, based on the received indication of the vertical axis, the aerial image to the reference grid.

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

REMARKS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Application No. 12/467,244
Reply to Office Action dated August 26, 2011

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

Respectfully submitted,
SEED Intellectual Property Law Group PLLC

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Jeremiah J. Baunach
Registration No. 44,527

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1980534_1.DOC

**TERMINAL DISCLAIMER TO OBTAIN A PROVISIONAL DOUBLE
PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION**

Docket Number
290115.403

In re Application of: Chris Pershing

Application No.: 12/467,244

Filed: May 15, 2009

For: PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION

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

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

Check either box 1 or 2 below, if appropriate.

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

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

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

/Jeremiah J. Baunach/

Signature

November 28,
2011

Date

Jeremiah J. Baunach

Typed or printed name

206-622-4900

Telephone Number

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

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

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

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

2042384_1.DOC

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

Examiner : Andre Pierre Louis
Art Unit : 2123
Docket No. : 290115.403
Date : November 28, 2011

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

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

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

Respectfully submitted,

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2042778_1.DOCX

Electronic Patent Application Fee Transmittal				
Application Number:		12467244		
Filing Date:		15-May-2009		
Title of Invention:		PITCH DETERMINATION SYSTEMS AND METHODS FOR AERIAL ROOF ESTIMATION		
First Named Inventor/Applicant Name:		Chris Pershing		
Filer:		Jeremiah J. Baunach/Yvette Chriscaden		
Attorney Docket Number:		290115.403		
Filed as Small Entity				
Utility under 35 USC 111(a) Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Statutory or terminal disclaimer	2814	1	80	80
Extension-of-Time:				

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

Electronic Acknowledgement Receipt

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

Payment information:

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

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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1		1_290115_403_Amendment.pdf	106218	yes	12
			0770f1043e8baa742c08bcbee4b459d763a09959		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Amendment/Req. Reconsideration-After Non-Final Reject		1	1	
	Claims		2	7	
	Applicant Arguments/Remarks Made in an Amendment		8	12	
Warnings:					
Information:					
2	Terminal Disclaimer Filed	2_290115_403_TerminalDisclaimer.pdf	83526	no	1
			89dd74b2e2d17040d3162bd15903c1e4b0888533		
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	3_290115_403_FDA.pdf	45788	no	1
			19068d1585405f7aea66cef4901f981a37b5f352		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30262	no	2
			7aeb0df85a575bd2c25aff70d47032c50a226da4		
Warnings:					
Information:					
Total Files Size (in bytes):			265794		

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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

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

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875					Application or Docket Number 12/467,244		Filing Date 05/15/2009		☐ To be Mailed	
APPLICATION AS FILED – PART I										
(Column 1)			(Column 2)			SMALL ENTITY ☒ OR		OTHER THAN SMALL ENTITY		
FOR	NUMBER FILED	NUMBER EXTRA	RATE (\$)	FEE (\$)		RATE (\$)	FEE (\$)			
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A				
☐ SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A				
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A				
TOTAL CLAIMS (37 CFR 1.16(j))	minus 20 =	*	X \$	=		X \$	=			
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X \$	=		X \$	=			
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).									
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))										
			TOTAL			TOTAL				
APPLICATION AS AMENDED – PART II										
(Column 1)			(Column 2)			SMALL ENTITY OR		OTHER THAN SMALL ENTITY		
AMENDMENT	11/28/2011	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)		RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))	* 28	Minus	** 28	= 0	X \$30 =	0		X \$ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X \$125 =	0		X \$ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE	0		TOTAL ADD'L FEE	
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)	ADDITIONAL FEE (\$)		RATE (\$)	ADDITIONAL FEE (\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X \$ =			X \$ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X \$ =			X \$ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE			TOTAL ADD'L FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.										

Legal Instrument Examiner:
/DAWN BREWER/

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

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

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

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

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

AMENDED SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT
TRANSMITTAL

Commissioner for Patents:

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

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

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

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

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

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

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

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

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

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

Respectfully submitted,
Seed Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
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1940325_1.DOCX

Electronic Acknowledgement Receipt

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

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	290115_403_AmendedSupplD STransmittal.pdf	54633 8dd3598643f9081e1937528b64d8682e720 ae408	no	3

Warnings:

Information:

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.



11-30-11

EXPRESS MAIL No. EV 887976986 US

1 Fin

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

Examiner : Andre Pierre Louis
Art Unit : 2123
Docket No. : 290115.403
Date : November 28, 2011

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

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

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

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

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

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

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

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

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

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

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

Respectfully submitted,
Seed Intellectual Property Law Group PLLC



Jeremiah J. Baunach
Registration No. 44,527

JJB:djs

Enclosures:

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

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

1940325_1.DOCX



EXPRESS MAIL No. EV 887976986 US

TRANSMITTAL FORM (To be used for all correspondence after initial filing)	Application Number	12/467,244
	Filing Date	May 15, 2009
	First Named Inventor	Chris Pershing
	Art Unit	2123
	Examiner Name	Andre Pierre Louis
	Attorney Docket No.	290115.403

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

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT			
Firm Name	Seed Intellectual Property Law Group PLLC		Customer Number 00500
Signature			
Printed Name	Jeremiah J. Baunach		
Date	November 28, 2011	Reg. No.	44,527

CERTIFICATE OF TRANSMISSION/MAILING	
I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below.	
Signature	
Typed or printed name	Yvette L. Chriscaden Date: 11/28/11

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

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

FEE TRANSMITTAL

For FY 2009

Complete if Known

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


☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$) **180**
METHOD OF PAYMENT (check all that apply)

- ☒ Check ☐ Credit Card ☐ Money Order ☐ Other (please identify): _____
☒ Deposit Account Deposit Account Number: 19-1090 Deposit Account Name: Seed IP Law Group PLLC
 For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)
☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**
☐ Charge any additional fee(s) or underpayments ☒ Charge any underpayments or credit any overpayments
 of fee(s) under 37 CFR 1.16 and 1.17

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

FEE CALCULATION**1. BASIC FILING, SEARCH, AND EXAMINATION FEES**

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

2. EXCESS CLAIM FEES

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

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

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

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

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

3. APPLICATION SIZE FEE

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

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

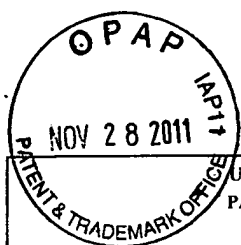
4. OTHER FEE(S)

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

SUBMITTED BY

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

1980227_1.DOCX

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

(Use several sheets if necessary)

APPLICANT
Chris PershingFILING DATE
May 15, 2009GROUP ART UNIT
2123

U.S. PATENT DOCUMENTS

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

EXAMINER

DATE CONSIDERED

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

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

U.S. PATENT DOCUMENTS

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

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

FOREIGN PATENT DOCUMENTS

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

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

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

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

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

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

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

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

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

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

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

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

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 2008230031 B8

EM# EV 887976986 US

USAN: 12/467,244

Inventor: Chris Pershing

(54) Title
Aerial roof estimation systems and methods

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

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

(30) Priority Data

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

(43) Publication Date: 2009.11.05

(43) Publication Journal Date: 2009.11.05

(44) Accepted Journal Date: 2010.06.10

(48) Corrigenda Journal Date: 2010.07.15

(71) Applicant(s)
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(72) Inventor(s)
Carlson, David P.;Pershing, Chris

(74) Agent / Attorney
Griffith Hack, Level 29, Northpoint 100 Miller Street, North Sydney, NSW, 2060

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

ABSTRACT OF THE DISCLOSURE

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

290115.401C1/ 1258906_1.DOC

2008230031 21 Oct 2008

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

Standard Patent

Applicant(s):

Eagle View Technologies, Inc.

Invention Title:

AERIAL ROOF ESTIMATION SYSTEMS AND METHODS

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

AERIAL ROOF ESTIMATION SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

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

BACKGROUND

1. Field of the Invention:

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

2. Description of the Related Art:

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

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

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

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

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

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

SUMMARY

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

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

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

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

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

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

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

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

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

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

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

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

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

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

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

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

DETAILED DESCRIPTION

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

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

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

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

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

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

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

[0028] Also shown in Figure 1 is an alternative setup of the system 10 wherein a preliminary report 101 is prepared by a separate roof estimating entity

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CLAIMS

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

a memory;

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

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

correlate the first aerial image with the second aerial image;

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

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

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

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

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

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

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

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

correlating the first aerial image with the second aerial image;

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

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

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

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

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

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

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

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

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

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

receiving one or more images of the building;

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

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

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

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

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

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

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

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

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

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

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

presenting the model to a customer; and

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

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

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

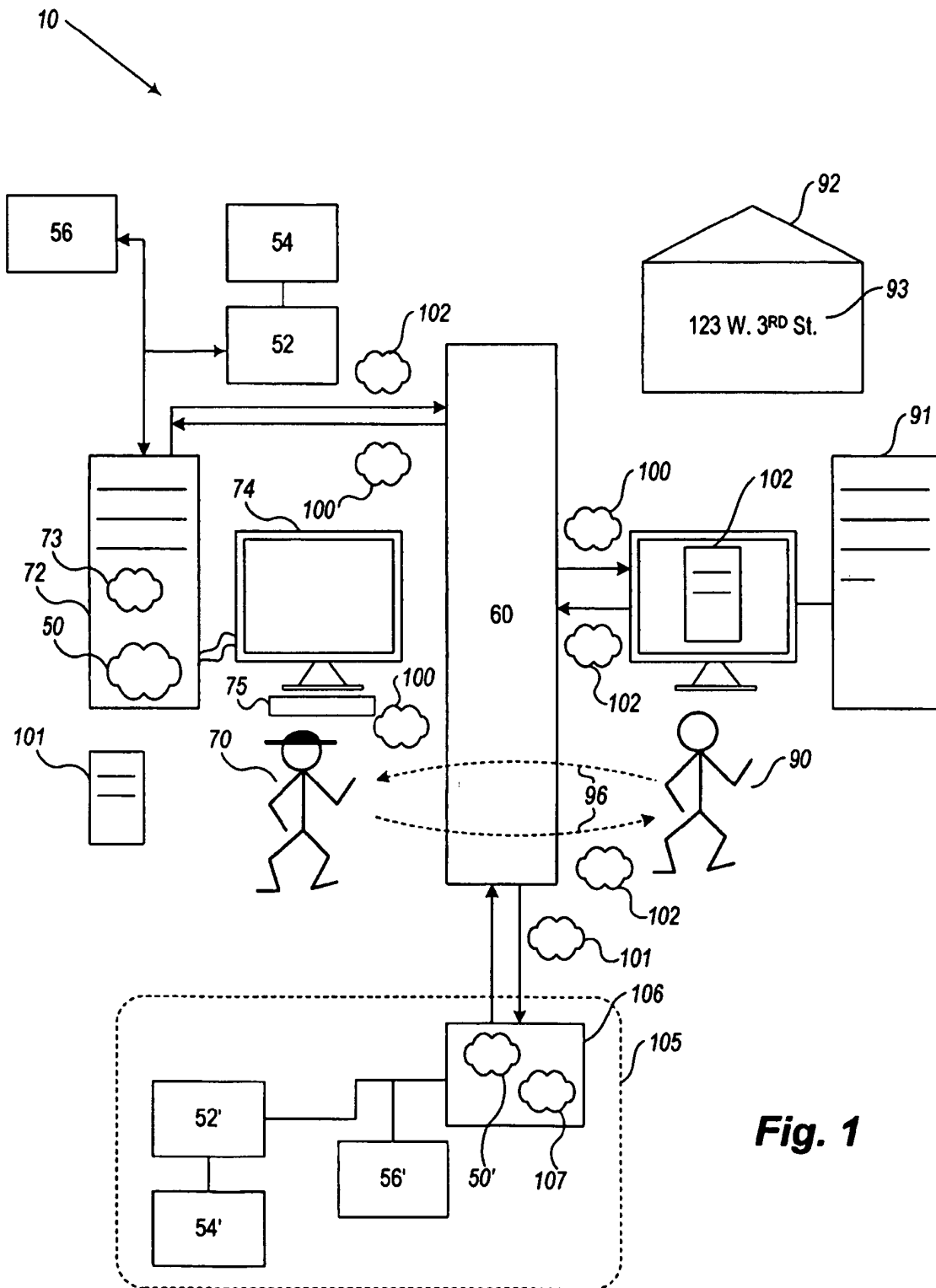


Fig. 1