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Aerial image segmentation for refineries

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Abstract

A system receives a two-dimensional digital image of an aerial industrial plant area. Based on requirements of image processing, the image is zoomed in to different sub-images, that are referred to as first images. The system identifies circular tanks, vegetation areas, process areas, and buildings in the first image. The system formulates a second digital image by concatenating the first images. The system creates one or more polygons of the regions segmented in the second digital image. Each polygon encompasses a tank area, a vegetation area, a process area, or a building area in the second digital image, which is a concatenated image of the individual regions. The system displays the second digital image on a computer display device.

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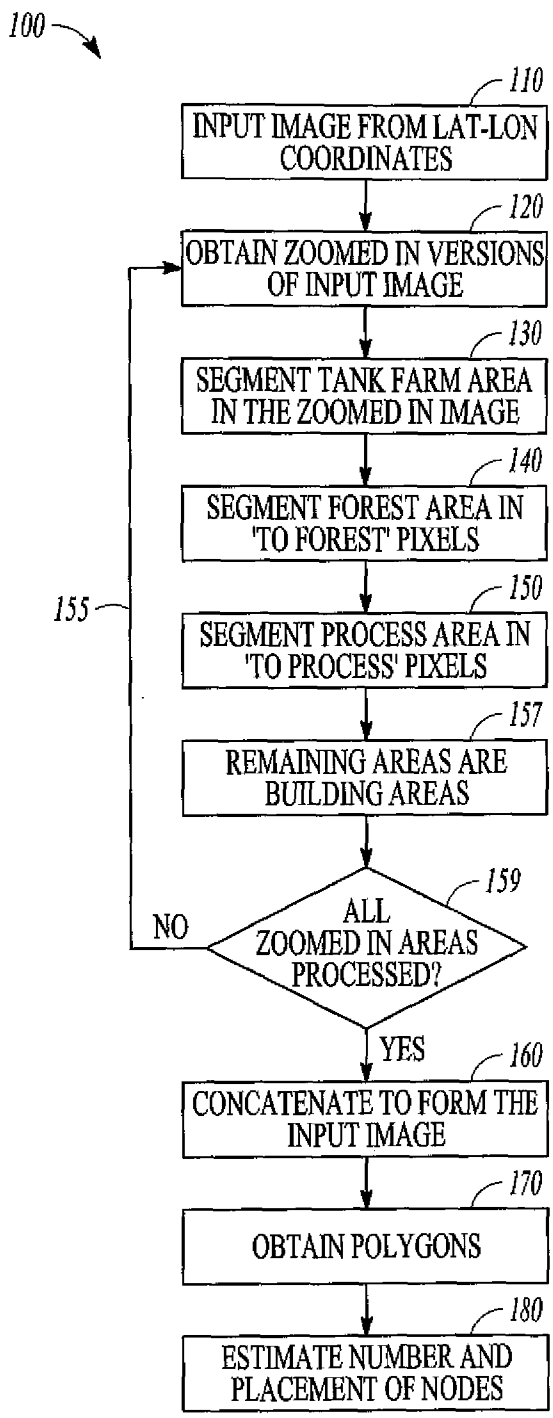

FIG. 1

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Australian Patents Act 1990 – Regulation 3.2

ORIGINAL COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title

Aerial image segmentation for refineries

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

Technical Field

[0001] The present disclosure relates to aerial image segmentation, and in an embodiment, but not by way of limitation, aerial image segmentation for use in connection with images of refineries.

Background

[0002] Aerial Image Segmentation is an important area for multiple analyses in a refinery. One such analysis is planning the number of radio frequency (RF) nodes to be installed for seamless connectivity. This is an important requirement for estimating wireless planning in industrial applications such as plants or refineries. In this context, an RF planning tool can be critical for detailed planning, considering the clutter and the terrain region, to design a good propagation model. Ideally, three dimensional mapping helps in giving height information for generating an appropriate RF propagation model for the tool. However, in a pre-sales situation, when the pre-sales person pitches the customer (*e.g.*, a plant owner) on the propagation model for the plant for estimating the location and number of wireless nodes to be deployed, there are normally no plant detail data for three dimensional modeling. At this stage, it would be helpful if an approximate number of nodes and their placement could be computed, notwithstanding the absence of detailed plant data for three dimensional modeling.

Brief Description of the Drawing

[0003] **FIG. 1** is a flowchart of an example embodiment of a process to identify and segment different areas in an industrial area such as a refinery.

[0004] **FIG. 2** illustrates an example of zoomed in image formulation and reconstruction.

[0005] **FIG. 3** is a flowchart of an example embodiment of a process to identify and segment clusters of tanks in an industrial area such as a refinery.

[0006] **FIG. 4** is a flowchart of an example embodiment of a process to identify and segment vegetation areas in an industrial area such as a refinery.

[0007] **FIG. 5** is a flowchart of an example embodiment of a process to identify and segment process areas in an industrial area such as a refinery.

[0008] **FIG. 6** is a block diagram illustrating an example of an output of a segmentation process wherein a tank area, a process area, a vegetation area, and a building area have been identified and segmented.

[0009] **FIG. 7** is a block diagram illustrating an example of polygon formulation after region segmentation.

[0010] **FIG. 8** is a block diagram of polygon formulation when zoomed in aerial images is considered for segmentation.

[0011] **FIG. 9** is a block diagram of a computer system upon which one or more disclosed embodiments can execute.

Detailed Description

[0012] In the following description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments which may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, electrical, and optical changes may be made without departing from the scope of the present invention. The following description of example embodiments is, therefore, not to be taken in a limited sense, and the scope of the present invention is defined by the appended claims.

[0013] To address the issues relating to a lack of detailed plant data in pre-sales and other similar situations, one or more embodiments in this disclosure compute an approximate model using data that is available to the sales team. In these pre-sales cases, the only data available are normally public data, for example, Google® Maps image data. Even though such data is two dimensional data, this two dimensional data relating to regions of tanks, vegetation clusters such as forests or smaller areas of trees, buildings, and process areas in the plant or industrial area are useful for generating a model and for approximating the number and placement of nodes.

Largely, the refineries contain the above mentioned areas that are primary, and other areas such as small sheds, parking, *etc.* can be classified as buildings area. Additionally, clutter, terrain, and land usage can give important information for the model to determine inventory requirements. This information is derived from and approximated using the regions (tanks, vegetation, buildings, *etc.*) mentioned above. Given this context, the basic requirement is to provide region-based classifications as mentioned above with the use of aerial images of the region of interest and provide the user with all the region details, which need to be solved as appropriate.

[0014] An embodiment focuses on providing a novel solution framework to address the problem of region segmentation of an industrial plant such as a refinery into tank farm, process, building, and forest (vegetation) areas. This segmentation can then be used to assist in modeling for sales planning or such applications wherein refinery map regions are useful. An embodiment uses as input readily available aerial images of the region of interest. The classification problem is formulated into a segmentation problem, and image processing techniques are used for the segmentation. The aerial view images are located using lat-long and then zoomed in to higher or required magnification if required, for segmentation. Each zoomed in image is separately segmented and results are stitched together for formulation of region classification at specified lat-long. The zooming in is performed when the resolution of image is insufficient for region segmentation. The embodiment includes three parts. First, the regions are detected as individual tanks, vegetation areas, and process areas. Second, individual adjacent regions are grouped by appropriately drawing polygons around the identified areas. The building areas are identified and segmented as those areas that remain after the tank, vegetation, and process areas have been identified after drawing respective polygons. The third part relates to situations wherein the zooming in of input images is required for appropriate input image resolution. The third part contains formulating the larger area un-zoomed image area by appropriately placing the zoomed in versions of the images. This is primarily the case when the overall larger aerial image has less resolution, but zooming in to the area can result in the same resolution sub-images. It is noted that higher resolution helps good region segmentation. Specifically, indicating lat-lon (in Google® Maps) and obtaining zoomed in versions of the overall image is one embodiment. Region processing is performed on the zoomed in images. It is to be noted that the approach of parts one and two above can be executed individually and without the third part.

[0015] A means of an embodiment is to use human visual system features as much as possible for segmentation. Layered segmentation can also be used for this purpose. Tanks are the easiest to segment since they are circular or near-circular. Consequently, tank farms are segmented first. Convex hull/Delaunay polygons are used to obtain the polygons for enclosing the tank and other areas. Vegetation areas are segmented next based on color information. The system can be configured to segment vegetation areas based on the green color of the vegetation (or the orange, red, or yellow colors that are prevalent in the fall). Next, any process areas are segmented using the concept of edge density patterns, one such implementation being block-based gradient density. Any remaining areas are then assumed to be building areas and no separate segmentation is needed.

[0016] An embodiment can work with Google images based on latitude and longitude information or any other type of aerial information and data. As noted above, the identification and segmentation of the areas of an industrial complex can be used in connection with tools that are used for the estimation and placement of wireless nodes or any such applications.

[0017] In short, an embodiment provides a systematic image region elimination method for region segmentation. This helps reduce false alarms in subsequent layered segmentation processes. The system uses visual attention consisting largely of color, texture, and edge features and information. The system can put emphasis on how the differentiation of the human visual system can segregate. For example, process areas in a refinery normally contain cluttered pipelines, which manifest themselves as long lines and high edges. This distinguishing pattern is therefore used for region segmentation. The system also uses Delaunay triangulation for region polygon formulation and bounding the region containing pipes and similar structures.

[0018] **FIGS. 1, 3, 4, 5, 7,** and **8** are flowcharts of example operations for segmenting images of industrial areas. The segmented images can be used to assist in the placement of wireless RF nodes. **FIGS. 1, 3, 4, 5, 7,** and **8** include a number of process blocks **110 – 170, 305 – 340, 410 – 460, 510 – 570, 710-760,** and **810-870.** Though arranged serially in the examples of **FIGS. 1, 3, 4, 5, 7,** and **8,** other examples may reorder the blocks, omit one or more blocks, and/or execute two or more blocks in parallel using multiple processors or a single processor organized as two or more virtual machines or sub-processors. Moreover, still other examples can implement the blocks as one or more specific interconnected hardware or integrated circuit modules with related control and data signals communicated between and through the modules.

Thus, any process flow is applicable to software, firmware, hardware, and hybrid implementations.

[0019] **FIG. 1** is a flowchart of an example embodiment of a process **100** to identify and segment different areas in an industrial area such as a refinery. An input image is received at block **110**. The input image can be received from a publicly available source such as Google® Maps or any other aerial image repository. The input image can be derived from latitude and longitude information. The input image can also be an aerial image of an industrial area such as an image from Google Image Maps. At **120**, zoomed-in versions of the input image are generated if the image resolution of the industrial area coverage is not sufficient for accurate image processing. The area that is zoomed-in is part of the industrial area of interest for the image segmentation task. In situations where the input image resolution is very high, zooming in may not be necessary. At **130**, any tank farm area in the industrial area is identified and segmented (*See* **FIG. 2**). As noted above, since the tanks are generally round, they are relatively easy to identify and segment, and therefore, in an embodiment, the tanks are identified and segmented first. Then, as indicated at **140**, vegetation areas are identified and segmented. As previously noted, the identification and segmentation of the vegetation area is a color-based identification and segmentation. At **150**, any process areas are identified and segmented. In an embodiment, process areas are pipeline areas in a refinery. At **157**, any remaining areas of the image are identified and segmented as building areas. As indicated by arrow **155**, operations **120-150** can be repeated multiple times, until all the zoomed in versions of the required industrial plant area are covered and their respective tank farms, vegetation areas, and process areas have been identified. At **159**, a check if all the zoomed in images are segmented is performed. After all areas have been identified for all the zoomed in images, these images are appropriately concatenated at **160** to form the final image, which is obtained either from Google Maps through lat-long, or from any other aerial image obtained from another source. Then at **170**, polygons are created to surround each identified area in order to segment the areas. At **180**, the number and placement of wireless nodes is estimated using the identified and segmented tank, vegetation, process and building areas for the concatenated image. For example, barrier and blocking aspects to wireless signals of the tank, vegetation, process, and building areas are considered in the placement of the wireless nodes.

[0020] **FIG. 2** illustrates an example of the zoomed in formulation and reconstruction of images. An aerial image **210** of an industrial plant has, for example, a 640 x 480 resolution. The image **210** is zoomed in (for example using lat-lon feature of Google Maps) into sub-images **220**. Each of the zoomed in sub-images **220** have a resolution that is equal to the initial aerial image **210**, in this example, 640 x 480. In reconstruction of the image, the sub-images are placed in their initial locations after processing. This placement forms a larger industrial image (after region segmentation). To bring the image to the size of the original image after segmentation, for example 640 x 480, the zoomed in image of **FIG. 2** can be resized accordingly. In situations wherein the input image size is very large such that sub-images are of appropriate resolution, this zooming in step may not be required.

[0021] **FIG. 3** is a flowchart of an example embodiment of a process **300** to identify and segment clusters of tanks in an industrial area such as a refinery. Referring to **FIG. 3**, the image is received into a computer processor at **305**. The image is pre-processed at **310**. The pre-processing can include a color-space conversion and an adaptive histogram equalization. Adaptive histogram equalization is a well-known basic image enhancement step helps equalize the pixel values across the image in case dark, highly saturated regions are present in the image. In a block for pre-processing the images, the image color data are recalibrated based on a model generated after texture study of the images, which removes most of the regions which are black due to shadow, hence mitigating the effect of shadow and sunlight angle on the segmentation results. At **320**, a circular Hough transform is applied to the image. The circular Hough transform uses a gradient magnitude. The gradient magnitude emphasizes the circular structure of the tanks in the image. This is given as input to the Hough transform to detect this circular structure. False alarms (*i.e.*, the pixels do not represent a tank farm) are removed at **330**. Domain knowledge can be used in this operation. For example, the tops of tanks generally are bright in nature. Therefore, if a round object in the image does not have such brightness, it is probably not a tank top, and it is then considered a false alarm. Though the tanks are not always bright at all times, in most cases, this assumption is valid. Also, the complete method explained in this embodiment, when put together, can accommodate these variations with slight approximations of the planning that may not be significant. At **340**, the positively identified tanks are grouped. This grouping can involve hierarchical tree clustering and Delaunay triangulation and Alpha shapes. In situations wherein the input image is zoomed in versions, the polygon formulation is done once all of the zoomed in images are processed and all tanks obtained from the concatenated image.

[0022] **FIG. 4** is a flowchart of an example embodiment of a process **400** to identify and segment vegetation areas in an industrial area such as a refinery. At **410**, the zoomed in input image is the received image. Then, at **420**, for each pixel in the zoomed-in image, at **430**, it is determined if the green channel of that pixel predominates. If the green channel does not predominate, then it is determined at **440** that that pixel is not a vegetation pixel. If the green channel does predominate for that pixel, then at **450**, it is determined that that pixel is part of a vegetation area. At **460**, if all pixels in the zoomed-in image have been examined, then the process terminates. Otherwise, operations **430**, **440**, and **450** are repeated for each remaining pixel in the received image.

[0023] **FIG. 5** is a flowchart of an example embodiment of a process **500** to identify and segment process areas in an industrial area such as a refinery. At **510**, an image is received, which is a zoomed in image of part of an industrial image, or an original image as necessary. Edge features have significant impact in process area segmentation. An embodiment describes edge concentrations or patterns within a smaller block or region as a distinguishing feature for segmentation. In this context, the embodiment uses gradient density or texture features for segmentation. Hereinafter, a focus is placed on double gradient features. At **520**, a double gradient of the image is obtained, and at **530**, the double gradient image is pre-processed to remove insignificant gradients either by a hard threshold or by using a mean and standard deviation method to avoid false detection. A block size is chosen at **540**, and for each block of the image, at **550**, the gradient density is computed. The gradient density is computed as a total number of gradient pixels that are greater than a threshold in a given image block divided by the number of pixels in the image block. At **560**, the block is post-processed and insignificant density blocks are removed. This is done by marking the pixels in insignificant density blocks as zero. At **570**, the final process region is obtained and segmented.

[0024] **FIG. 6** is a block diagram illustrating an example of an output wherein a tank area, a process area, a vegetation area, and a building area have been identified and segmented. Specifically, reference number **605** represents identified tanks, and **610** represents the polygon surrounding the tanks. The reference number **620** indicates pipes that have been identified in the refinery or industrial area, and reference number **625** represents the polygon surrounding the pipes. Reference number **635** is the polygon segmenting the identified vegetation area **630**, and **645** is the remaining area that is the building area. The building area is not separately segmented, as is an industrial plant. If a region is not a tank farm, vegetation area, or a process area, it is a building or an area that can be grouped as a building area. It is noted that **FIG. 6** is an illustrative example, and that the polygons need not be rectangles, but could be various shapes that are defined as polygons.

[0025] **FIG. 7** is a block diagram of a process of forming polygons from segmented regions. Storage tanks are detected at **710**, and outer tank circles are obtained in **740**. Process regions are detected at **720** and vegetation regions are detected at **730**. At **750**, polygons of the regions are obtained using convex hull/Delaunay triangles. At **760**, the regions that remain after the formation of the polygons are the building areas of the industrial plants.

[0026] **FIG. 8** is a block diagram of a process of forming polygons of segmented regions when a zoomed in version of sub images are considered for segmentation. First, tanks are detected at **810**, process regions are detected at **820**, and vegetation areas are detected at **830**. At **840**, zoomed in images are concatenated by placing them in a zoomed in order such that one image is formed. In the case of tanks, at **850**, outer tank circles are obtained. At **860**, polygons of regions are obtained using convex hull/Delaunay triangles, and at **870**, the regions that remain after the formulation of the polygons are building areas.

[0027] **FIG. 9** is an overview diagram of hardware and an operating environment in conjunction with which embodiments of the invention may be practiced. The description of **FIG. 9** is intended to provide a brief, general description of suitable computer hardware and a suitable computing environment in conjunction with which the invention may be implemented. In some embodiments, the invention is described in the general context of computer-executable instructions, such as program modules, being executed by a computer, such as a personal computer. Generally, program modules include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types.

[0028] Moreover, those skilled in the art will appreciate that the invention may be practiced with other computer system configurations, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, network

PCS, minicomputers, mainframe computers, and the like. The invention may also be practiced in distributed computer environments where tasks are performed by I/ 0 remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

[0029] In the embodiment shown in **FIG. 9**, a hardware and operating environment is provided that is applicable to any of the servers and/or remote clients shown in the other Figures.

[0030] As shown in **FIG. 9**, one embodiment of the hardware and operating environment includes a general purpose computing device in the form of a computer **20** (*e.g.*, a personal computer, workstation, or server), including one or more processing units **21**, a system memory **22**, and a system bus **23** that operatively couples various system components including the system memory **22** to the processing unit **21**. There may be only one or there may be more than one processing unit **21**, such that the processor of computer **20** comprises a single central-processing unit (CPU), or a plurality of processing units, commonly referred to as a multiprocessor or parallel-processor environment. A multiprocessor system can include cloud computing environments. In various embodiments, computer **20** is a conventional computer, a distributed computer, or any other type of computer.

[0031] The system bus **23** can be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory can also be referred to as simply the memory, and, in some embodiments, includes read-only memory (ROM) **24** and random-access memory (RAM) **25**. A basic input/output system (BIOS) program **26**, containing the basic routines that help to transfer information between elements within the computer **20**, such as during start-up, may be stored in ROM **24**. The computer **20** further includes a hard disk drive **27** for reading from and writing to a hard disk, not shown, a magnetic disk drive **28** for reading from or writing to a removable magnetic disk **29**, and an optical disk drive **30** for reading from or writing to a removable optical disk **31** such as a CD ROM or other optical media.

[0032] The hard disk drive **27**, magnetic disk drive **28**, and optical disk drive **30** couple with a hard disk drive interface **32**, a magnetic disk drive interface **33**, and an optical disk drive interface **34**, respectively. The drives and their associated computer-readable media provide non volatile storage of computer-readable instructions, data structures, program modules and other data for the computer **20**. It should be appreciated by those skilled in the art that any type of computer-readable media which can store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, random access memories (RAMs), read only memories (ROMs), redundant arrays of independent disks (*e.g.*, RAID storage devices) and the like, can be used in the exemplary operating environment.

[0033] A plurality of program modules can be stored on the hard disk, magnetic disk **29**, optical disk **31**, ROM **24**, or RAM **25**, including an operating system **35**, one or more application programs **36**, other program modules **37**, and program data **38**. A plug in containing a security transmission engine for the present invention can be resident on any one or number of these computer-readable media.

[0034] A user may enter commands and information into computer **20** through input devices such as a keyboard **40** and pointing device **42**. Other input devices (not shown) can include a microphone, joystick, game pad, satellite dish, scanner, or the like. These other input devices are often connected to the processing unit **21** through a serial port interface **46** that is coupled to the system bus **23**, but can be connected by other interfaces, such as a parallel port, game port, or a universal serial bus (USB). A monitor **47** or other type of display device can also be connected to the system bus **23** via an interface, such as a video adapter **48**. The monitor **40** can display a graphical user interface for the user. In addition to the monitor **40**, computers typically include other peripheral output devices (not shown), such as speakers and printers.

[0035] The computer **20** may operate in a networked environment using logical connections to one or more remote computers or servers, such as remote computer **49**. These logical connections are achieved by a communication device coupled to or a part of the computer **20**; the invention is not limited to a particular type of communications device. The remote computer **49** can be another computer, a server, a router, a network PC, a client, a peer device or other common network node, and typically includes many or all of the elements described above I/O relative to the computer **20**, although only a memory storage device **50** has been illustrated. The logical connections depicted in **FIG. 9** include a local area network (LAN) **51** and/or a wide area network (WAN) **52**. Such networking environments are commonplace in office networks, enterprise-wide computer networks, intranets and the internet, which are all types of networks.

[0036] When used in a LAN-networking environment, the computer **20** is connected to the LAN **51** through a network interface or adapter **53**, which is one type of communications device. In some embodiments, when used in a WAN-networking environment, the computer **20**

typically includes a modem **54** (another type of communications device) or any other type of communications device, *e.g.*, a wireless transceiver, for establishing communications over the wide-area network **52**, such as the internet. The modem **54**, which may be internal or external, is connected to the system bus 23 via the serial port interface **46**. In a networked environment, program modules depicted relative to the computer **20** can be stored in the remote memory storage device **50** of remote computer, or server **49**. It is appreciated that the network connections shown are exemplary and other means of, and communications devices for, establishing a communications link between the computers may be used including hybrid fiber-coax connections, T1-T3 lines, DSL's, OC-3 and/or OC-12, TCP/IP, microwave, wireless application protocol, and any other electronic media through any suitable switches, routers, outlets and power lines, as the same are known and understood by one of ordinary skill in the art.

[0037] It should be understood that there exist implementations of other variations and modifications of the invention and its various aspects, as may be readily apparent, for example, to those of ordinary skill in the art, and that the invention is not limited by specific embodiments described herein. Features and embodiments described above may be combined with each other in different combinations. It is therefore contemplated to cover any and all modifications, variations, combinations or equivalents that fall within the scope of the present invention.

[0038] The Abstract is provided to comply with 37 C.F.R. §1.72(b) and will allow the reader to quickly ascertain the nature and gist of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

[0039] In the foregoing description of the embodiments, various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting that the claimed embodiments have more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Description of the Embodiments, with each claim standing on its own as a separate example embodiment.

[0040] Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0041] The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A system comprising:

a computer processor configured to:

receive a two dimensional aerial digital image of an area; (110, 120)

identify one or more circular tanks in the area; (130)

identify one or more vegetation areas in the area using color information in the digital image; (140)

identify one or more process areas using edge patterns; (150)

identify one or more remaining areas as building areas; (157)

concatenate the one or more tank areas, the one or more vegetation areas, the one or more process areas, and the one or more building areas to form a second digital image; (160)

create one or more polygons, each polygon encompassing a tank area, a vegetation area, a process area, or a building area in the second digital image; (160) and

display the second digital image on a computer display device. (180)

2. The system of claim 1, wherein the computer processor is operable to generate or receive a zoomed-in view of the digital image. (410)

3. The system of claim 1, wherein the computer processor is operable to identify the one or more circular tanks by:

processing the first aerial digital image via a color space conversion and producing an intermediate image after an adaptive histogram equalization; (310)

using gradient magnitude of the intermediate image on circular Hough transform, thereby identifying circular regions representing tanks in the intermediate image; (320)

removing false alarms by utilizing domain knowledge including identifying pixels that do not have a threshold level of brightness; (330) and

grouping the one or more tanks into a polygonal tank farm area using one or more of a hierarchical tree cluster, Delaunay triangulation, and an alpha shape. (340)

4. The system of claim 1, wherein the computer processor is operable to identify the one or more vegetation areas by:

examining a plurality of pixels to determine whether the pixel comprises a green channel superiority; (420)

clustering one or more groups of pixels comprising the green channel superiority; (430) and

creating a polygon around each of the one or more groups of pixels comprising the green channel superiority. (450)

5. The system of claim 1, wherein the computer processor is operable to identify the one or more process areas by:

creating an edge image of the first digital image; (520)

receiving a sub-image block size; (540)

computing an edge pattern for each sub-image block of the image using features include as texture, gradient, or double gradient; (530)

computing a density of texture, gradient, or double gradient within sub-image blocks; (550)

removing blocks having insignificant feature density; (560) and

creating a polygon around an outer block of segmented image patch having a significant density. (570)

6. The system of claim 1, wherein the aerial image is a zoomed in version of an input image comprising a refinery. (410, 600)

7. The system of claim 1, wherein the computer processor is operable to estimate a placement of wireless nodes using the second digital image. (180)

8. A process comprising:

receiving a two dimensional aerial digital image of an area; (110, 120) identifying one or more circular tanks in the area; (130)

identifying one or more vegetation areas in the area using color information in the digital image; (140)

identifying one or more process areas using edge patterns; (150)

identifying one or more remaining areas as building areas; (157)

concatenating the one or more tank areas, the one or more vegetation areas, the one or more process areas, and the one or more building areas to form a second digital image; (160)

creating one or more polygons, each polygon encompassing a tank area, a vegetation area, a process area, or a building area in the second digital image; (160) and

displaying the second digital image on a computer display device. (180)

9. The process of claim 8, comprising:

analyzing the second digital image formulated after polygon formation; (170) and

estimating a placement of wireless nodes using the second digital image. (180)

10. A computer storage device comprising instructions that when executed by a processor execute a process comprising:

receiving a two dimensional aerial digital image of an area; (110, 120)

identifying one or more circular tanks in the area; (130)

identifying one or more vegetation areas in the area using color information in the digital image; (140)

identifying one or more process areas using edge patterns; (150)

identifying one or more remaining areas as building areas; (157)

concatenating the one or more tank areas, the one or more vegetation areas, the one or more process areas, and the one or more building areas to form a second digital image; (160)

creating one or more polygons, each polygon encompassing a tank area, a vegetation area, a process area, or a building area in the second digital image; (160) and

displaying the second digital image on a computer display device. (180)

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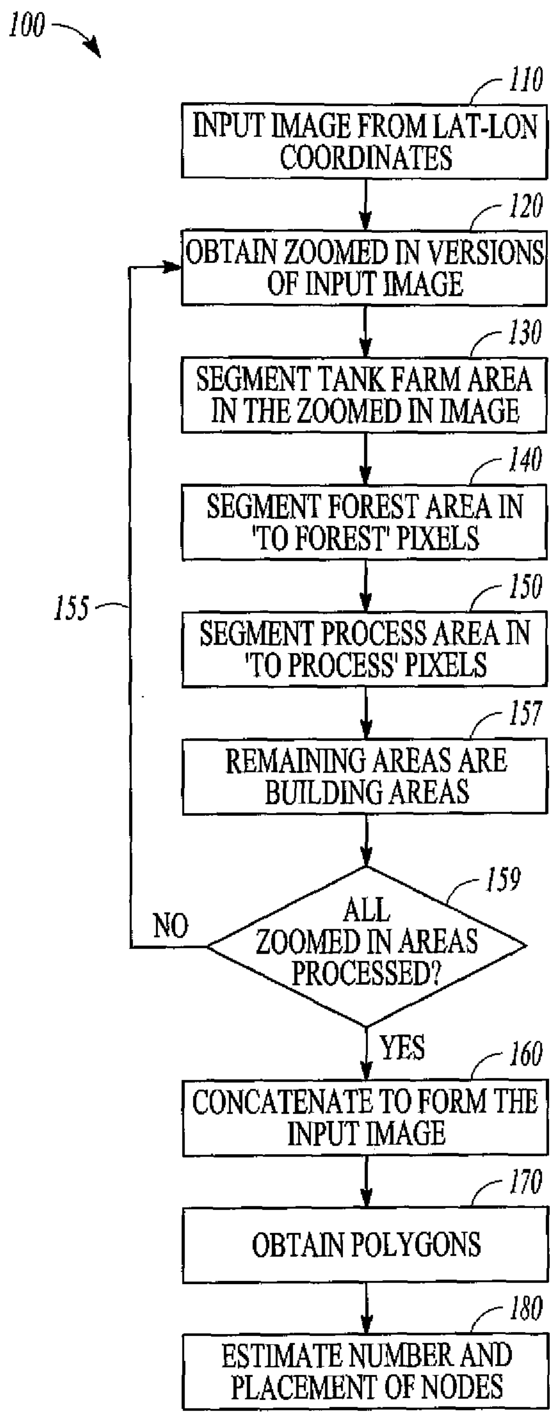

FIG. 1

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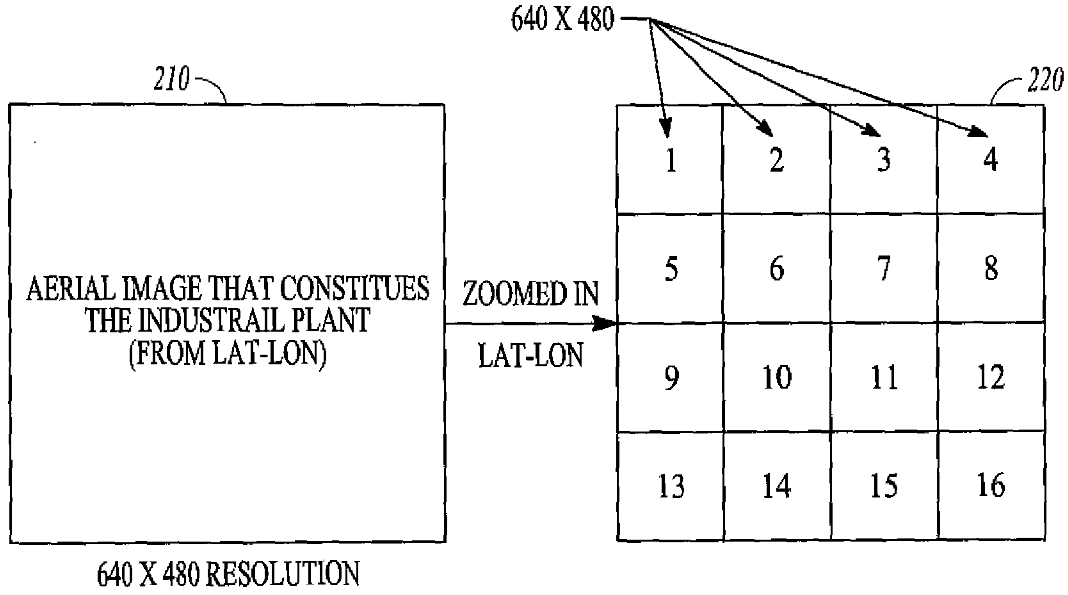

FIG. 2

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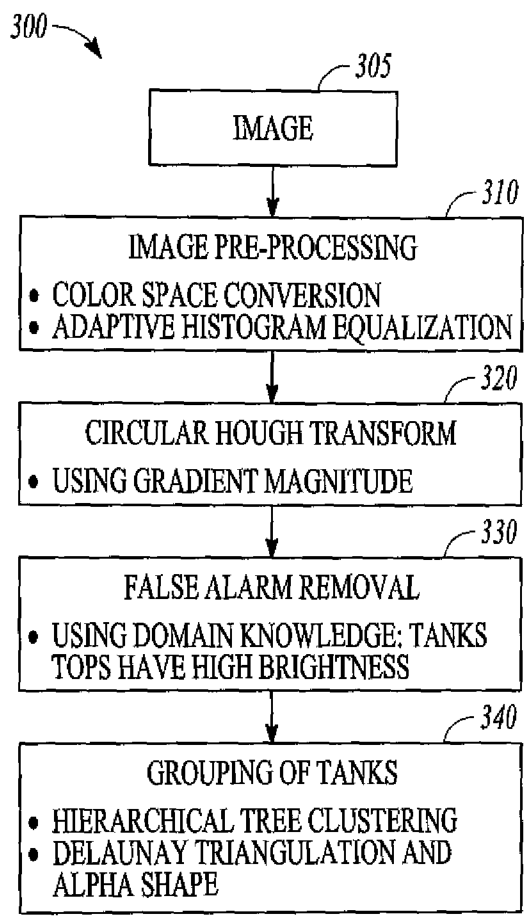

FIG. 3

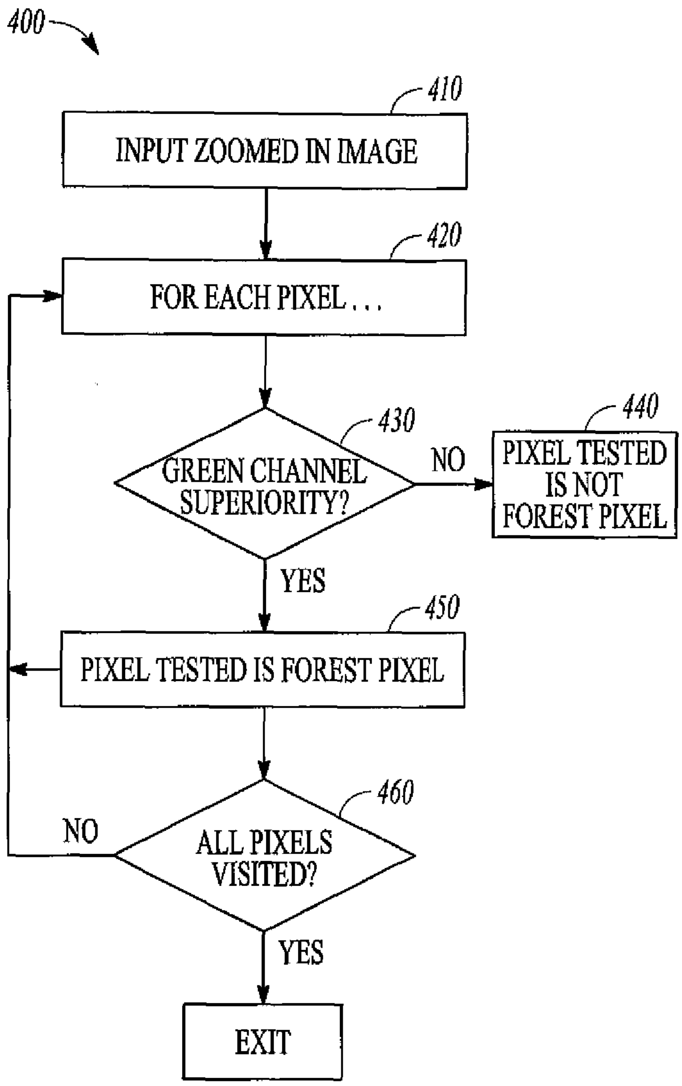
400
410
INPUT ZOOMED IN IMAGE
420
FOR EACH PIXEL . . .
430
GREEN CHANNEL SUPERIORITY?
NO
440
PIXEL TESTED IS NOT FOREST PIXEL
YES
450
PIXEL TESTED IS FOREST PIXEL
460
NO
ALL PIXELS VISITED?
YES
EXIT

FIG. 4

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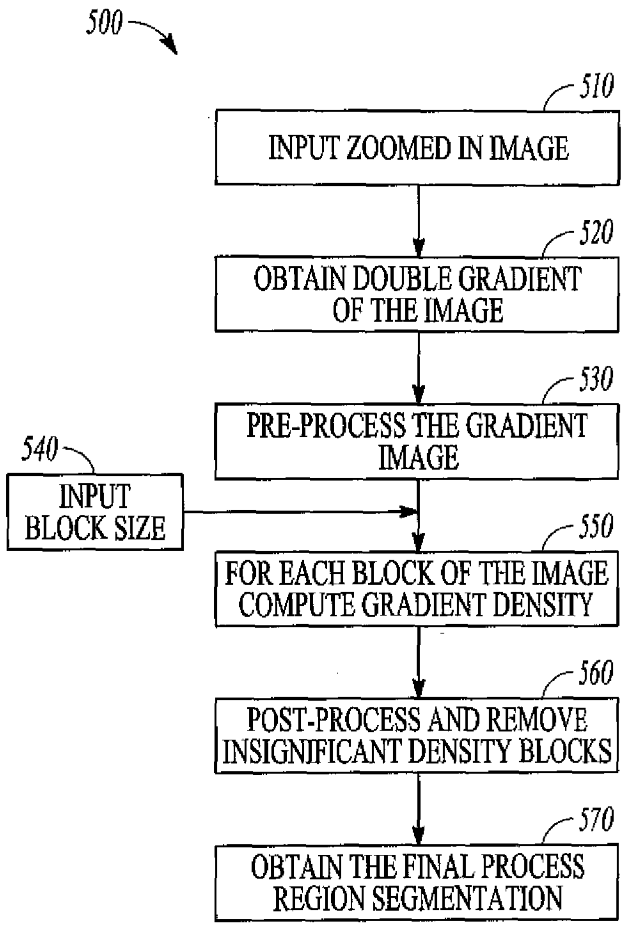


FIG. 5

06 May 2014
20142202457

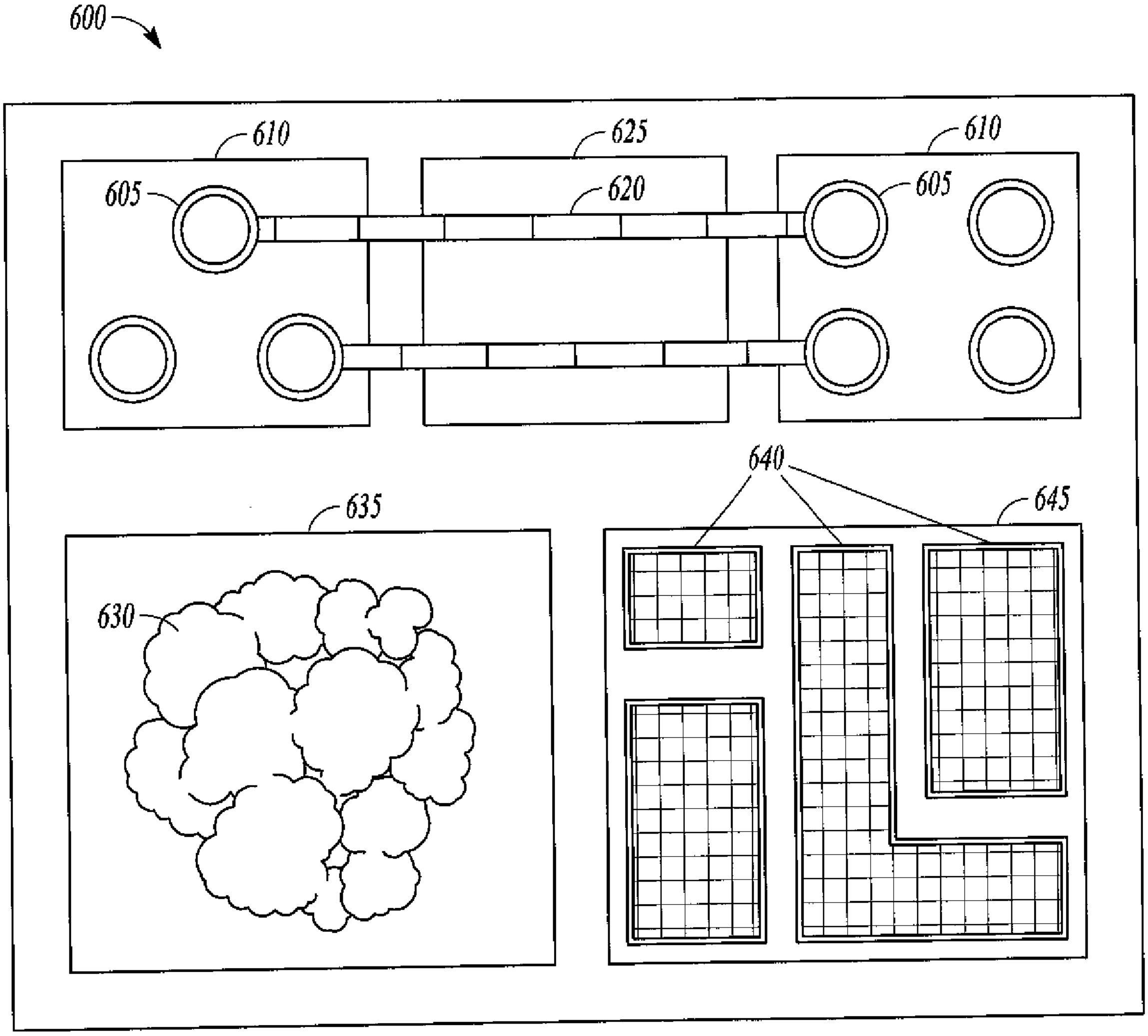


FIG. 6

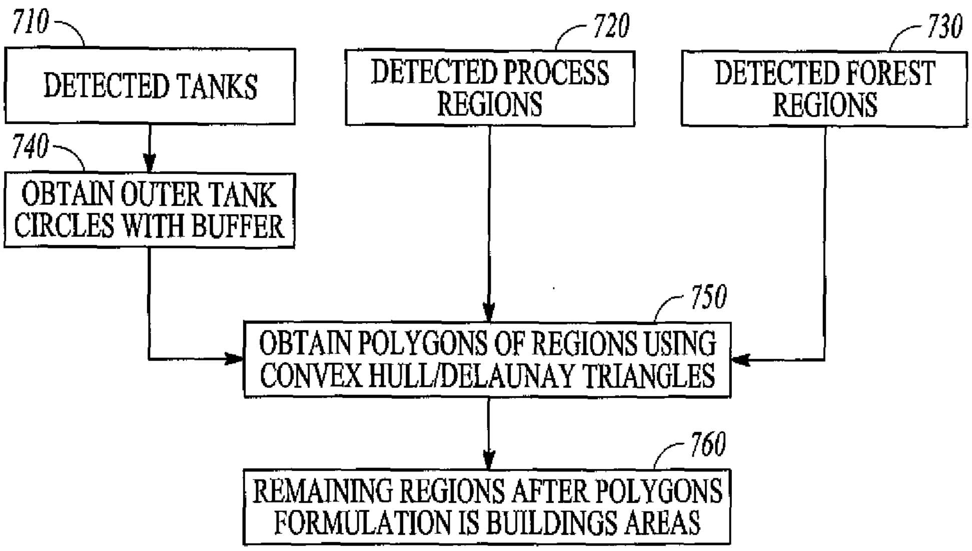

710
DETECTED TANKS
720
DETECTED PROCESS REGIONS
730
DETECTED FOREST REGIONS
740
OBTAIN OUTER TANK CIRCLES WITH BUFFER
750
OBTAIN POLYGONS OF REGIONS USING CONVEX HULL/DELAUNAY TRIANGLES
760
REMAINING REGIONS AFTER POLYGONS FORMULATION IS BUILDINGS AREAS

FIG. 7

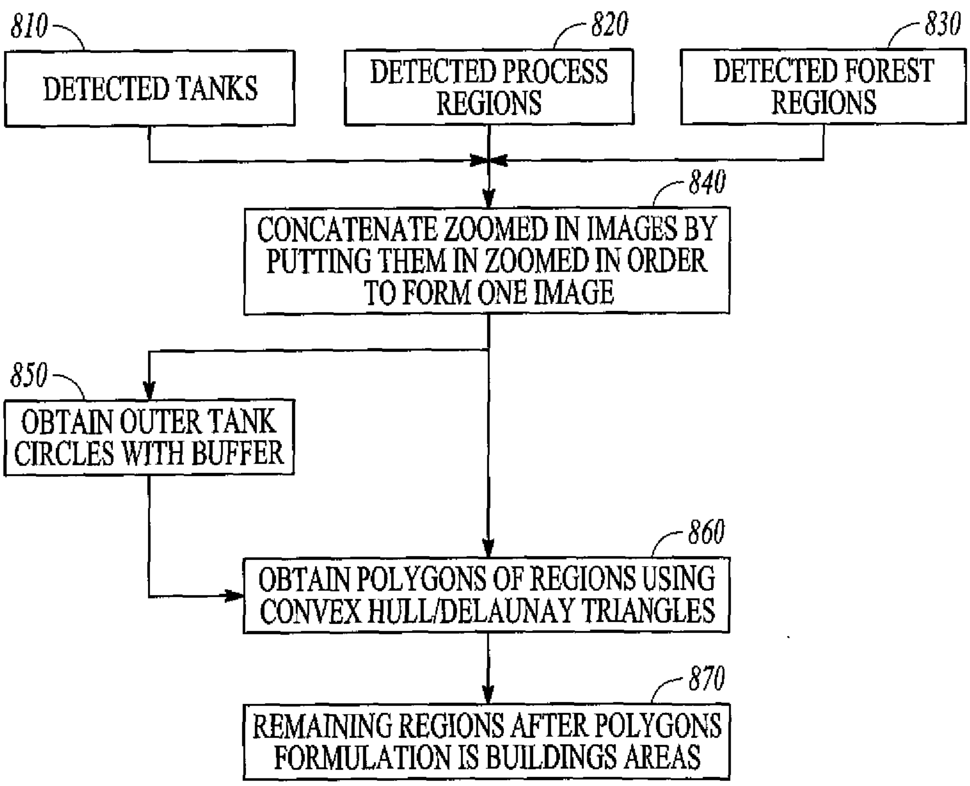
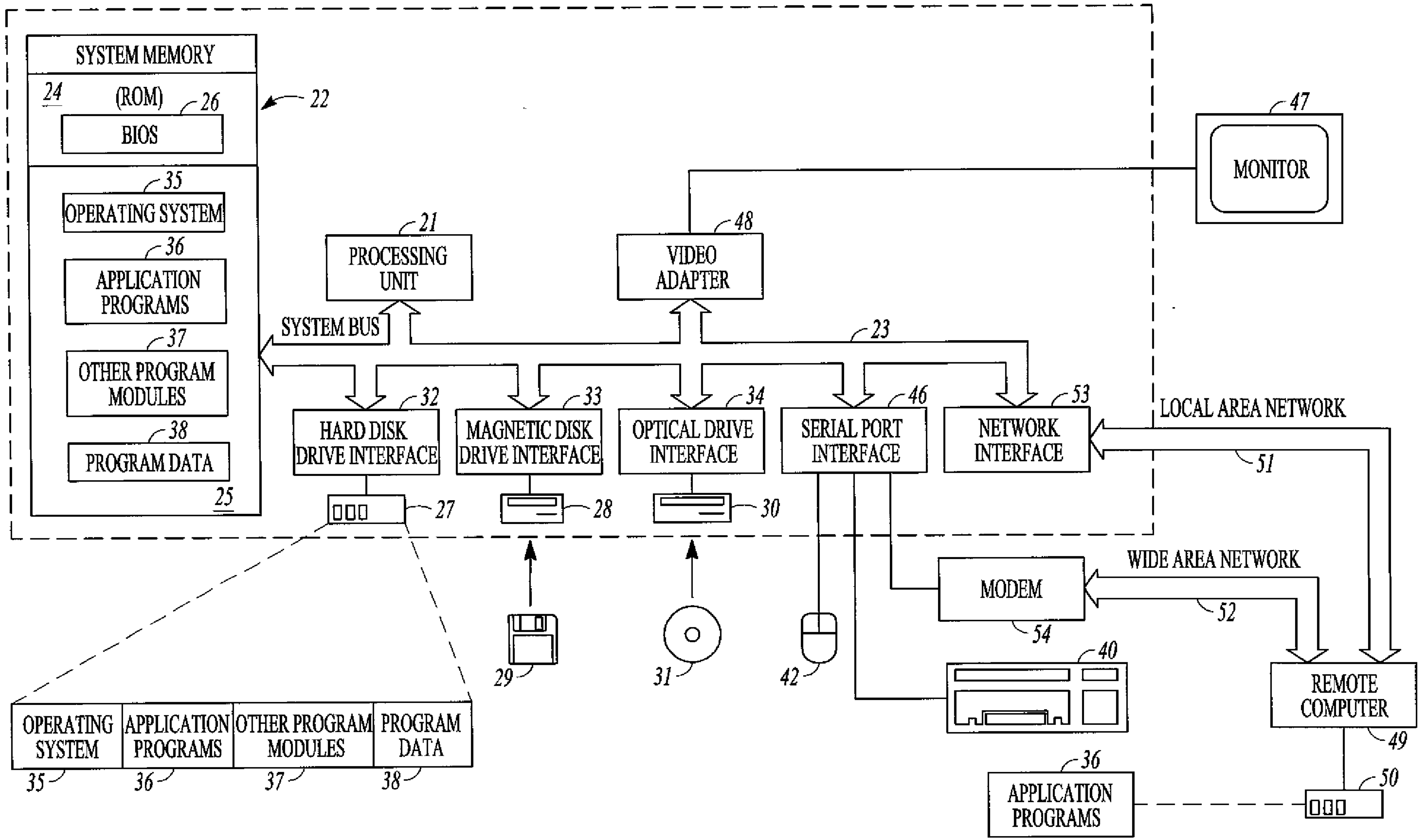

810
DETECTED TANKS
820
DETECTED PROCESS REGIONS
830
DETECTED FOREST REGIONS
840
CONCATENATE ZOOMED IN IMAGES BY PUTTING THEM IN ZOOMED IN ORDER TO FORM ONE IMAGE
850
OBTAIN OUTER TANK CIRCLES WITH BUFFER
860
OBTAIN POLYGONS OF REGIONS USING CONVEX HULL/DELAUNAY TRIANGLES
870
REMAINING REGIONS AFTER POLYGONS FORMULATION IS BUILDINGS AREAS

FIG. 8



SYSTEM MEMORY
24
(ROM)
26
BIOS
22
35
OPERATING SYSTEM
36
APPLICATION PROGRAMS
37
OTHER PROGRAM MODULES
38
PROGRAM DATA
25
21
PROCESSING UNIT
SYSTEM BUS
48
VIDEO ADAPTER
23
47
MONITOR
32
HARD DISK DRIVE INTERFACE
33
MAGNETIC DISK DRIVE INTERFACE
34
OPTICAL DRIVE INTERFACE
46
SERIAL PORT INTERFACE
53
NETWORK INTERFACE
LOCAL AREA NETWORK
51
27
28
30
WIDE AREA NETWORK
MODEM
52
54
29
31
42
40
REMOTE COMPUTER
49
OPERATING SYSTEM
APPLICATION PROGRAMS
OTHER PROGRAM MODULES
PROGRAM DATA
35
36
37
38
36
APPLICATION PROGRAMS
50

FIG. 9