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(54) **COMPUTER VISION SYSTEMS AND METHODS FOR DETERMINING ROOF SHAPES FROM IMAGERY USING SEGMENTATION NETWORKS**

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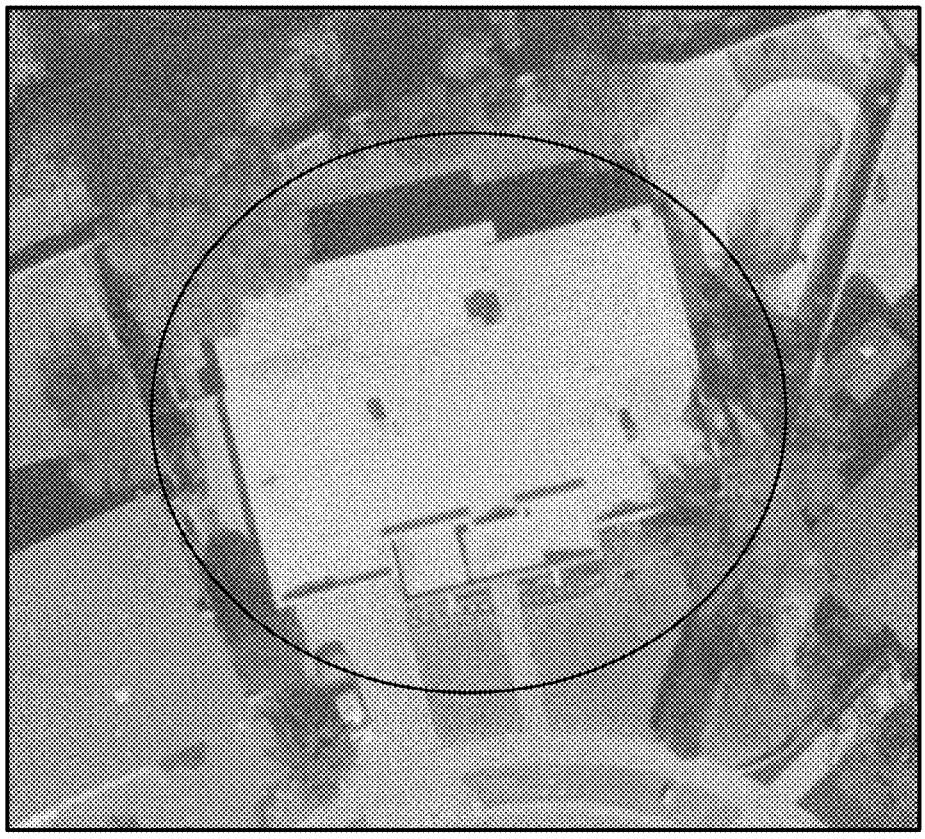
(57) **ABSTRACT**

Computer vision systems and methods for determining roof shapes from imagery using segmentation networks are provided. The system obtains an image of a structure from an image database, and determines a flat roof structure ratio and a sloped roof structure ratio of the roof structure using a neural network. Based on segmentation processing by the neural network, the system determines a flat roof structure ratio and a sloped roof structure ratio based on a portion of the roof structure classified as being flat and a portion of the roof structure classified as being sloped. Then, the system determines a ratio of each shape type of the roof structure using a neural network. The system generates a roof structure shape report indicative of a predominant shape of the roof structure and ratios of each shape type of the roof structure.



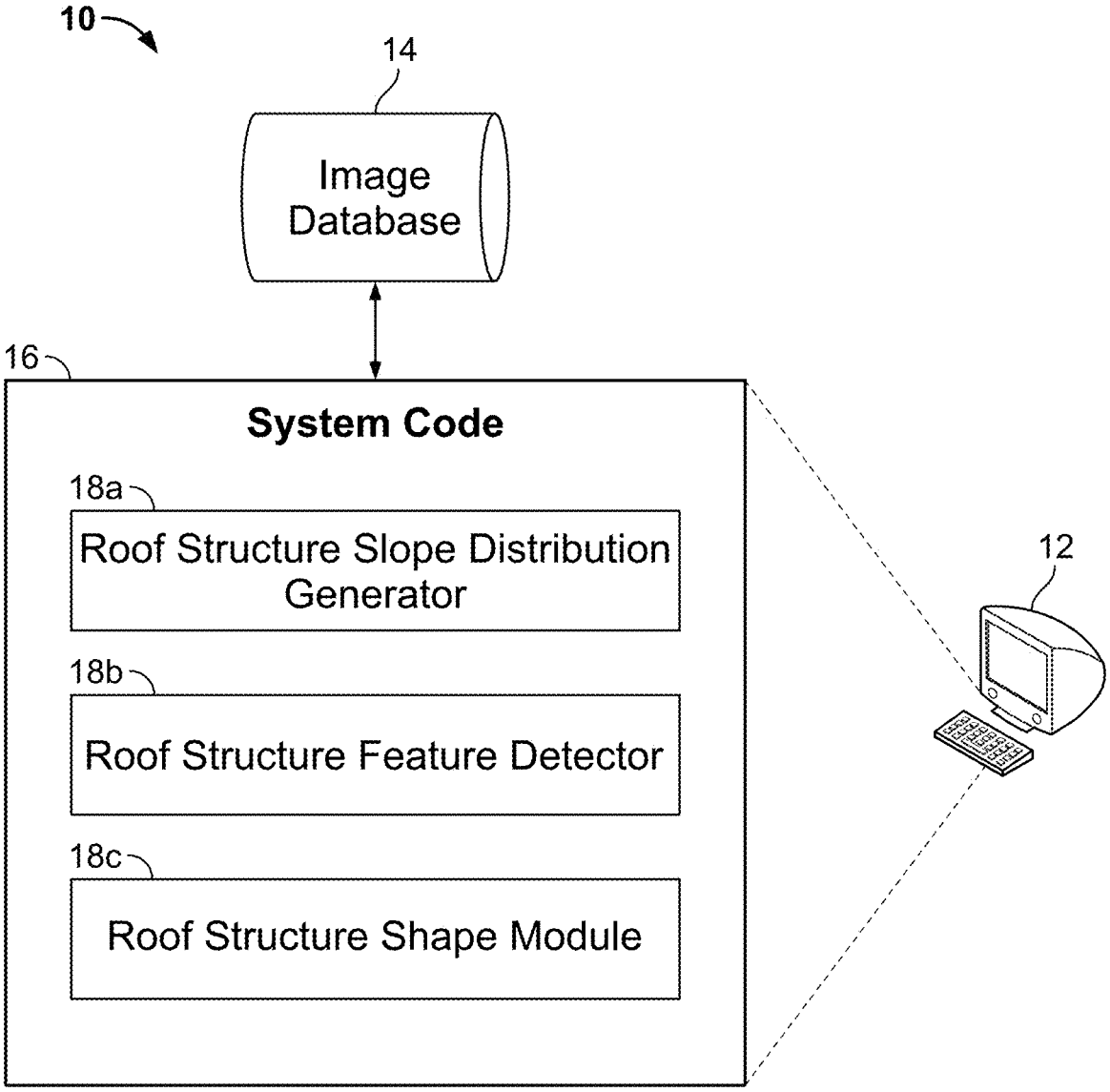

10
14
Image Database
16
System Code
18a
Roof Structure Slope Distribution Generator
18b
Roof Structure Feature Detector
18c
Roof Structure Shape Module
12

FIG. 1

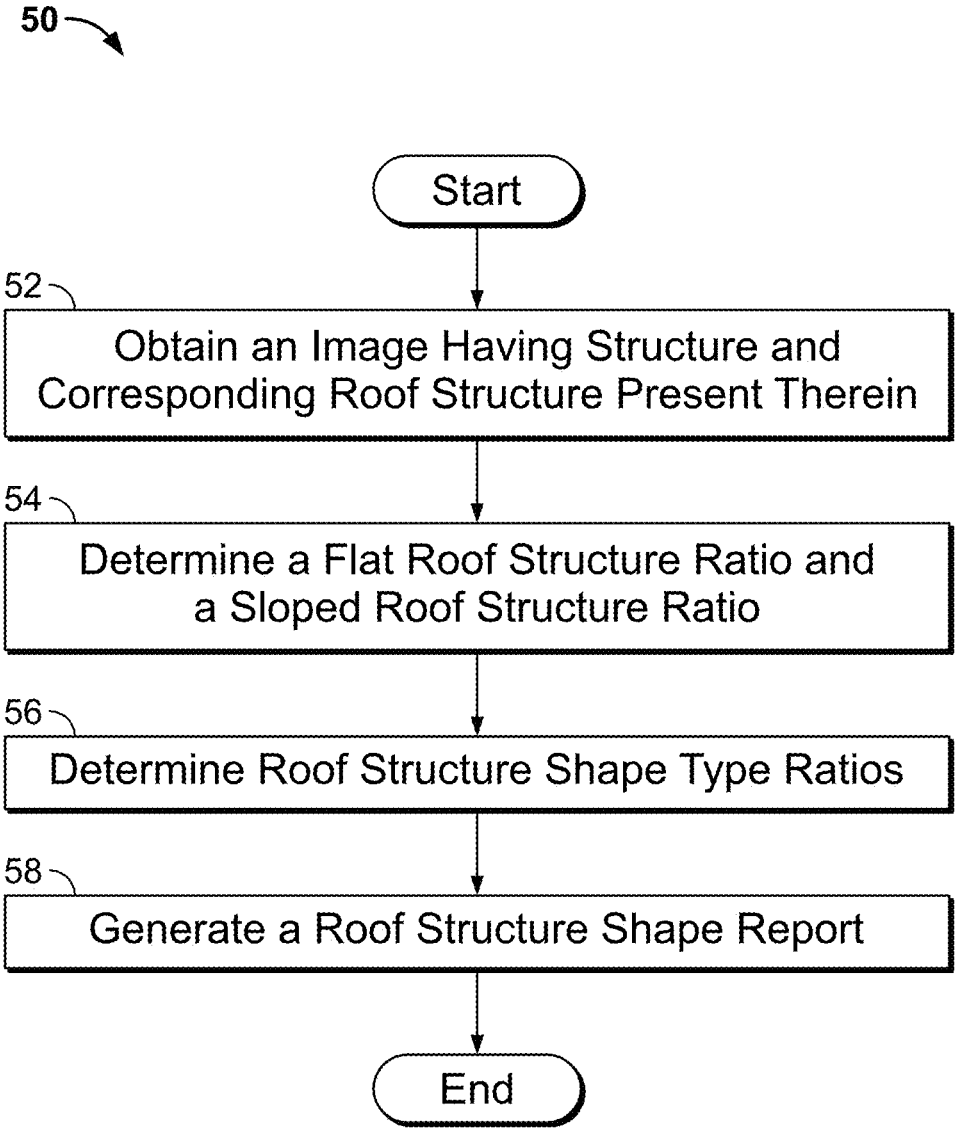

50
Start
52
Obtain an Image Having Structure and Corresponding Roof Structure Present Therein
54
Determine a Flat Roof Structure Ratio and a Sloped Roof Structure Ratio
56
Determine Roof Structure Shape Type Ratios
58
Generate a Roof Structure Shape Report
End

FIG. 2

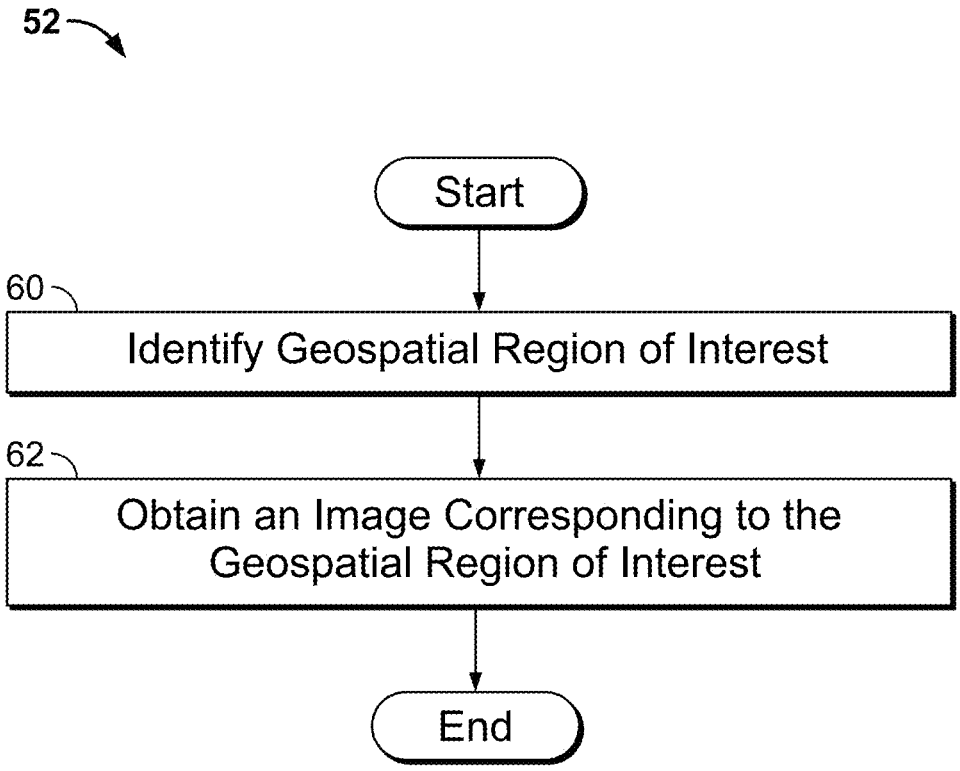

52
Start
60
Identify Geospatial Region of Interest
62
Obtain an Image Corresponding to the Geospatial Region of Interest
End

FIG. 3

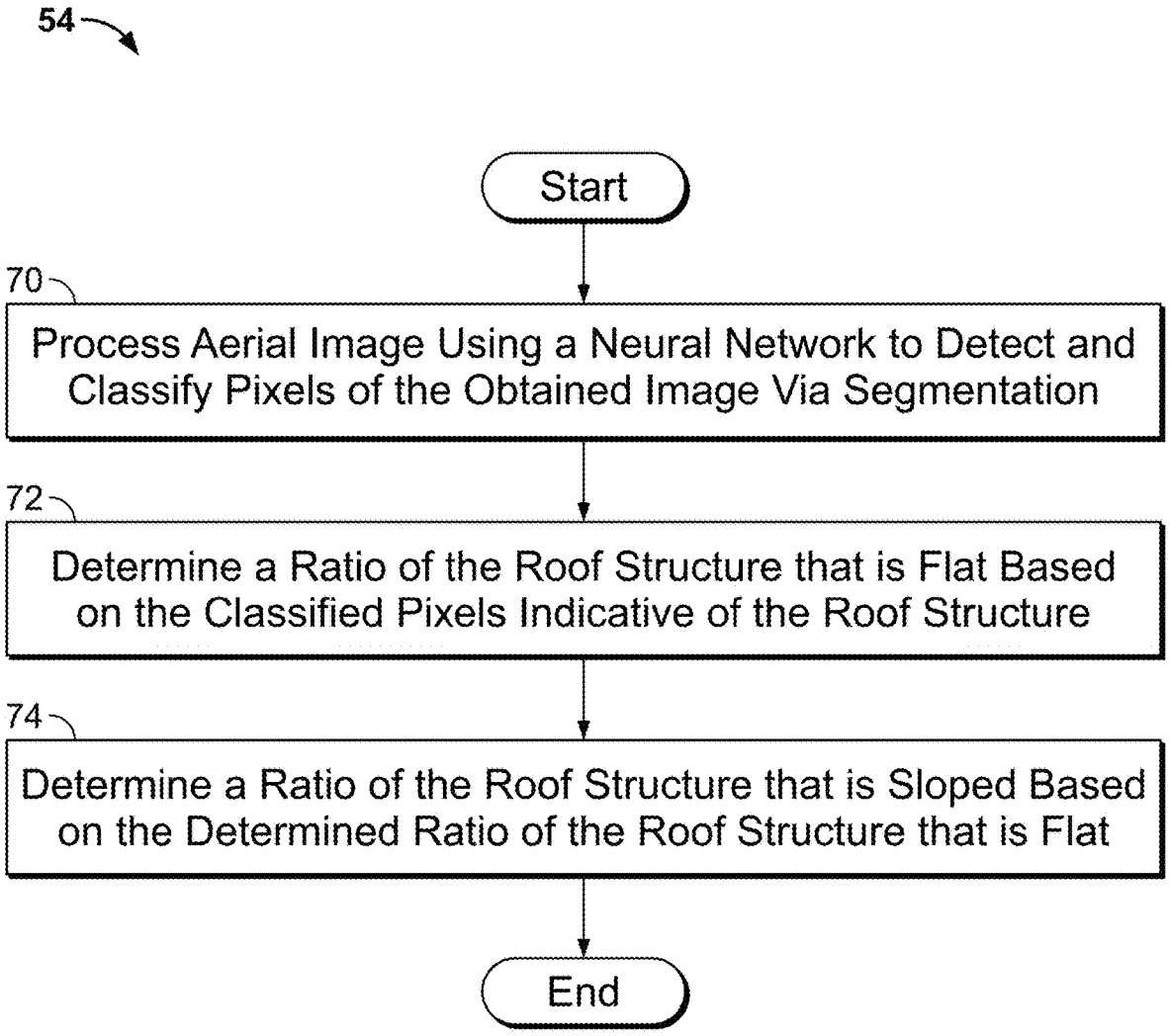

54
Start
70
Process Aerial Image Using a Neural Network to Detect and Classify Pixels of the Obtained Image Via Segmentation
72
Determine a Ratio of the Roof Structure that is Flat Based on the Classified Pixels Indicative of the Roof Structure
74
Determine a Ratio of the Roof Structure that is Sloped Based on the Determined Ratio of the Roof Structure that is Flat
End

FIG. 4

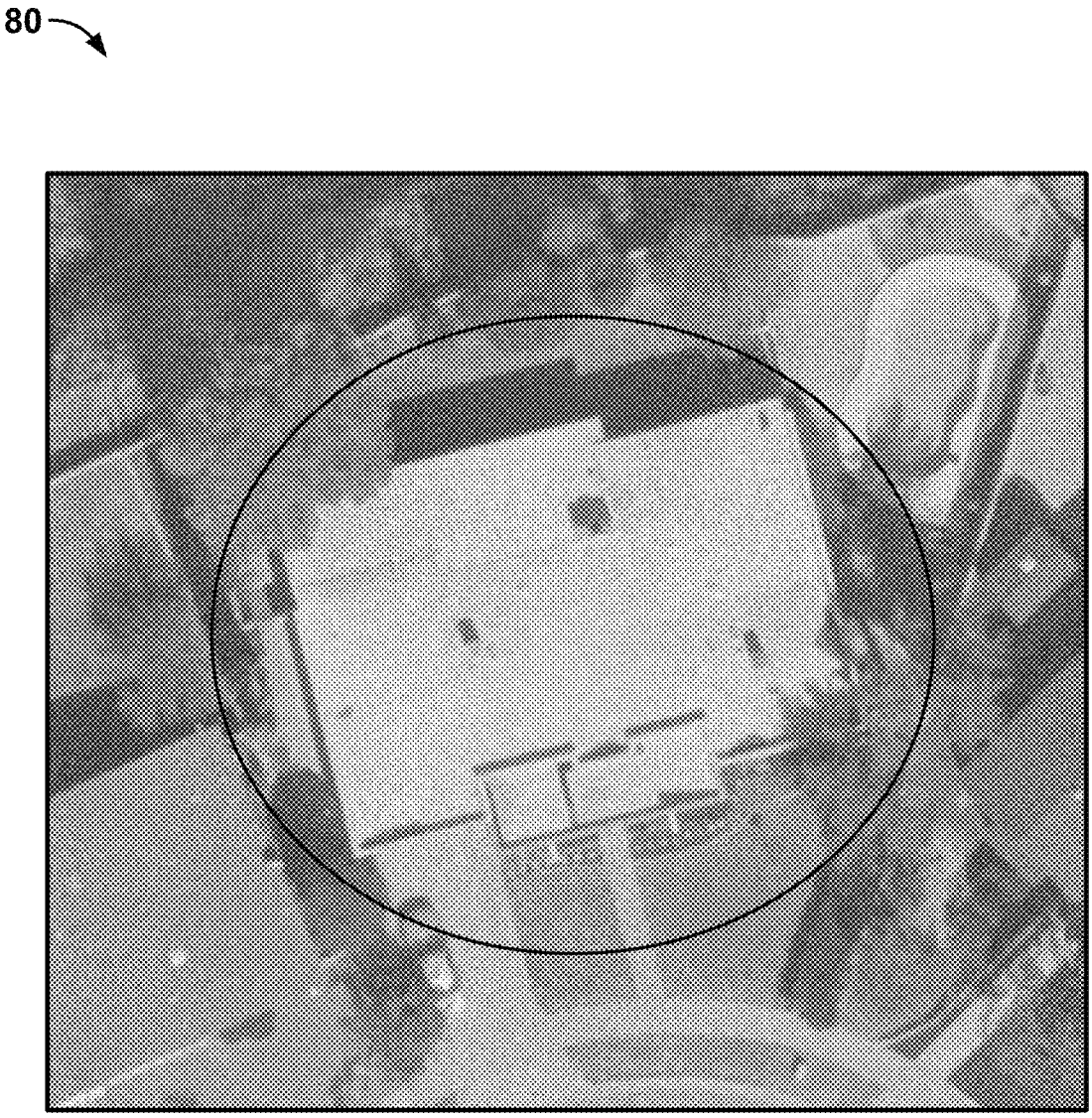


FIG. 5

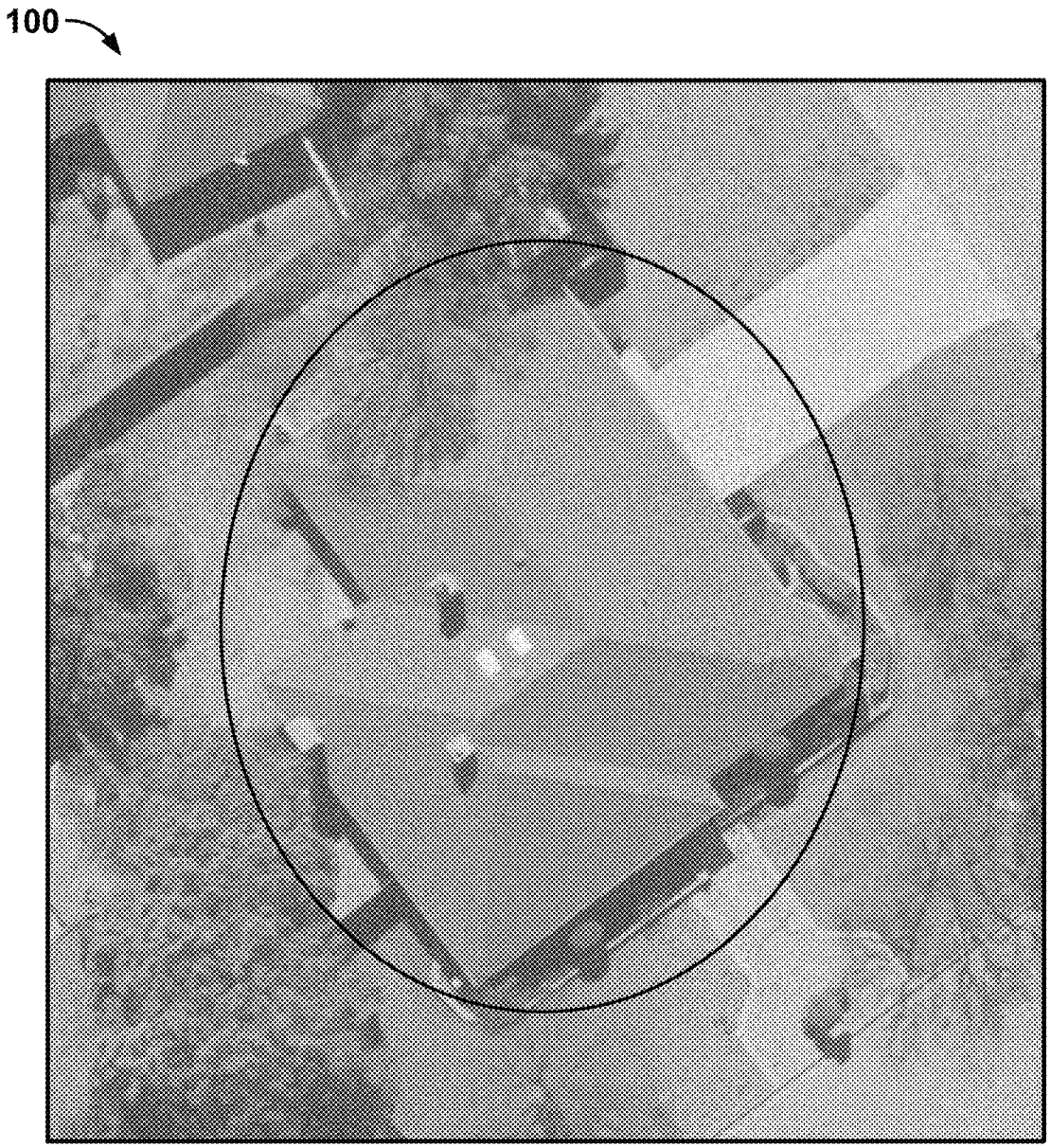


FIG. 6

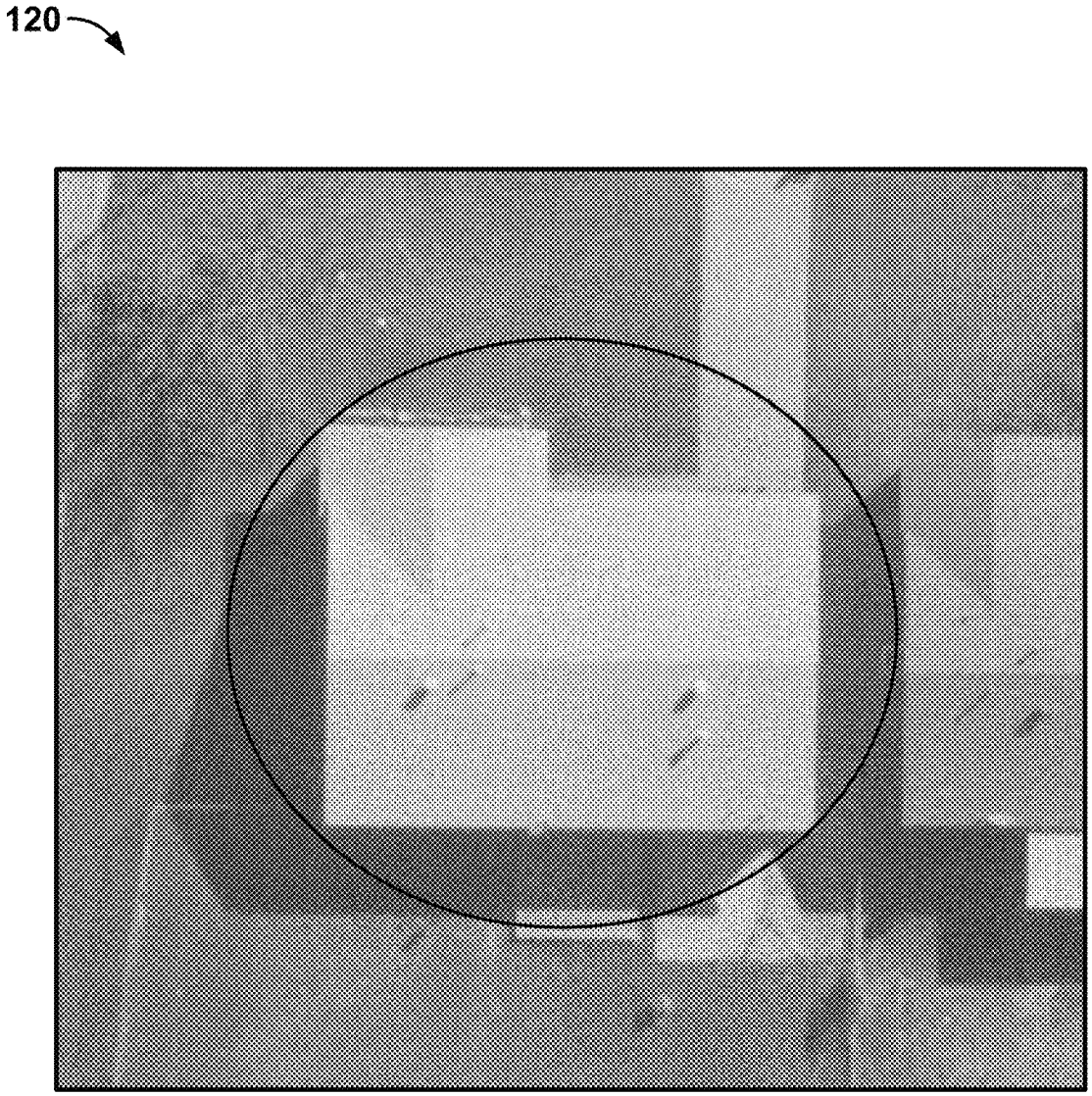


FIG. 7

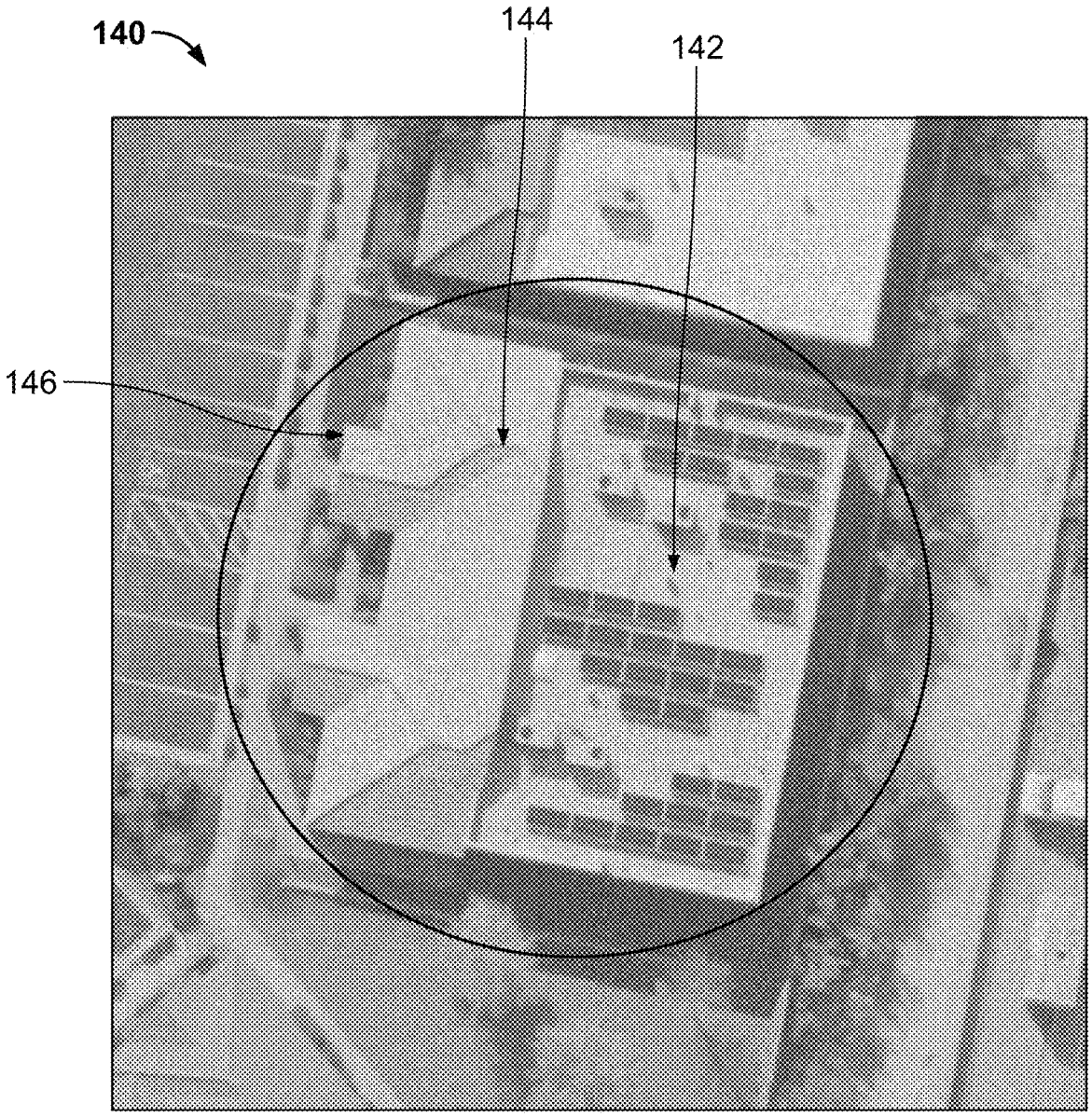


FIG. 8

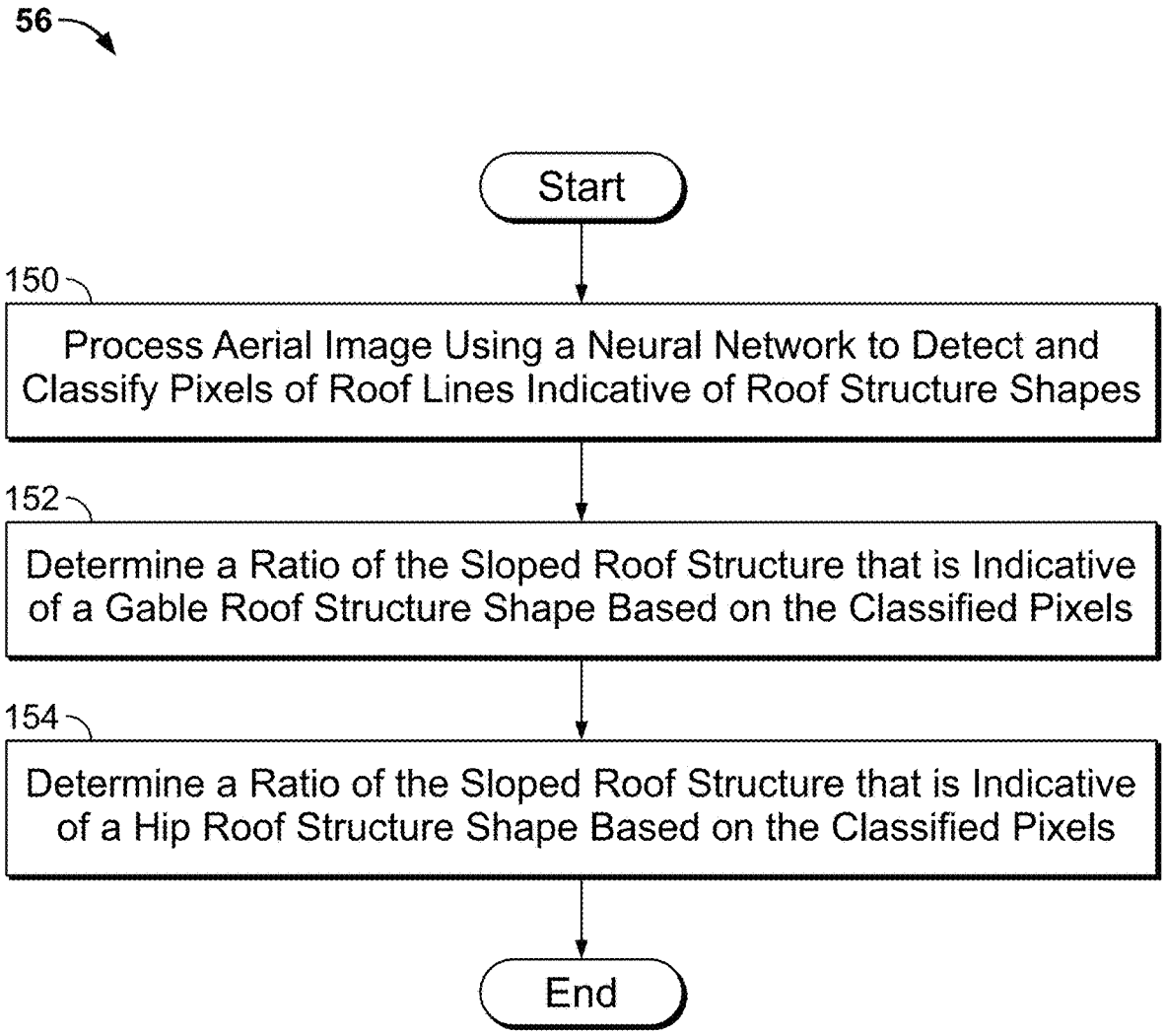

56
Start
150
Process Aerial Image Using a Neural Network to Detect and Classify Pixels of Roof Lines Indicative of Roof Structure Shapes
152
Determine a Ratio of the Sloped Roof Structure that is Indicative of a Gable Roof Structure Shape Based on the Classified Pixels
154
Determine a Ratio of the Sloped Roof Structure that is Indicative of a Hip Roof Structure Shape Based on the Classified Pixels
End

FIG. 9

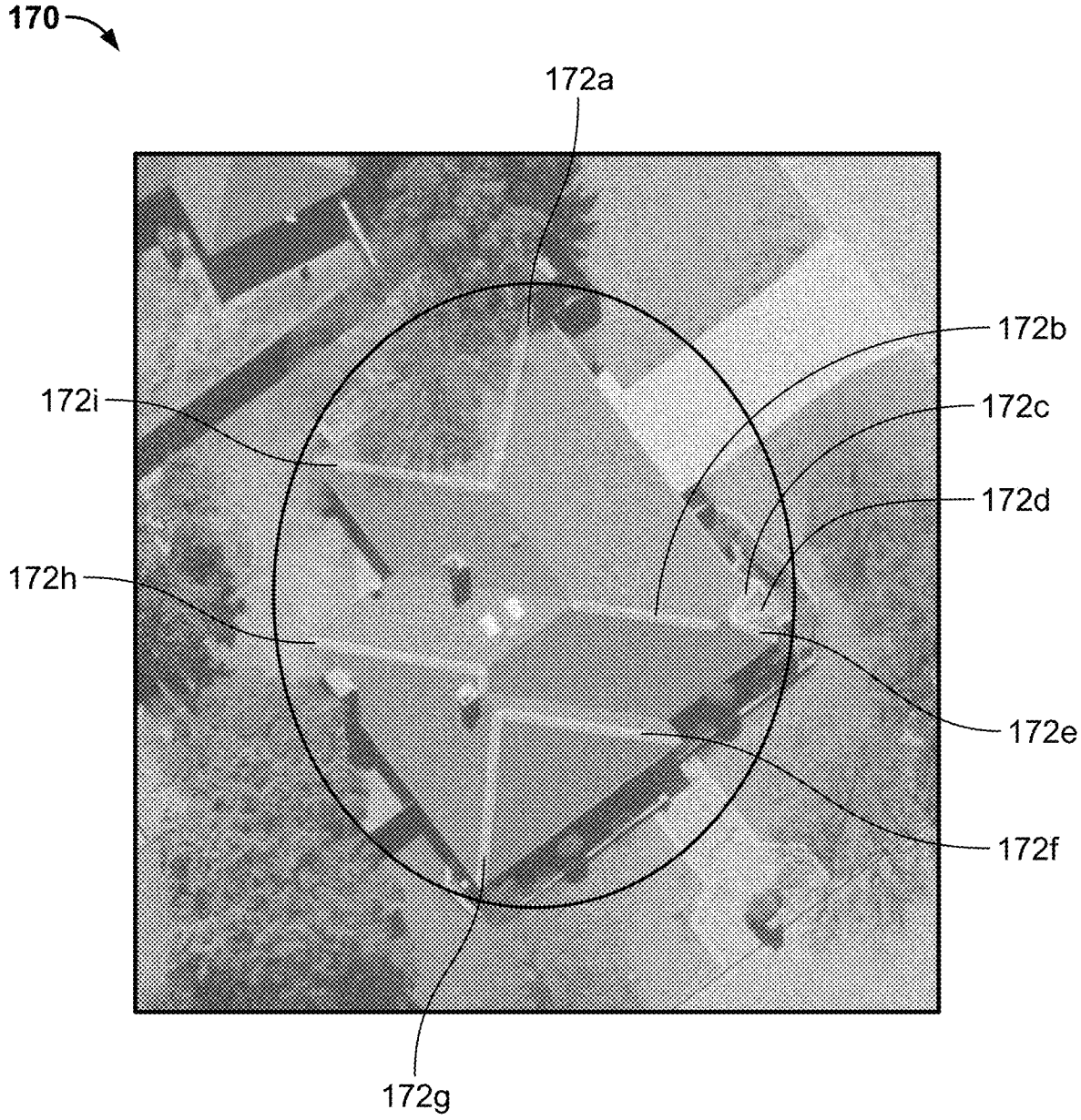


FIG. 10

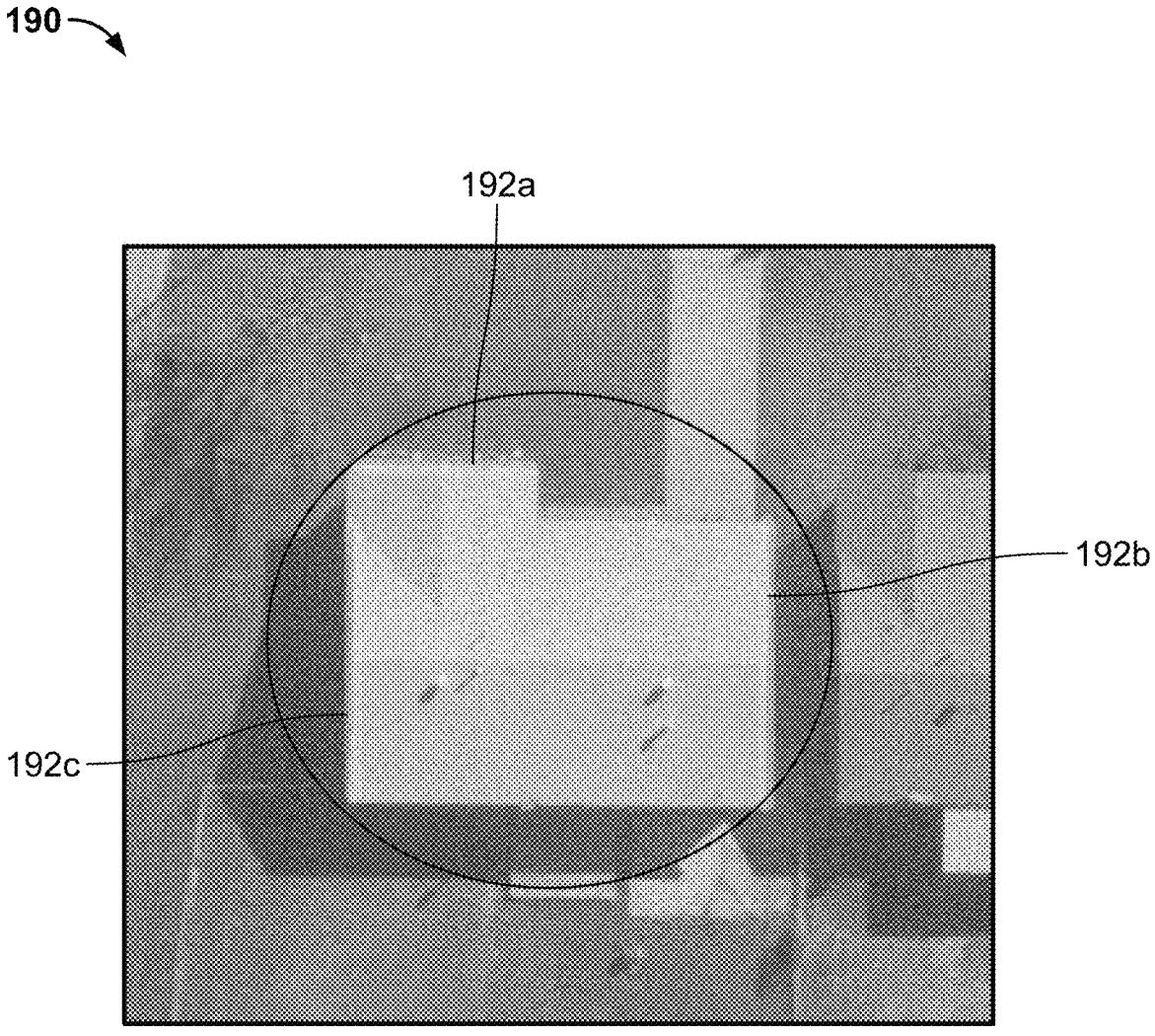


FIG. 11

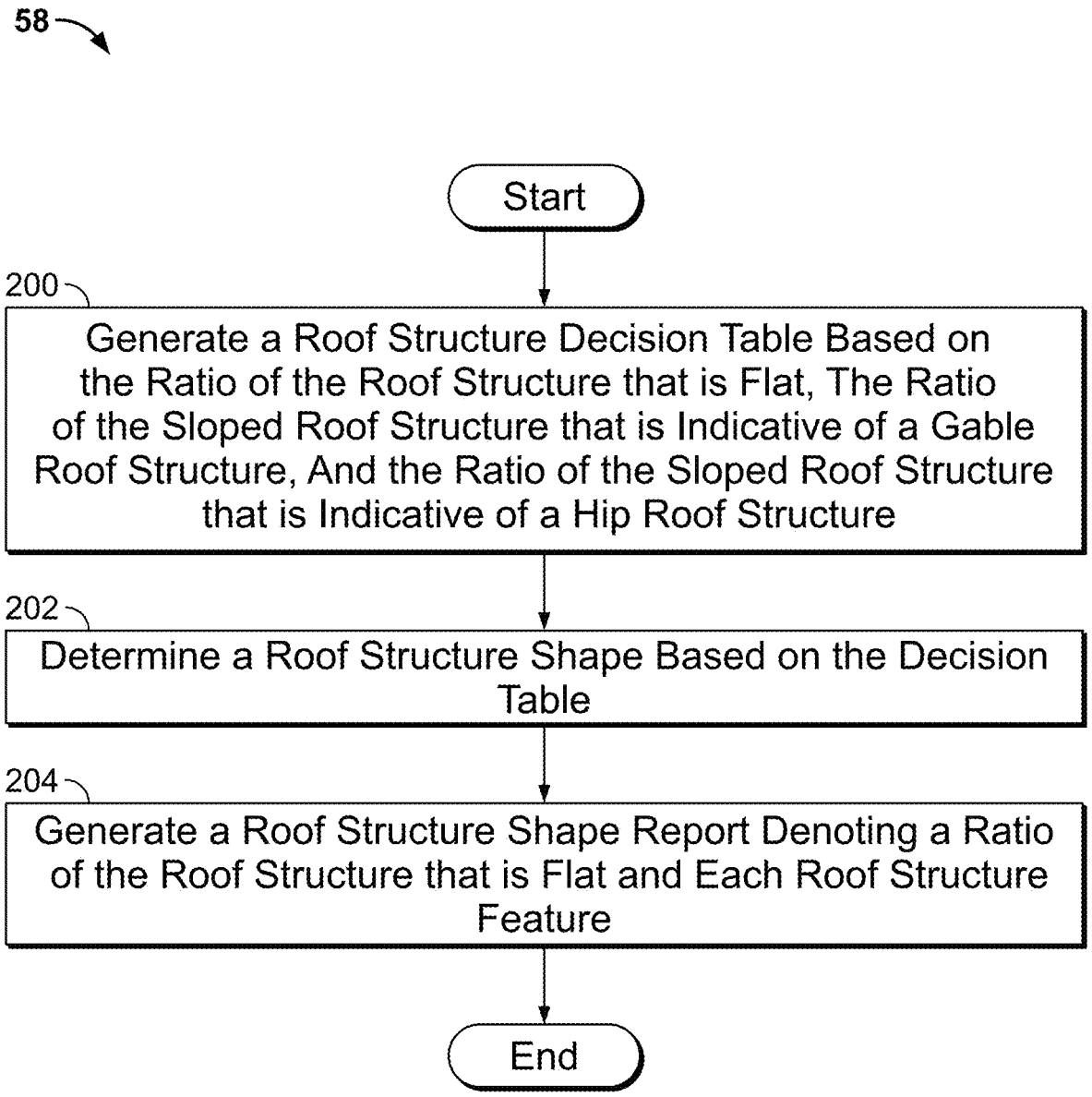

58
Start
200
Generate a Roof Structure Decision Table Based on the Ratio of the Roof Structure that is Flat, The Ratio of the Sloped Roof Structure that is Indicative of a Gable Roof Structure, And the Ratio of the Sloped Roof Structure that is Indicative of a Hip Roof Structure
202
Determine a Roof Structure Shape Based on the Decision Table
204
Generate a Roof Structure Shape Report Denoting a Ratio of the Roof Structure that is Flat and Each Roof Structure Feature
End

FIG. 12

220

Flat > Sloped	Rake > Hip	Predominant Shape
True	True	Flat
True	False	Flat
False	True	Gable
False	False	Hip

FIG. 13

240

Predominant Shape	Hip
Flat Ratio	0.25
Hip Ratio	0.5
Rake Ratio	0.25

FIG. 14

260

Roof Shape	Ratio
Flat	0.25
Hip	0.5
Rake	0.25

FIG. 15

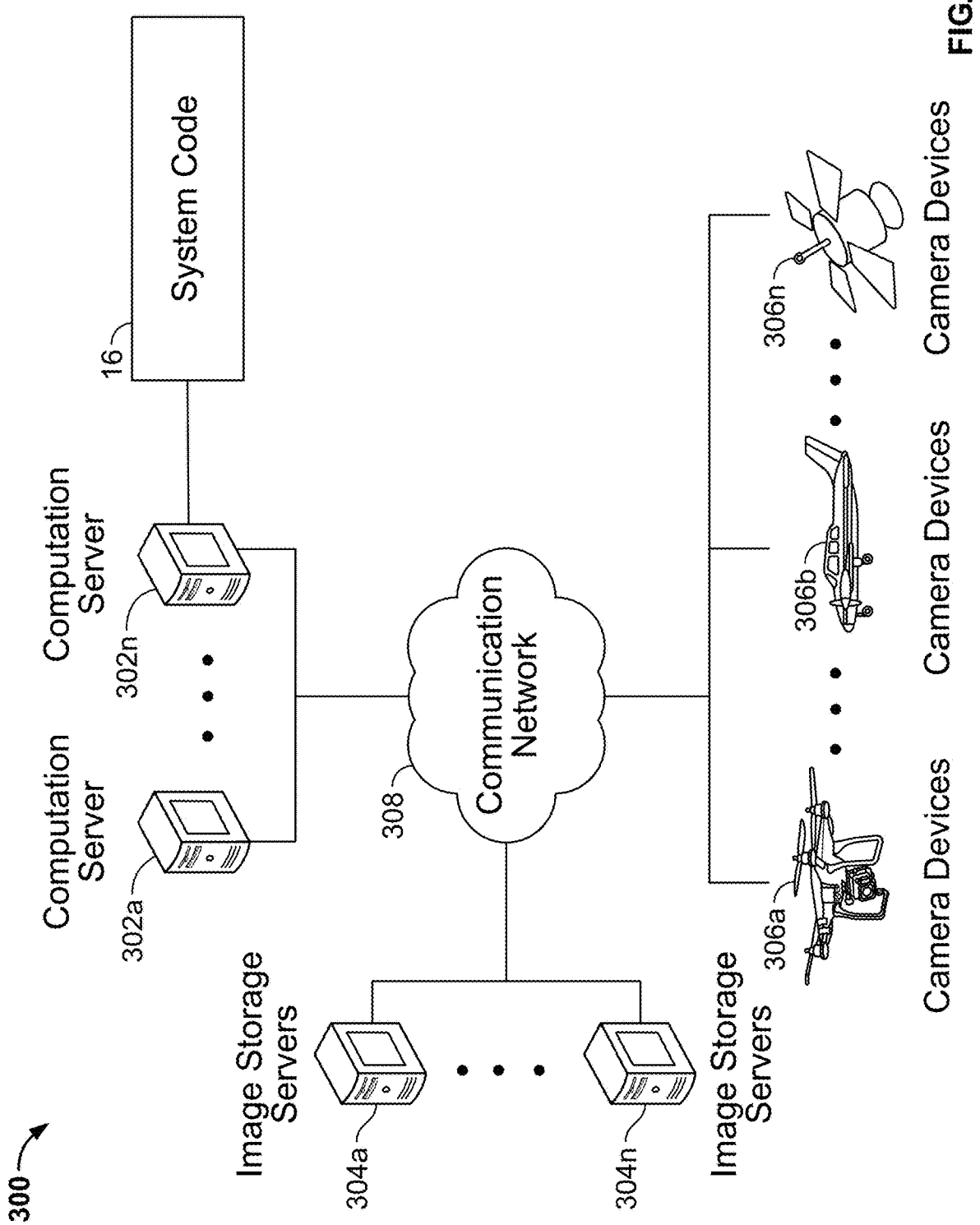

300
System Code
16
Computation Server
302a
Computation Server
302n
Communication Network
308
Image Storage Servers
304a
Image Storage Servers
304n
Camera Devices
306a
Camera Devices
306b
Camera Devices
306n

FIG. 16

COMPUTER VISION SYSTEMS AND METHODS FOR DETERMINING ROOF SHAPES FROM IMAGERY USING SEGMENTATION NETWORKS

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 17/716,623 filed on Apr. 8, 2022, now U.S. Pat. No. 11,651,511 issued on May 16, 2023, which claims the priority of U.S. Provisional Application Ser. No. 63/172,286 filed on Apr. 8, 2021, the entire disclosures of which is expressly incorporated herein by reference.

BACKGROUND

Technical Field

[0002] The present disclosure relates generally to the field of computer modeling of structures. More particularly, the present disclosure relates to computer vision systems and methods for determining roof shapes from imagery using segmentation networks.

RELATED ART

[0003] Accurate and rapid identification and depiction of objects from digital images (e.g., aerial images, satellite images, etc.) is increasingly important for a variety of applications. For example, information related to various structures and/or features of buildings, such as roofs, walls, doors, etc., is often used by construction professionals to specify materials and associated costs for both newly-constructed buildings, as well as for repairing, replacing or upgrading existing structures. Further, in the insurance industry, accurate information about structures may be used to determine the proper costs for insuring buildings. For example, a predominant shape of a roof structure and roof ratios of each shape type (e.g., flat, hip or gable) of the roof structure are valuable sources of information for evaluating weather related risks and estimating costs for repairing or replacing a roof structure.

[0004] Various software systems have been implemented to process ground images, aerial images and/or overlapping image content of an aerial image pair to generate a three-dimensional (3D) model of a building present in the images and/or a 3D model of the structures thereof (e.g., a roof structure). However, these systems can be computationally expensive and have drawbacks, such as necessitating a plurality of image types (e.g., a ground and/or an aerial image) and/or views thereof (e.g., a nadir, a low oblique, and/or a high oblique view) for processing, missing camera parameter information associated with each ground and/or aerial image, and an inability to provide a higher resolution estimate of a position of each aerial image (where the aerial images overlap) to provide a smooth transition for display. Moreover, such systems often require manual inspection of the structures and/or features of buildings (e.g., a roof structure) by an individual to determine respective geometries and features of the structures and a modeler (e.g., a user) to generate accurate models of structures.

[0005] There is currently significant interest in developing systems that automatically determine a predominant shape of a roof structure and roof ratios of each shape type of the roof structure present in a single nadir aerial image requiring no (or, minimal) user involvement, and with a high degree of accuracy. As such, the ability to automatically determine a predominant shape of a roof structure and roof ratios of each shape type of the roof structure present in an aerial image (e.g., in a single nadir image), as well as generate a report of such attributes, without first performing a manual inspection of the roof structure to determine roof structure geometries and features thereof, is a powerful tool. Thus, what would be desirable is a system that automatically and efficiently determines a predominant shape of a roof structure and roof ratios of each shape type of the roof structure and generates reports of such attributes without requiring manual inspection of the roof structure. Accordingly, the computer vision systems and methods disclosed herein solve these and other needs.

SUMMARY

[0006] The present disclosure relates to computer vision systems and methods for determining roof shapes from imagery using segmentation networks. The system obtains an aerial image (e.g., a single nadir image) from an image database having a structure and corresponding roof structure present therein. In particular, the system receives a geospatial region of interest (ROI) specified by a user and obtains an aerial image associated with the geospatial ROI from the image database. Then, the system determines a flat roof structure ratio and a sloped roof structure ratio of the roof structure using a neural network, such as a segmentation network. Based on segmentation processing by the neural network, the system determines a flat roof structure ratio and a sloped roof structure ratio based on a portion of the roof structure classified as being flat and a portion of the roof structure classified as being sloped. Then, the system determines a ratio of each shape type of the roof structure using a neural network. In particular, the system utilizes the neural network to determine roof structure shape type ratios based on detected and classified roof lines of the roof structure. The system generates a roof structure shape report indicative of a predominant shape of the roof structure (e.g., flat, hip or gable) and ratios of each shape type of the roof structure (e.g., their respective contributions toward (percentages of composition of) the total roof structure).

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The foregoing features of the invention will be apparent from the following Detailed Description of the Invention, taken in connection with the accompanying drawings, in which:

[0008] FIG. **1** is a diagram illustrating an embodiment of the system of the present disclosure;

[0009] FIG. **2** is a flowchart illustrating overall processing steps carried out by the system of the present disclosure;

[0010] FIG. **3** is a flowchart illustrating step **52** of FIG. **2** in greater detail;

[0011] FIG. **4** is a diagram illustrating step **54** of FIG. **2** in greater detail;

[0012] FIG. **5** is a diagram illustrating a flat roof structure;

[0013] FIG. **6** is a diagram illustrating a hip roof structure;

[0014] FIG. **7** is a diagram illustrating a gable roof structure;

[0015] FIG. **8** is a diagram illustrating a roof structure having flat, hip and gable roof structure sections;

[0016] FIG. **9** is a flowchart illustrating step **56** of FIG. **2** in greater detail;

[0017] FIG. **10** is a diagram illustrating hip ridges of the roof structure of FIG. **6**;

[0018] FIG. **11** is a diagram illustrating rake edges of the roof structure of FIG. **7**;

[0019] FIG. **12** is a flowchart illustrating step **58** of FIG. **2** in greater detail;

[0020] FIG. **13** is a diagram illustrating a roof structure decision table;

[0021] FIG. **14** is a diagram illustrating a roof structure shape report;

[0022] FIG. **15** is a diagram illustrating another embodiment of the roof structure shape report of FIG. **14**; and

[0023] FIG. **16** is a diagram illustrating another embodiment of the system of the present disclosure.

DETAILED DESCRIPTION

[0024] The present disclosure relates to computer vision systems and methods for determining roof shapes from imagery using segmentation networks, as described in detail below in connection with FIGS. **1-16**.

[0025] By way of background, the systems and methods of the present disclosure utilize an algorithm to automatically determine a shape of a roof structure associated with a building based on an aerial image (e.g., a single nadir image) of the building. A roof structure can include basic geometries (e.g., shapes) such as planar (e.g., flat), hip, and gable geometries, and can be defined by multiple sections of these basic roof structure shapes and the respective features thereof (e.g., roof lines). In particular, a flat roof structure can be defined as a roof structure or roof structure section having a small slope (e.g., a slope less than or equal to one inch rise over twelve inch run) without prominent ridges. Additionally, a hip roof structure can be defined as a roof structure or roof structure section having a sloped roof ridge formed by an intersection of two roof faces. It should be understood that a roof ridge can be flat (e.g., a horizontal roof segment formed by an intersection of two roof faces which each slope away from the intersection). Lastly, a gable roof structure can be defined as a roof structure or a roof structure section having sloped roof edges or rakes. It should be understood that a roof edge can also be flat (e.g., a horizontal roof edge or eave). A roof structure can include several other features or roof lines (e.g., an intersection of two planar sections of a roof structure or an edge of a roof structure) including, but not limited to, a sloped valley (e.g., a non-horizontal roof segment formed by an intersection of two roof faces which form concave roof surfaces), and a flat valley (e.g., a horizontal roof segment formed by an intersection of two roof faces which form concave roof surfaces).

[0026] The systems and methods of the present disclosure do not require a modeler (e.g., a user) to determine the aforementioned roof structure geometries and features thereof, and can be refined by a user to increase an accuracy of a roof structure shape determination. Additionally, the algorithm utilizes camera parameters to determine an image crop of a building of interest present in a nadir aerial image and does not utilize the camera parameters to determine a shape of a roof structure associated with the building.

[0027] Turning to the drawings, FIG. **1** is a diagram illustrating an embodiment of the system **10** of the present disclosure. The system **10** could be embodied as a central processing unit **12** (processor) in communication with an image database **14**. The processor **12** could include, but is not limited to, a computer system, a server, a personal computer, a cloud computing device, a smart phone, or any other suitable device programmed to carry out the processes disclosed herein. The system **10** could determine a shape of a roof structure associated with a building or structure based on a building or structure present in an image obtained from the image database **14**.

[0028] The image database **14** could include digital images and/or digital image datasets comprising aerial images, satellite images, etc. Further, the datasets could include, but are not limited to, images of residential and commercial buildings. The database **14** could store one or more three-dimensional representations of an imaged location (including structures at the location), such as point clouds, LiDAR files, etc., and the system **10** could operate with such three-dimensional representations. As such, by the terms "image" and "imagery" as used herein, it is meant not only optical imagery (including aerial and satellite imagery), but also three-dimensional imagery and computer-generated imagery, including, but not limited to, LiDAR, point clouds, three-dimensional images, etc. The processor **12** executes system code **16** which determines a shape of a roof structure using segmentation networks based on an image obtained from the image database **14** having a building or structure and corresponding roof structure present therein.

[0029] The system **10** includes system code **16** (non-transitory, computer-readable instructions) stored on a computer-readable medium and executable by the hardware processor **12** or one or more computer systems. The code **16** could include various custom-written software modules that carry out the steps/processes discussed herein, and could include, but is not limited to, a roof structure slope distribution generator **18***a*, a roof structure feature detector **18***b*, and a roof structure shape module **18***c*. The code **16** could be programmed using any suitable programming languages including, but not limited to, C, C++, C #, Java, Python or any other suitable language. Additionally, the code **16** could be distributed across multiple computer systems in communication with each other over a communications network, and/or stored and executed on a cloud computing platform and remotely accessed by a computer system in communication with the cloud platform. The code **16** could communicate with the image database **14**, which could be stored on the same computer system as the code **16**, or on one or more other computer systems in communication with the code **16**.

[0030] Still further, the system **10** could be embodied as a customized hardware component such as a field-programmable gate array ("FPGA"), application-specific integrated circuit ("ASIC"), embedded system, or other customized hardware components without departing from the spirit or scope of the present disclosure. It should be understood that FIG. **1** is only one potential configuration, and the system **10** of the present disclosure can be implemented using a number of different configurations.

[0031] FIG. **2** is a flowchart illustrating overall processing steps **50** carried out by the system **10** of the present disclosure. Beginning in step **52**, the system **10** obtains an image from the image database **14** having a structure and corresponding roof structure present therein. The image can be a single nadir aerial image, or any other suitable image. In step **54**, the system **10** processes the image to determine a flat roof structure ratio and a sloped roof structure ratio using a neural network. In particular, the system **10** utilizes a semantic segmentation convolutional neural network to determine a flat roof structure ratio and a sloped roof

structure ratio based on a portion of the roof structure classified as being flat and a portion of the roof structure classified as being sloped. Then, in step **56**, the system **10** determines a ratio of each shape type of the roof structure using a neural network. In particular, the system **10** utilizes the neural network to determine roof structure shape type ratios based on detected and classified roof lines of the roof structure. In step **58**, the system **10** generates a roof structure shape report indicative of a predominant shape of the roof structure (e.g., flat, hip or gable) and ratios of each shape type of the roof structure (e.g., their respective contributions toward (percentages of composition of) the total roof structure).

[0032] FIG. **3** is a flowchart illustrating step **52** of FIG. **2** in greater detail. Beginning in step **60**, the system **10** identifies a geospatial region of interest (ROI) specified by a user. For example, a user can input latitude and longitude coordinates of an ROI. Alternatively, a user can input an address or a world point of an ROI. The geospatial ROI can be represented by a generic polygon enclosing a geocoding point indicative of the address or the world point. The region can be of interest to the user because of one or more structures present in the region. A property parcel included within the ROI can be selected based on the geocoding point. As discussed in further detail below, a deep learning neural network can be applied over the area of the parcel to detect a structure or a plurality of structures situated thereon.

[0033] The geospatial ROI can also be represented as a polygon bounded by latitude and longitude coordinates. In a first example, the bound can be a rectangle or any other shape centered on a postal address. In a second example, the bound can be determined from survey data of property parcel boundaries. In a third example, the bound can be determined from a selection of the user (e.g., in a geospatial mapping interface). Those skilled in the art would understand that other methods can be used to determine the bound of the polygon. The ROI may be represented in any computer format, such as, for example, well-known text ("WKT") data, TeX data, HTML data, XML data, etc. For example, a WKT polygon can comprise one or more computed independent world areas based on the detected structure in the parcel.

[0034] In step **62**, after the user inputs the geospatial ROI, the system **10** obtains an aerial image (e.g., a single nadir image) associated with the geospatial ROI from the image database **14**. As mentioned above, the images can be digital images such as aerial images, satellite images, etc. However, those skilled in the art would understand that any type of image captured by any type of image capture source. For example, the aerial images can be captured by image capture sources including, but not limited to, a plane, a helicopter, a paraglider, a satellite, or an unmanned aerial vehicle (UAV). It should be understood that multiple images can overlap all or a portion of the geospatial ROI and that the images can be orthorectified and/or modified if necessary.

[0035] FIG. **4** is a flowchart illustrating step **54** of FIG. **2** in greater detail. In step **70**, the system **10** processes the aerial image using a neural network to detect and classify pixels of a roof structure present in the obtained image via segmentation. It should be understood that the system **10** can utilize any neural network which is trained to segment a roof structure. For example, the system **10** can utilize a semantic segmentation convolutional neural network to classify each pixel of the roof structure according to various classes including, but not limited to, a background class, a flat roof structure class and a sloped roof structure class. It should be understood that additional classes can be included to classify pixels associated with particular roof structure features (e.g., a chimney) and/or neighboring structures (e.g., a pergola, a terrace, or a gazebo). Pixels classified as neighboring structures can be labeled as background to reduce label computational processing and to avoid necessitating an instance based building mask as an additional input at inference time.

[0036] Based on the neural network segmentation processing, in step **72**, the system **10** determines a ratio of the roof structure that is flat based on the classified pixels indicative of the roof structure. In particular, the system **10** determines the flat roof structure ratio based on the pixels classified as being flat and the pixels classified as being sloped according to Equation 1 below:

$$\text{ratio}_{flat} = \frac{N_{flat}}{(N_{slope} + N_{flat})} \quad \text{Equation 1}$$

[0037] Then, in step **74**, the system **10** determines a ratio of the roof structure that is sloped based on the flat roof structure ratio. In particular, the system **10** determines the sloped roof structure ratio as the complement of the flat roof structure ratio according to Equation 2 below:

$$\text{ratio}_{slope} = 1 - \text{ratio}_{flat} \quad \text{Equation 2}$$

[0038] FIGS. **5-8** are diagrams illustrating various roof structure shapes associated with structures present in respective nadir aerial images. In particular FIG. **5** is a diagram **80** illustrating a flat roof structure, FIG. **6** is a diagram **100** illustrating a hip roof structure, FIG. **7** is a diagram **120** illustrating a gable roof structure, and FIG. **8** is a diagram **140** illustrating a roof structure having a flat roof structure section **142**, a hip roof structure section **144** and a gable roof structure section **146**. As described in further detail below with respect to FIGS. **9-11**, the system **10** can determine a hip roof structure shape or a gable roof structure shape based on detected and classified roof lines of a roof structure and the sloped roof structure ratio.

[0039] FIG. **9** is a flowchart illustrating step **56** of FIG. **2** in greater detail. As mentioned above, the system **10** utilizes a neural network to detect and classify pixels of a roof structure present in the obtained image via segmentation. Similarly, in step **150**, the system **10** processes an aerial image using a neural network to detect and classify pixels of roof lines (e.g., roof line segments) indicative of roof structure shapes such as a hip roof structure or a gable roof structure. It should be understood that the system **10** can utilize any neural network which is trained to detect and classify roof lines including, but not limited to, a hip ridge, a rake, a flat ridge, an eave, a sloped valley and a flat valley. For example, FIG. **10** is a diagram **170** illustrating the detection and classification of hip ridges **172***a-i* of the hip roof structure of FIG. **6** and FIG. **11** is a diagram **190** illustrating the detection and classification of rakes **192***a-c* of the gable roof structure of FIG. **7**. As respectively shown in FIGS. **10** and **11**, a hip ridge line can be defined as a

sloped intersection between two adjacent roof planes and a rake line can be defined as a sloped edge having an adjacent roof plane.

[0040] Referring back to FIG. **9**, the system **10** can detect and classify roof lines via several techniques including, but not limited to, line segment semantic segmentation and a line segment detection neural network. With respect to line segment semantic segmentation, the system **10** assigns each pixel a class of background or a line type label via a semantic segmentation convolutional neural network to yield an image mask of the roof segments. The system **10** can further refine these roof segments into respective line segments via traditional computer vision techniques (e.g., Hough lines, a Line Segment Detector (LSD) or object aligned bounding boxes). In addition to the line type label, the system **10** can train the neural network to learn additional features to assist in extracting specific line segments from an image. These features can include, but are not limited to, corner detection (e.g., an intersection of two or more roof lines), line orientation detection, roof gradient estimation and roof face type segmentation.

[0041] With respect to a line segment detection neural network, the system **10** can utilize an object detection sub network (e.g., a faster convolutional neural network (Faster R-CNN) or a Single Shot Detector (SSD) network) to detect corners and yield a candidate line segment for each unique pair of detected corners. The system **10** can construct a feature vector for each candidate line segment from neural network embedding sampled from points along the line segment. The system **10** subsequently classifies each candidate line segment via a sub network as either not a segment or a segment associated with a classification. Utilizing a line segment detection neural network can be advantageous over semantic segmentation followed by a non-learned segment extraction algorithm because it provides for a faster and more computationally efficient network architecture and requires fewer post processing steps to extract line segments.

[0042] Based on the neural network segmentation processing, in step **152**, the system **10** determines a ratio of the sloped roof structure that is indicative of a gable roof structure shape based on the classified pixels according to Equation 3 below:

$$\text{ratio}_{gable} = \text{ratio}_{slope} * \frac{\sum l_{rake}}{\sum l_{rake} = c * \sum l_{hip}} \quad \text{Equation 3}$$

[0043] Then, in step **154**, the system **10** determines a ratio of the sloped roof structure that is indicative of a hip roof structure shape based on the classified pixels according to Equation 4 below:

$$\text{ratio}_{hip} = \text{ratio}_{slope} * \frac{c * \sum l_{hip}}{\sum l_{rake} = c * \sum l_{hip}} \quad \text{Equation 4}$$

[0044] In Equations 3 and 4, l denotes a length of a roof line, and c denotes a constant to account for a hip segment being longer than a rake segment relative to an amount of a roof structure that a hip segment represents because a hip segment is orientated 45 degrees relative to a roof eave. The constant c can have a default value of but this value can be adjusted utilizing hip and gable ratios if known values are available to account for systematic under/over estimation of line segment lengths.

[0045] FIG. **12** is a flowchart illustrating step **58** of FIG. **2** in greater detail. In step **200**, the system **10** generates a roof structure decision table based on the flat roof structure ratio, the ratio of the sloped roof structure that is indicative of a gable roof structure and the ratio of the sloped roof structure that is indicative of a hip roof structure. FIG. **13** is a diagram **220** illustrating a roof structure decision table. As shown in FIG. **13**, the system **10** utilizes the roof structure decision table to determine a predominant shape of a roof structure (e.g., flat, gable or hip) based on whether particular features of the roof structure are true or false (e.g., flat>sloped or rake>hip). Accordingly and referring back to FIG. **12**, in step **202**, the system **10** determines a predominant shape of the roof structure based on the roof structure decision table. In step **204**, the system **10** generates a roof structure shape report indicative of a predominant shape of the roof structure (e.g., flat, gable or hip) and ratios of each shape type of the roof structure (e.g., their respective contributions toward (percentages of composition of) the total roof structure). For example, FIG. **14** is a diagram **240** illustrating a roof structure shape report and FIG. **15** is a diagram **260** illustrating another embodiment of the roof structure shape report of FIG. **14**.

[0046] FIG. **16** a diagram illustrating another embodiment of the system **300** of the present disclosure. In particular, FIG. **16** illustrates additional computer hardware and network components on which the system **300** could be implemented. The system **300** can include a plurality of computation servers **302***a*-**302***n* having at least one processor and memory for executing the computer instructions and methods described above (which could be embodied as system code **16**). The system **300** can also include a plurality of image storage servers **304***a*-**304***n* for receiving image data and/or video data. The system **300** can also include a plurality of camera devices **306***a*-**306***n* for capturing image data and/or video data. For example, the camera devices can include, but are not limited to, an unmanned aerial vehicle **306***a*, an airplane **306***b*, and a satellite **306***n*. The computation servers **302***a*-**302***n*, the image storage servers **304***a*-**304***n*, and the camera devices **306***a*-**306***n* can communicate over a communication network **308**. Of course, the system **300** need not be implemented on multiple devices, and indeed, the system **300** could be implemented on a single computer system (e.g., a personal computer, server, mobile computer, smart phone, etc.) without departing from the spirit or scope of the present disclosure.

[0047] Having thus described the system and method in detail, it is to be understood that the foregoing description is not intended to limit the spirit or scope thereof. It will be understood that the embodiments of the present disclosure described herein are merely exemplary and that a person skilled in the art can make any variations and modification without departing from the spirit and scope of the disclosure. All such variations and modifications, including those discussed above, are intended to be included within the scope of the disclosure.

What is claimed is:

1. A computer vision system for determining roof shapes from imagery, comprising:

a memory storing at least one image of a structure having a roof structure; and

a processor in communication with the memory, the processor programmed to perform the steps of:

retrieving the at least one image of the structure from the memory;

processing the at least one image of the structure using a neural network to determine at least one ratio of roof structure types using the neural network; and

generating and transmitting a roof structure shape report indicative of a predominant shape of the roof structure based on the at least one ratio of roof structure types.

2. The system of claim **1**, wherein the roof structure shape report includes the at least one ratio of roof structure types.

3. The system of claim **1**, wherein the neural network comprises a convolutional neural network.

4. The system of claim **1**, wherein the system generates a flat roof structure ratio that represents a portion of the roof structure classified by the neural network as being flat.

5. The system of claim **4**, wherein the system generates a sloped roof structure ratio that represents a portion of the roof classified by the neural network as being sloped.

6. The system of claim **1**, wherein the neural network determines the at least one ratio of roof structure types based on roof lines of the roof structure detected by the neural network.

7. The system of claim **1**, wherein the predominant shape of the roof structure comprises one or more of a flat roof shape, a hip roof shape, or a gable roof shape.

8. The system of claim **7**, wherein the at least one ratio indicates a contribution of a roof shape to a total roof structure.

9. The system of claim **1**, wherein the system retrieves the at least one image based on a geospatial region of interest.

10. The system of claim **1**, wherein the neural network processes the at least one image to detect and classify pixels of the at least one image via segmentation.

11. The system of claim **10**, wherein the neural network determines a flat roof structure ratio based on classified pixels of the at least one image indicative of the roof structure.

12. The system of claim **1**, wherein the neural network determines a sloped roof structure ration based on the flat roof structure ratio.

13. The system of claim **1**, wherein the neural network processes the at least one image to detect and classify pixels of roof lines that are indicative of roof structure shapes.

14. The system of claim **13**, wherein the system generates a sloped roof structure ratio that indicates a gable roof structure and is based on the classified pixels.

15. The system of claim **13**, wherein the system generates a sloped roof structure ratio that indicates a hip roof structure shape and is based on the classified pixels.

16. The system of claim **1**, wherein the processor generates a roof structure decision table based on a flat roof structure ratio, a sloped roof structure ratio indicative of a gable roof, and a sloped roof structure ratio indicative of a hip roof structure shape.

17. The system of claim **16**, wherein the processor determines a roof structure shape based on the decision table.

18. A computer vision method for determining roof shapes from imagery, comprising the steps of:

retrieving by a processor at least one image of a structure stored in a memory;

processing the at least one image of the structure using a neural network to determine at least one ratio of roof structure types; and

generating and transmitting a roof structure shape report indicative of a predominant shape of the roof structure based on the at least one ratio of roof structure types.

19. The method of claim **18**, wherein the roof structure shape report includes the at least one ratio of roof structure types.

20. The method of claim **18**, wherein the neural network comprises a convolutional neural network.

21. The method of claim **18**, further comprising generating a flat roof structure ratio that represents a portion of the roof structure classified by the neural network as being flat.

22. The method of claim **21**, further comprising generating a sloped roof structure ratio that represents a portion of the roof classified by the neural network as being sloped.

23. The method of claim **18**, further comprising determining the at least one ratio of roof structure types based on roof lines of the roof structure detected by the neural network.

24. The method of claim **18**, wherein the predominant shape of the roof structure comprises one or more of a flat roof shape, a hip roof shape, or a gable roof shape.

25. The method of claim **24**, wherein the at least one ratio indicates a contribution of a roof shape to a total roof structure.

26. The method of claim **18**, further comprising retrieving the at least one image based on a geospatial region of interest.

27. The method of claim **18**, further comprising processing the at least one image to detect and classify pixels of the at least one image via segmentation.

28. The method of claim **27**, further comprising determining a flat roof structure ratio based on classified pixels of the at least one image indicative of the roof structure.

29. The method of claim **1**, further comprising determining a sloped roof structure ration based on a flat roof structure ratio.

30. The method of claim **18**, further comprising processing the at least one image to detect and classify pixels of roof lines that are indicative of roof structure shapes.

31. The method of claim **30**, further comprising generating a sloped roof structure ratio that indicates a gable roof structure and is based on the classified pixels.

32. The method of claim **30**, further comprising generating a sloped roof structure ratio that indicates a hip roof structure shape and is based on the classified pixels.

33. The method of claim **32**, further comprising generating a roof structure decision table based on a flat roof structure ratio, a sloped roof structure ratio indicative of a gable roof, and a sloped roof structure ratio indicative of a hip roof structure shape.

34. The method of claim **33**, further comprising determining a roof structure shape based on the decision table.

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