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क्रम सं/SL No :011196364

पेटेंट कार्यालय,भारत सरकार | The Patent Office, Government Of India

पेटेंट प्रमाण पत्र | Patent Certificate

(पेटेंट नियमावली का नियम 74) | (Rule 74 of The Patents Rules)

पेटेंट सं. / Patent No.	:	507169
आवेदन सं. / Application No.	:	201611017172
फाइल करने की तारीख / Date of Filing	:	18/05/2016
पेटेंटी / Patentee	:	1.GAIL (India) Limited 2.National Remote Sensing Centre (NRSC)

प्रमाणित किया जाता है कि पेटेंटी को, उपरोक्त आवेदन में यथाप्रकटित *METHOD AND SYSTEM OF GENERATING AND RENDERING INFORMATION ABOUT A SPACE-REPRESENTATION OF TERRAIN AROUND A PIPELINE* नामक आविष्कार के लिए, पेटेंट अधिनियम, 1970 के उपबंधों के अनुसार आज तारीख मई 2016 के अठारहवें दिन से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled *METHOD AND SYSTEM OF GENERATING AND RENDERING INFORMATION ABOUT A SPACE-REPRESENTATION OF TERRAIN AROUND A PIPELINE* as disclosed in the above mentioned application for the term of 20 years from the 18th day of May 2016 in accordance with the provisions of the Patents Act,1970.

अनुदान की तारीख : 05/02/2024
Date of Grant :

पेटेंट नियंत्रक
Controller of Patents

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, मई 2018 के अठारहवें दिन को और उसके पश्चात प्रत्येक वर्ष मे उसी दिन देय होगी।

Note. - The fees for renewal of this patent, if it is to be maintained, will fall / has fallen due on 18th day of May 2018 and on the same day in every year thereafter.

FORM 2
THE PATENTS ACT 1970
(39 of 1970)
&
The Patents [Amendment] Rules, 2006
COMPLETE SPECIFICATION

(See section 10 and rule 13)

1. TITLE OF THE INVENTION

Method And System Of Generating And Rendering Information About A Space-Representation Of Terrain Around A Pipeline

2. APPLICANTS

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification particularly describes the invention and the manner in which it is to be performed:

TECHNICAL FIELD

[0001] The present invention is related in general to geographical information systems and in particular relates to generating representations of terrain of specified area and operating upon said generated representations.

BACKGROUND

[0002] For transportation of fluids and gaseous substance (e.g. petroleum products) from the source to a distant destination in the country, pipelines are laid under-ground. Once the pipeline is laid, no construction activity (barring agricultural activity) is allowed in the vicinity of pipeline. Accordingly, a portion of the land lying in the vicinity requires a right of user (RoU) to be acquired for performing any operation thereupon and lies in a range of about 15 to 25 meters on either side of the pipeline above the ground. Such tract of land as associated with the RoU is monitored frequently for encroachments, expanding settlements, washouts, digging activities etc.

[0003] At present, the monitoring of a region's surface associated with the RoU is performed conventionally through aerial surveillance, line walks, etc. The aerial surveillance may be done monthly through single or double engine helicopters with or without monitoring cameras fixed to it, and the line-walk may be done once or twice a year after the monsoons,. Such provision of helicopters requires substantial investment owing to exorbitant aviation fuel. Moreover, through helicopters, it is difficult to navigate along the RoU region, as a human-eye based navigation from the helicopter involves subjectivity and expertise. In large homogeneous areas, distinguishing among an agricultural field, water bodies, forest areas is also difficult. Moreover, the markers mounted along the RoU portion (mounted during the laying phase of pipeline to identify underground pipeline) get stolen and renders a manual observation difficult. Since no image based recording is feasible through flying helicopters, an only resort is do it manually. In addition, such image based recording also involves management of heavy records.

[0004] As far as line walks are concerned, the same are done once or twice in a year especially after the rainy season is over. During line walks, a team of executives have to walk on foot along the ROU portion for monitoring exceptional situations such as landslides, wash-out of the land above the pipeline, pipeline exposure etc. Such line walks are not only time consuming but also have several problems such as difficulty in covering long distances, walking through non-accessible areas (ie., agricultural fields, forests, rivers, terrains etc) and during unpleasant whether situations, risk to life due to animals, rodents, local threats etc. Further, line walk mechanisms very often fall short of manpower

[0005] While satellites are useful to provide aerial-images and for doing away with manual imaging or surveillance, these are frequently rendered non-usable due to the non-availability of high-resolution satellites at the required frequency for monitoring and for covering an optimum area. More specifically, the existing satellite monitoring methods are unable to provide sufficient coverage during cloudy season and are accordingly discreetly usable only based on a prior-cloud information.

[0006] Accordingly, there lies a need to a mechanism which generates a representation of the terrain of the ROU region around a laid pipeline with substantial-resolution imaging, irrespective of the weather conditions

[0007] There lies another need of system that may enable an operation over the image representation of the ROU region so as to enable rendering of information at one or more automatically determined locations within the representation.

SUMMARY

[0008] This summary is provided to introduce a selection of concepts in a simplified format that are further described in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

[0009] In an embodiment, the present subject matter describes a method of generating an aerial representation of terrain around a pipeline laid for transportation of substances. The method comprises acquiring remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline; processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS); and creating a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

[00010] In another embodiment, the present subject matter describes digitally displaying at a pipeline running across a region and/or the region' surface, wherein said region defines a pre-defined neighborhood of said pipeline; comparing said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface; receiving a field-information about said at least one site from at least designated entity associated to said at least one site; and rendering said

received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface.

[00011] To further clarify advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which is illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail with the accompanying drawings

BRIEF DESCRIPTION OF THE DRAWINGS

[00012] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[00013] Figure 1 illustrates a method in accordance with a first embodiment of the present subject matter

[00014] Figure 2 illustrates a system in accordance with a first embodiment of the present subject matter

[00015] Figure 3 illustrates an exemplary implementation of a part of method steps as depicted in Fig. 1.

[00016] Figure 4 illustrates an exemplary implementation of a part of method steps as depicted in Fig. 1.

[00017] Figure 5 illustrates an exemplary implementation of a part of a method steps as depicted in Fig. 1.

[00018] Figure 6 illustrates a method in accordance with a second embodiment of the present subject matter

[00019] Figure 7 illustrates a system in accordance with a second embodiment of the present subject matter

[00020] Figure 8 illustrates an exemplary implementation of the method steps as depicted in Fig. 1 and Fig. 6

[00021] Figure 9 illustrate a detailed internal construction of the system as depicted in Fig. 2 and Fig.7 in terms of a computing architecture.

[00022] Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have been necessarily been drawn to scale. For example, the flow charts

illustrate the method in terms of the most prominent steps involved to help to improve understanding of aspects of the present invention. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having benefit of the description herein.

DETAILED DESCRIPTION OF THE DRAWINGS

[00023] For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated system, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

[00024] It will be understood by those skilled in the art that the foregoing general description and the following detailed description are exemplary and explanatory of the invention and are not intended to be restrictive thereof.

[00025] Reference throughout this specification to “an aspect”, “another aspect” or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrase “in an embodiment”, “in another embodiment” and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[00026] The terms "comprises", "comprising", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that one or more devices or sub-systems or elements or structures or components proceeded by "comprises... a" does not, without more constraints, preclude the existence of other devices or other sub-systems or other elements or other structures or other components or additional devices or additional sub-systems or additional elements or additional structures or additional components.

[00027] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The system, methods, and examples provided herein are illustrative only and not intended

to be limiting.

[00028] Embodiments of the present invention will be described below in detail with reference to the accompanying drawings.

[00029] Figure 1 illustrates a method in accordance with a first embodiment of the present subject matter, wherein the method is about generating an aerial representation of terrain around a pipeline laid for transportation of substances.

[00030] The method comprises acquiring (step 102) remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline. Such remote sensing data may be a high-resolution data captured through at least one of: satellites, manned aerial vehicles and unmanned aerial vehicles (UAV) based on sensitiveness of the region. In addition, the high-resolution data may be either a microwave data collected under overcast weather conditions through satellites or optical data collected under non-overcast weather conditions either through said satellites or said manned or unmanned aerial vehicles UAV. While the UAV may be a drone aircraft, the manned aerial vehicles may denote a manually driven aircraft or helicopter.

[00031] Further, the zone around the pipeline, in respect of which the remote sensing data is acquired, may be a right of use (ROU) based zone associated with said pipeline. In an example, said ROU may be defined by at least one of: a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground, and a second zone neighbouring said pipeline and defined by a range of about 50 to 500 meters on either side of said pipeline above the ground. The acquisition comprises acquiring said data at least once in month, based on the sensitiveness associated with said region.

[00032] Further, the method comprises processing (step 104) said data for representing said region' surface at least in terms of geographical position coordinates (GPS). The processing comprises applying at least a digital photogrammetric technique to the acquired data and thereafter subjecting the acquired data to an ortho-rectification process. The application of digital photogrammetric technique comprises using a digital elevation model (DEM) of said region's surface. Thereafter, the image-enhancement techniques are applied to said ortho-rectified images based on ascertaining said acquired data as at least one of an optical data or a microwave data. In other words, the image based on microware data may require a different image enhancement technique than the image based on the optical data.

[00033] Further, a representation or model of the region's surface is created (step 106) based on said processing. The model may a 2-dimensional map and represents a representation of said region as viewed from a flying object in the sky or the space outside earth. Within such model, the pipeline is rendered as passing across said region's surface within the model as a geographical information system (GIS) layer. Such rendering is performed at least based on GPS coordinates of said pipeline.

[00034] Fig. 2 represents exemplary hardware architecture in respect of the first embodiment as defined by a system 200. The system comprises an acquisition module 202, a processing module 204 and a generation module 206 for discharging the method steps 102, 104 and 106, respectively. Each of the module may be implemented within the chipset of a computing machine through ASIC or FPGA techniques.

[00035] Figure 3 represents an exemplary implementation of a part of the method steps as per the first embodiment. More specifically, the present Fig. 3 refers to an exemplary implementation relates to step 102 of the present invention.

[00036] In an implementation of the present invention, High resolution Satellite images have been effectively used for monitoring of the RoU region to detect any encroachment or wash-out due to natural disasters or human-being performed activities so as to establish compliance with the standards and a surveillance policy associated with pipeline.

[00037] In an example, as depicted by steps 302, a weather pattern of a particular geographical region (i.e. the region around the pipeline or the RoU region) may be gathered so as to broadly ascertain overcast and non-overcast weather conditions based time periods in a given calendar year. Based on such gathered data, an optimized plan of satellite data collection may be formulated as per the further step 304. As per this plan, microware based satellite data may be scheduled to be collected during the overcast conditions, e.g. monsoon season, as reflected by steps 306-1 and 306-3. On the other hand, optical data capturing by satellites may be scheduled as per steps 306-2 and 306-4 during the non-overcast or non-cloudy conditions in the year. In addition, in cases when the satellite-orbital pass on ground is away from pipeline, imaging sensor can be tilted up to +/- 26 degrees (angle) with the high resolution satellites having a high agility capability, to improve the coverage and frequency.

[00038] Step 308 depicts another level of optimization of terms of satellite data collection. Irrespective of the type of satellite data collection (microware or optical data), a frequency of satellite data collection may be decided. In an example, satellite data gathering for the entire

pipeline network may be scheduled for at least once in a month. In high risk areas, the frequency of gathering high resolution image data can be further increased, e,g, performing twice or thrice monthly. Such frequency may be increased by further gathering of data not just by multiple high resolution remote sensing satellites but also from UAVs as a part of the further optimization level. The high risk areas along the ROU of pipeline network may be designated based on the geospatial analysis of land use, settlements, drainage, road/rail patterns.

[00039] Figure 4 represents an exemplary implementation of steps 104 and 106 as depicted in Fig. 1. More specifically, Fig. 4 depicts processing and ortho-rectification of the gathered data from high resolution satellites and other sources as previously depicted in Fig. 3.

[00040] Generally, Very High Resolution satellite image data swath width on ground is about 10 km to 11 km. However, most of the Very High Resolution satellite image data providers sell the data based on a per sq.km cost and minimum width and length dimensions of each image data procurement order. Accordingly, the present step 402 denotes optimizing high resolution satellite data procurement cost by procuring satellite data as per the required pipeline ROU and customized ROUs as required for monitoring and surveillances.

[00041] Further, step 402 denotes that as a part of aforesaid procurement, standard ortho-kit product is also procured from satellite image data provider. The standard ortho-kit product contains image data along-with satellite generic sensor model in the form of Rational Polynomial Coefficients (RPCs).

[00042] In step 404, the high resolution images as procured are processed for ortho-rectification in WGS84 datum & appropriate projection by digital photogrammetric techniques using corresponding RPCs, accurate GPS control points and digital elevation model DEM. Ortho-rectification ensures the accurate conversion of image coordinates to corresponding ground coordinates of pipeline.

[00043] In step 406, the ortho-rectified images undergo image enhancements using image processing techniques for better interpretability. In case of optical data as gathered during the cloud-free days, high resolution color multi-spectral image data and very high resolution black & white panchromatic are merged using different image fusing techniques to generate a Very High Resolution Natural Color Composite (NCC) image. However during overcast conditions, very high resolution microwave data can be used as optimized product. Accordingly, for microwave image data, speckle noise removal/ suppression techniques may be applied as image enhancement techniques.

[00044] In step 408, the ortho-rectified and processed image data is added with the representation of pipeline as a GIS layer. The present step denotes exemplification of step 106. The combination as resulted may be then uploaded to a web based application and published for further visualisation and analysis.

[00045] Fig. 5 represents the pipeline representation in the form a GIS layer that may be added to remotely sensed data as have been illustrated in step 408. The representation having accurate pipeline location and alignment has a topographic mapping on a 1:500 scale GIS database carried out by a DGPS survey and a total station survey. Further GPS coordinates generated PIG operations, as known on content of a laid pipeline, can also be added to the GIS database for generation of accurate pipeline location and alignment with 10-cm positional accuracy. GIS buffers have been generated as per the pipeline ROU and also customized buffers at 100m and 500m on either side of the pipeline alignment. The area within the pipeline ROU buffer may be monitored for any specified encroachments and areas under customized 100 meters and 500 meters buffers are monitored closely as precursor encroachments to avoid any expected encroachments in ROU.

[00046] Fig. 6 describes a method in accordance with a second embodiment of the present subject matter, wherein the method is about rendering information about a pipeline laid for transportation of substances.

[00047] The method comprises digitally displaying (step 602) a pipeline running across a region and/or the region' surface, wherein said region defines a pre-defined neighbourhood of said pipeline. The region defining said pre-defined neighbourhood denotes an ROU in respect of said pipeline wherein, said ROU may be a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground; and a second type of zone neighboring said pipeline and defined by a range of about 50 to 500 meters at either side of said pipeline above the ground. The digital display further comprises displaying simulation of land use, drainage, a railway-track, a water body, and physical infrastructure along said pipeline's corridor.

[00048] Further, the method comprises comparing (step 604) said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface. The pre-stored data relates to an earlier captured display of said pipeline and said region's surface. The modifications at said at least one site relate to changes in terrain associated with said at least one site within the ROU. The modifications are reported as a type of change with respect to said at least one site in a GIS file format to one or more field personnel manning the pipeline at a geographical location

corresponding to said at least one site.

[00049] The method further comprises receiving (step 606) a field-information about said at least one site from at least one designated entity associated to said at least one site; and wherein said field information as received comprises geo-tagged photographic and field-observations captured by said personnel through a mobile or aerial device. The field information is received from said field personnel in real-time or in an offline state from said field personnel to modify an information as associated with said digitally displayed pipeline and said region's surface

[00050] The method further comprises rendering (step 608) said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface. The rendering of information comprises displaying said information at an appropriate geo-location or chainage over said displayed region's surface.

[00051] In an implementation, the method as described in the current embodiment further comprises automatically changing a current display of said pipeline and said regions' surface based on traversing the length of the displayed pipeline. The method may also comprise annotating the displayed pipeline and the displayed region's surface based on an information received from said user.

[00052] Fig. 7 depicts exemplary hardware architecture in respect of the second embodiment as defined by a system 700. The system comprises a first processor 702, a comparator 704, a receiver 706 and a second processor 706. Each of the modules may be implemented within the chipset of a computing machine through ASIC or FPGA techniques.

[00053] Figure 8 illustrates an exemplary implementation of the method steps as depicted in Fig. 1 and Fig. 6. More specifically, at least the result of the first embodiment, i.e. satellite data model provided with an added GIS layer of the pipeline representation may be hosted as a geo-portal at a remotely located server and is accessible through internet as a Web enabled application. Such application depicts pipeline network GIS layers, time series very high resolution satellite data and necessary geospatial visualization/analysis tools and exception report generation.

[00054] In an example, the visualization tools within the geo-portal may enable a user to perform one or more:

a) select a particular pipeline segment out of the displayed GIS layers of pipeline network,

b) view image catalog of current and past very high resolution satellite images,

c) select a specifically dated image specified date(s) image(s),

d) render a display of flythrough generated during reconnaissance done by UAVs along the pipeline corridor in respect of selected image superimposed with the pipeline GIS layer between any two selected chainage points along the pipeline,

e) a comparison based analysis of image data selected with respect to any two images selected by swiping images one over the other

f) identifying available image data sets at any point on the pipeline

g) visualisation of ROU buffer or customised buffers as opted by the user

h) visualisation of land use, drainage and physical infrastructure along the pipeline corridor

i) visualisation near future satellite data acquisitions over the pipeline corridor

j) automatically generated change indication based two specifically dated images over the pipeline

k) marking or annotating the exceptions in the GIS along with attributes such as type of exception, date of image, date of marking exception,

l) a personalized report generation in GIS format

m) visualization of geo-tagged photographs and attributes uploaded through GPS mechanism in a mobile device of the field inspectors (i.e.. field personnel) in real time through a mobile device application that enables mobile App of exceptions.

[00055] In operation, the geoportals store all the pipeline network data, satellite image data, reports and other related on the highly secured central servers with necessary disaster recovery mechanism. Administrative, operational and maintenance access towards such geoportal is provided in the form of a secured user name and password to authorized executives and field personnel aligned with Administrative /Regional/ Operation/Maintenance offices. In fact, the information may be regularly updated and published at the geoportal and automatically communicated to the pipeline administration/ operational maintenance team/regional offices and field personnel in the form of emails, SMS, for analysis so as to identify any exceptions / changes with reference to the earlier image data sets.

[00056] Specifically, any exceptions / changes identified within ROU are considered and an exception report is generated. Such report comprises the type of exception / change as per the image comparison, GIS layer shape with ground coordinates/ chain age of the pipeline, and date of observation. The report is thereafter electronically communicated, for example, directly to an identified field level pipeline management personnel to verify the exception by physical and manual inspection. Finally, the field personnel send the geo-tagged photographic and field observations using internet enabled mobile app in near real time as a feedback to the geoportal host. Such geo-tagged information is thereafter integrated with the published information at the geo-portal based

web-application in near real time and immediately depicted at appropriate geo-location/chainage over the pipeline ROU for further investigation and necessary actions.

[00057] Fig. 9, a typical hardware configuration of the system 200, 700 in the form of a computer system 900 is shown. The computer system 900 can include a set of instructions that can be executed to cause the computer system 900 to perform any one or more of the methods disclosed. The computer system 900 may operate as a standalone device or may be connected, e.g., using a network, to other computer systems or peripheral devices.

[00058] In a networked deployment, the computer system 900 may operate in the capacity of a server or as a client user computer in a server-client user network environment, or as a peer computer system in a peer-to-peer (or distributed) network environment. The computer system 900 can also be implemented as or incorporated across various devices, such as a personal computer (PC), a tablet PC, a personal digital assistant (PDA), a mobile device, a palmtop computer, a laptop computer, a desktop computer, a communications device, a wireless telephone, a land-line telephone, a web appliance, a network router, switch or bridge, or any other machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while a single computer system 900 is illustrated, the term "system" shall also be taken to include any collection of systems or sub-systems that individually or jointly execute a set, or multiple sets, of instructions to perform one or more computer functions.

[00059] The computer system 900 may include a processor 902 e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both. The processor 902 may be a component in a variety of systems. For example, the processor 902 may be part of a standard personal computer or a workstation. The processor 902 may be one or more general processors, digital signal processors, application specific integrated circuits, field programmable gate arrays, servers, networks, digital circuits, analog circuits, combinations thereof, or other now known or later developed devices for analysing and processing data The processor 902 may implement a software program, such as code generated manually (i.e., programmed).

[00060] The computer system 900 may include a memory 904, such as a memory 904 that can communicate via a bus 908. The memory 904 may be a main memory, a static memory, or a dynamic memory. The memory 904 may include, but is not limited to computer readable storage media such as various types of volatile and non-volatile storage media, including but not limited to random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic

tape or disk, optical media and the like. In one example, the memory 904 includes a cache or random access memory for the processor 902. In alternative examples, the memory 904 is separate from the processor 902, such as a cache memory of a processor, the system memory, or other memory. The memory 904 may be an external storage device or database for storing data. Examples include a hard drive, compact disc ("CD"), digital video disc ("DVD"), memory card, memory stick, floppy disc, universal serial bus ("USB") memory device, or any other device operative to store data. The memory 904 is operable to store instructions executable by the processor 902. The functions, acts or tasks illustrated in the figures or described may be performed by the programmed processor 902 executing the instructions stored in the memory 904. The functions, acts or tasks are independent of the particular type of instructions set, storage media, processor or processing strategy and may be performed by software, hardware, integrated circuits, firm-ware, micro-code and the like, operating alone or in combination. Likewise, processing strategies may include multiprocessing, multitasking, parallel processing and the like.

[00061] As shown, the computer system 900 may or may not further include a display unit 910, such as a liquid crystal display (LCD), an organic light emitting diode (OLED), a flat panel display, a solid state display, a cathode ray tube (CRT), a projector, a printer or other now known or later developed display device for outputting determined information. The display 910 may act as an interface for the user to see the functioning of the processor 902, or specifically as an interface with the software stored in the memory 904 or in the drive unit 916.

[00062] Additionally, the computer system 900 may include an input device 912 configured to allow a user to interact with any of the components of system 900. The input device 912 may be a number pad, a keyboard, or a cursor control device, such as a mouse, or a joystick, touch screen display, remote control or any other device operative to interact with the computer system 900.

[00063] The computer system 900 may also include a disk or optical drive unit 916. The disk drive unit 916 may include a computer-readable medium 922 in which one or more sets of instructions 924, e.g. software, can be embedded. Further, the instructions 924 may embody one or more of the methods or logic as described. In a particular example, the instructions 924 may reside completely, or at least partially, within the memory 904 or within the processor 902 during execution by the computer system 900. The memory 904 and the processor 902 also may include computer-readable media as discussed above.

[00064] The present invention contemplates a computer-readable medium that includes instructions 924 or receives and executes instructions 924 responsive to a propagated signal so that

a device connected to a network 926 can communicate voice, video, audio, images or any other data over the network 926. Further, the instructions 924 may be transmitted or received over the network 926 via a communication port or interface 920 or using a bus 908. The communication port or interface 920 may be a part of the processor 902 or may be a separate component. The communication port 920 may be created in software or may be a physical connection in hardware. The communication port 920 may be configured to connect with a network 926, external media, the display 910, or any other components in system 900, or combinations thereof. The connection with the network 926 may be a physical connection, such as a wired Ethernet connection or may be established wirelessly as discussed later. Likewise, the additional connections with other components of the system 900 may be physical connections or may be established wirelessly. The network 926 may alternatively be directly connected to the bus 908.

[00065] The network 926 may include wired networks, wireless networks, Ethernet AVB networks, or combinations thereof. The wireless network may be a cellular telephone network, an 802.11, 802.16, 802.20, 802.1Q or WiMax network. Further, the network 926 may be a public network, such as the Internet, a private network, such as an intranet, or combinations thereof, and may utilize a variety of networking protocols now available or later developed including, but not limited to TCP/IP based networking protocols.

[00066] In an alternative example, dedicated hardware implementations, such as application specific integrated circuits, programmable logic arrays and other hardware devices, can be constructed to implement various parts of the system 900.

[00067] Applications that may include the systems can broadly include a variety of electronic and computer systems. One or more examples described may implement functions using two or more specific interconnected hardware modules or devices with related control and data signals that can be communicated between and through the modules, or as portions of an application-specific integrated circuit. Accordingly, the present system encompasses software, firmware, and hardware implementations.

[00068] The system described may be implemented by software programs executable by a computer system. Further, in a non-limited example, implementations can include distributed processing, component/object distributed processing, and parallel processing. Alternatively, virtual computer system processing can be constructed to implement various parts of the system.

[00069] The system is not limited to operation with any particular standards and protocols. For example, standards for Internet and other packet switched network transmission (e.g., TCP/IP,

UDP/IP, HTML, HTTP) may be used. Such standards are periodically superseded by faster or more efficient equivalents having essentially the same functions. Accordingly, replacement standards and protocols having the same or similar functions as those disclosed are considered equivalents thereof.

[00070] At least by virtue of aforesaid, the present invention proves advantageous at least by doing away with the requirement of helicopters and link-walks for monitoring and surveying the pipeline, thereby requiring a minimum extent of human-involvement and altogether eliminating physical and life threatening difficulties to human during helicopter monitoring and line walks. In addition, virtual-marking of ROU is possible irrespective of the pipeline markers presence, thereby facilitating identification of ROU in large homogeneous areas such dense forests, agri fields, water bodies, forest areas etc. Addition marking of risk zone and possibility of varying the extent of RoU buffer is possible for further analysis.

[00071] The present invention further facilitates wide coverage of pipeline and corresponding RoU, an ease of change-analysis and exception marking for a particular portion of the pipeline or RoU, identification of pipeline route including bends, and near real time alert generations in case of exception generation through depicting images. Further, virtual marking of various turning points like river & canal crossings, rail crossings, roads crossings, settlements and also marking of risk zones, different RoU buffers etc., along the RoU is possible for predicting possibility of current and future risks/threats. Further, the present invention makes data available for frequent reference and operation by substantial number of people, thereby reducing the possibility of human error.

[00072] Further, the present subject matter facilitates automatic or manual panning of images, a bird-eye viewing, comparison of images – either automatic and manual, identification of bends, and overall a user-friendly and intuitive web-enabled tool for accessing information related to a terrain neighboring the pipeline.

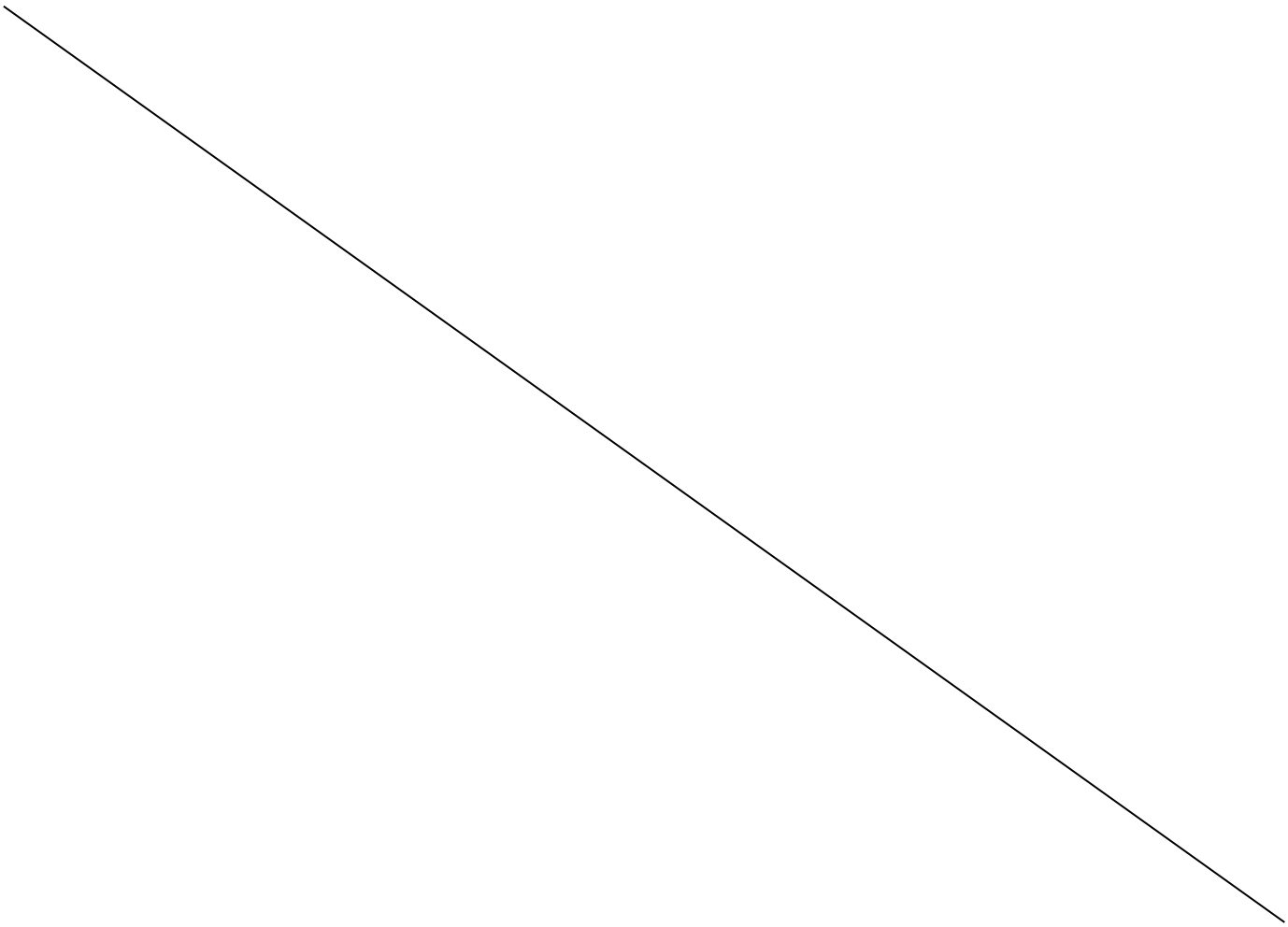
[00073] While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

[00074] The drawings and the forgoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For

example, orders of processes described herein may be changed and are not limited to the manner described herein.

[00075] Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

[00076] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.



FORM 2
THE PATENTS ACT 1970
(39 of 1970)
&
The Patents [Amendment] Rules, 2006
COMPLETE SPECIFICATION

(See section 10 and rule 13)

1. TITLE OF THE INVENTION

Method And System Of Generating And Rendering Information About A Space-Representation Of Terrain Around A Pipeline

2. APPLICANTS

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification particularly describes the invention and the manner in which it is to be performed:

TECHNICAL FIELD

The present invention is related in general to geographical information systems and in particular relates to generating representations of terrain of specified area and operating upon said generated representations.

BACKGROUND

For transportation of fluids and gaseous substance (e.g. petroleum products) from the source to a distant destination in the country, pipelines are laid under-ground. Once the pipeline is laid, no construction activity (barring agricultural activity) is allowed in the vicinity of pipeline. Accordingly, a portion of the land lying in the vicinity requires a right of user (RoU) to be acquired for performing any operation thereupon and lies in a range of about 15 to 25 meters on either side of the pipeline above the ground. Such tract of land as associated with the RoU is monitored frequently for encroachments, expanding settlements, washouts, digging activities etc.

At present, the monitoring of a region's surface associated with the RoU is performed conventionally through aerial surveillance, line walks, etc. The aerial surveillance may be done monthly through single or double engine helicopters with or without monitoring cameras fixed to it, and the line-walk may be done once or twice a year after the monsoons,. Such provision of helicopters requires substantial investment owing to exorbitant aviation fuel. Moreover, through helicopters, it is difficult to navigate along the RoU region, as a human-eye based navigation from the helicopter involves subjectivity and expertise. In large homogeneous areas, distinguishing among an agricultural field, water bodies, forest areas is also difficult. Moreover, the markers mounted along the RoU portion (mounted during the laying phase of pipeline to identify underground pipeline) get stolen and renders a manual observation difficult. Since no image based recording is feasible through flying helicopters, an only resort is do it manually. In addition, such image based recording also involves management of heavy records.

As far as line walks are concerned, the same are done once or twice in a year especially after the rainy season is over. During line walks, a team of executives have to walk on foot along the ROU portion for monitoring exceptional situations such as landslides, wash-out of the land above the pipeline, pipeline exposure etc. Such line walks are not only time consuming but also have several problems such as difficulty in covering long distances, walking through non-accessible areas (ie., agricultural fields, forests, rivers, terrains etc) and during unpleasant whether

situations, risk to life due to animals, rodents, local threats etc. Further, line walk mechanisms very often fall short of manpower

While satellites are useful to provide aerial-images and for doing away with manual imaging or surveillance, these are frequently rendered non-usable due to the non-availability of high-resolution satellites at the required frequency for monitoring and for covering an optimum area. More specifically, the existing satellite monitoring methods are unable to provide sufficient coverage during cloudy season and are accordingly discreetly usable only based on a prior-cloud information.

Accordingly, there lies a need to a mechanism which generates a representation of the terrain of the ROU region around a laid pipeline with substantial-resolution imaging, irrespective of the weather conditions

There lies another need of system that may enable an operation over the image representation of the ROU region so as to enable rendering of information at one or more automatically determined locations within the representation.

SUMMARY

This summary is provided to introduce a selection of concepts in a simplified format that are further described in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

In an embodiment, the present subject matter describes a method of generating an aerial representation of terrain around a pipeline laid for transportation of substances. The method comprises acquiring remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline; processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS); and creating a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

In another embodiment, the present subject matter describes digitally displaying at a pipeline running across a region and/or the region' surface, wherein said region defines a pre-defined neighborhood of said pipeline; comparing said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at

least one of: said displayed pipeline and surface; receiving a field-information about said at least one site from at least designated entity associated to said at least one site; and rendering said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface.

To further clarify advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which is illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail with the accompanying drawings

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

Figure 1 illustrates a method in accordance with a first embodiment of the present subject matter

Figure 2 illustrates a system in accordance with a first embodiment of the present subject matter

Figure 3 illustrates an exemplary implementation of a part of method steps as depicted in Fig. 1.

Figure 4 illustrates an exemplary implementation of a part of method steps as depicted in Fig. 1.

Figure 5 illustrates an exemplary implementation of a part of a method steps as depicted in Fig. 1.

Figure 6 illustrates a method in accordance with a second embodiment of the present subject matter

Figure 7 illustrates a system in accordance with a second embodiment of the present subject matter

Figure 8 illustrates an exemplary implementation of the method steps as depicted in Fig. 1 and Fig. 6

Figure 9 illustrate a detailed internal construction of the system as depicted in Fig. 2 and Fig.7 in terms of a computing architecture.

Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have been necessarily been drawn to scale. For example, the flow charts illustrate the method in terms of the most prominent steps involved to help to improve understanding of aspects of the present invention. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having benefit of the description herein.

DETAILED DESCRIPTION OF THE DRAWINGS

For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated system, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

It will be understood by those skilled in the art that the foregoing general description and the following detailed description are exemplary and explanatory of the invention and are not intended to be restrictive thereof.

Reference throughout this specification to “an aspect”, “another aspect” or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrase “in an embodiment”, “in another embodiment” and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

The terms "comprises", "comprising", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that one or more devices or sub-systems or elements or structures or components proceeded by "comprises... a" does not, without more constraints, preclude the existence of other devices or other sub-systems or other elements or other structures or other components or additional devices or additional sub-systems or additional elements or additional structures or additional components.

Unless otherwise defined, all technical and scientific terms used herein have the

same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The system, methods, and examples provided herein are illustrative only and not intended to be limiting.

Embodiments of the present invention will be described below in detail with reference to the accompanying drawings.

Figure 1 illustrates a method in accordance with a first embodiment of the present subject matter, wherein the method is about generating an aerial representation of terrain around a pipeline laid for transportation of substances.

The method comprises acquiring (step 102) remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline. Such remote sensing data may be a high-resolution data captured through at least one of: satellites, manned aerial vehicles and unmanned aerial vehicles (UAV) based on sensitiveness of the region. In addition, the high-resolution data may be either a microwave data collected under overcast weather conditions through satellites or optical data collected under non-overcast weather conditions either through said satellites or said manned or unmanned aerial vehicles UAV. While the UAV may be a drone aircraft, the manned aerial vehicles may denote a manually driven aircraft or helicopter.

Further, the zone around the pipeline, in respect of which the remote sensing data is acquired, may be a right of use (ROU) based zone associated with said pipeline. In an example, said ROU may be defined by at least one of: a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground, and a second zone neighbouring said pipeline and defined by a range of about 50 to 500 meters on either side of said pipeline above the ground. The acquisition comprises acquiring said data at least once in month, based on the sensitiveness associated with said region.

Further, the method comprises processing (step 104) said data for representing said region' surface at least in terms of geographical position coordinates (GPS). The processing comprises applying at least a digital photogrammetric technique to the acquired data and thereafter subjecting the acquired data to an ortho-rectification process. The application of digital photogrammetric technique comprises using a digital elevation model (DEM) of said region's surface. Thereafter, the image-enhancement techniques are applied to said ortho-rectified images based on ascertaining said acquired data as at least one of an optical data or a microwave data. In other words, the image based on microware data may require a different image enhancement

technique than the image based on the optical data.

Further, a representation or model of the region's surface is created (step 106) based on said processing. The model may a 2-dimensional map and represents a representation of said region as viewed from a flying object in the sky or the space outside earth. Within such model, the pipeline is rendered as passing across said region's surface within the model as a geographical information system (GIS) layer. Such rendering is performed at least based on GPS coordinates of said pipeline.

Fig. 2 represents exemplary hardware architecture in respect of the first embodiment as defined by a system 200. The system comprises an acquisition module 202, a processing module 204 and a generation module 206 for discharging the method steps 102, 104 and 106, respectively. Each of the module may be implemented within the chipset of a computing machine through ASIC or FPGA techniques.

Figure 3 represents an exemplary implementation of a part of the method steps as per the first embodiment. More specifically, the present Fig. 3 refers to an exemplary implementation relates to step 102 of the present invention.

In an implementation of the present invention, High resolution Satellite images have been effectively used for monitoring of the RoU region to detect any encroachment or wash-out due to natural disasters or human-being performed activities so as to establish compliance with the standards and a surveillance policy associated with pipeline.

In an example, as depicted by steps 302, a weather pattern of a particular geographical region (i.e. the region around the pipeline or the RoU region) may be gathered so as to broadly ascertain overcast and non-overcast weather conditions based time periods in a given calendar year. Based on such gathered data, an optimized plan of satellite data collection may be formulated as per the further step 304. As per this plan, microware based satellite data may be scheduled to be collected during the overcast conditions, e.g. monsoon season, as reflected by steps 306-1 and 306-3. On the other hand, optical data capturing by satellites may be scheduled as per steps 306-2 and 306-4 during the non-overcast or non-cloudy conditions in the year. In addition, in cases when the satellite-orbital pass on ground is away from pipeline, imaging sensor can be tilted up to +/- 26 degrees (angle) with the high resolution satellites having a high agility capability, to improve the coverage and frequency.

Step 308 depicts another level of optimization of terms of satellite data collection.

Irrespective of the type of satellite data collection (microware or optical data), a frequency of satellite data collection may be decided. In an example, satellite data gathering for the entire pipeline network may be scheduled for at least once in a month. In high risk areas, the frequency of gathering high resolution image data can be further increased, e,g, performing twice or thrice monthly. Such frequency may be increased by further gathering of data not just by multiple high resolution remote sensing satellites but also from UAVs as a part of the further optimization level. The high risk areas along the ROU of pipeline network may be designated based on the geospatial analysis of land use, settlements, drainage, road/rail patterns.

Figure 4 represents an exemplary implementation of steps 104 and 106 as depicted in Fig. 1. More specifically, Fig. 4 depicts processing and ortho-rectification of the gathered data from high resolution satellites and other sources as previously depicted in Fig. 3.

Generally, Very High Resolution satellite image data swath width on ground is about 10 km to 11 km. However, most of the Very High Resolution satellite image data providers sell the data based on a per sq.km cost and minimum width and length dimensions of each image data procurement order. Accordingly, the present step 402 denotes optimizing high resolution satellite data procurement cost by procuring satellite data as per the required pipeline ROU and customized ROUs as required for monitoring and surveillances.

Further, step 402 denotes that as a part of aforesaid procurement, standard ortho-kit product is also procured from satellite image data provider. The standard ortho-kit product contains image data along-with satellite generic sensor model in the form of Rational Polynomial Coefficients (RPCs).

In step 404, the high resolution images as procured are processed for ortho-rectification in WGS84 datum & appropriate projection by digital photogrammetric techniques using corresponding RPCs, accurate GPS control points and digital elevation model DEM. Ortho-rectification ensures the accurate conversion of image coordinates to corresponding ground coordinates of pipeline.

In step 406, the ortho-rectified images undergo image enhancements using image processing techniques for better interpretability. In case of optical data as gathered during the cloud-free days, high resolution color multi-spectral image data and very high resolution black & white panchromatic are merged using different image fusing techniques to generate a Very High Resolution Natural Color Composite (NCC) image. However during overcast conditions, very high resolution microwave data can be used as optimized product. Accordingly, for microwave image

data, speckle noise removal/ suppression techniques may be applied as image enhancement techniques.

In step 408, the ortho-rectified and processed image data is added with the representation of pipeline as a GIS layer. The present step denotes exemplification of step 106. The combination as resulted may be then uploaded to a web based application and published for further visualisation and analysis.

Fig. 5 represents the pipeline representation in the form a GIS layer that may be added to remotely sensed data as have been illustrated in step 408. The representation having accurate pipeline location and alignment has a topographic mapping on a 1:500 scale GIS database carried out by a DGPS survey and a total station survey. Further GPS coordinates generated PIG operations, as known on content of a laid pipeline, can also be added to the GIS database for generation of accurate pipeline location and alignment with 10-cm positional accuracy. GIS buffers have been generated as per the pipeline ROU and also customized buffers at 100m and 500m on either side of the pipeline alignment. The area within the pipeline ROU buffer may be monitored for any specified encroachments and areas under customized 100 meters and 500 meters buffers are monitored closely as precursor encroachments to avoid any expected encroachments in ROU.

Fig. 6 describes a method in accordance with a second embodiment of the present subject matter, wherein the method is about rendering information about a pipeline laid for transportation of substances.

The method comprises digitally displaying (step 602) a pipeline running across a region and/or the region' surface, wherein said region defines a pre-defined neighbourhood of said pipeline. The region defining said pre-defined neighbourhood denotes an ROU in respect of said pipeline wherein, said ROU may be a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground; and a second type of zone neighboring said pipeline and defined by a range of about 50 to 500 meters at either side of said pipeline above the ground. The digital display further comprises displaying simulation of land use, drainage, a railway-track, a water body, and physical infrastructure along said pipeline's corridor.

Further, the method comprises comparing (step 604) said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface. The pre-stored data relates to an earlier captured display of said pipeline and said region's surface. The modifications at said at least one site relate to changes in terrain associated with said at least one site within the ROU. The

modifications are reported as a type of change with respect to said at least one site in a GIS file format to one or more field personnel manning the pipeline at a geographical location corresponding to said at least one site.

The method further comprises receiving (step 606) a field-information about said at least one site from at least one designated entity associated to said at least one site; and wherein said field information as received comprises geo-tagged photographic and field-observations captured by said personnel through a mobile or aerial device. The field information is received from said field personnel in real-time or in an offline state from said field personnel to modify an information as associated with said digitally displayed pipeline and said region's surface

The method further comprises rendering (step 608) said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface. The rendering of information comprises displaying said information at an appropriate geo-location or chainage over said displayed region's surface.

In an implementation, the method as described in the current embodiment further comprises automatically changing a current display of said pipeline and said regions' surface based on traversing the length of the displayed pipeline. The method may also comprise annotating the displayed pipeline and the displayed region's surface based on an information received from said user.

Fig. 7 depicts exemplary hardware architecture in respect of the second embodiment as defined by a system 700. The system comprises a first processor 702, a comparator 704, a receiver 706 and a second processor 706. Each of the modules may be implemented within the chipset of a computing machine through ASIC or FPGA techniques.

Figure 8 illustrates an exemplary implementation of the method steps as depicted in Fig. 1 and Fig. 6. More specifically, at least the result of the first embodiment, i.e. satellite data model provided with an added GIS layer of the pipeline representation may be hosted as a geo-portal at a remotely located server and is accessible through internet as a Web enabled application. Such application depicts pipeline network GIS layers, time series very high resolution satellite data and necessary geospatial visualization/analysis tools and exception report generation.

In an example, the visualization tools within the geo-portal may enable a user to perform one or more:

a) select a particular pipeline segment out of the displayed GIS layers of pipeline network,

b) view image catalog of current and past very high resolution satellite images,

c) select a specifically dated image specified date(s) image(s),

d) render a display of flythrough generated during reconnaissance done by UAVs along the pipeline corridor in respect of selected image superimposed with the pipeline GIS layer between any two selected chainage points along the pipeline,

e) a comparison based analysis of image data selected with respect to any two images selected by swiping images one over the other

f) identifying available image data sets at any point on the pipeline

g) visualisation of ROU buffer or customised buffers as opted by the user

h) visualisation of land use, drainage and physical infrastructure along the pipeline corridor

i) visualisation near future satellite data acquisitions over the pipeline corridor

j) automatically generated change indication based two specifically dated images over the pipeline

k) marking or annotating the exceptions in the GIS along with attributes such as type of exception, date of image, date of marking exception,

l) a personalized report generation in GIS format

m) visualization of geo-tagged photographs and attributes uploaded through GPS mechanism in a mobile device of the field inspectors (i.e.. field personnel) in real time through a mobile device application that enables mobile App of exceptions.

In operation, the geoportals store all the pipeline network data, satellite image data, reports and other related on the highly secured central servers with necessary disaster recovery mechanism. Administrative, operational and maintenance access towards such geoportal is provided in the form of a secured user name and password to authorized executives and field personnel aligned with Administrative /Regional/ Operation/Maintenance offices. In fact, the information may be regularly updated and published at the geoportal and automatically communicated to the pipeline administration/ operational maintenance team/regional offices and field personnel in the form of emails, SMS, for analysis so as to identify any exceptions / changes with reference to the earlier image data sets.

Specifically, any exceptions / changes identified within ROU are considered and an exception report is generated. Such report comprises the type of exception / change as per the image comparison, GIS layer shape with ground coordinates/ chain age of the pipeline, and date of observation. The report is thereafter electronically communicated, for example, directly to an identified field level pipeline management personnel to verify the exception by physical and manual inspection. Finally, the field personnel send the geo-tagged photographic and field observations

using internet enabled mobile app in near real time as a feedback to the geoportal host. Such geo-tagged information is thereafter integrated with the published information at the geo-portal based web-application in near real time and immediately depicted at appropriate geo-location/chainage over the pipeline ROU for further investigation and necessary actions.

Fig. 9, a typical hardware configuration of the system 200, 700 in the form of a computer system 900 is shown. The computer system 900 can include a set of instructions that can be executed to cause the computer system 900 to perform any one or more of the methods disclosed. The computer system 900 may operate as a standalone device or may be connected, e.g., using a network, to other computer systems or peripheral devices.

In a networked deployment, the computer system 900 may operate in the capacity of a server or as a client user computer in a server-client user network environment, or as a peer computer system in a peer-to-peer (or distributed) network environment. The computer system 900 can also be implemented as or incorporated across various devices, such as a personal computer (PC), a tablet PC, a personal digital assistant (PDA), a mobile device, a palmtop computer, a laptop computer, a desktop computer, a communications device, a wireless telephone, a land-line telephone, a web appliance, a network router, switch or bridge, or any other machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while a single computer system 900 is illustrated, the term "system" shall also be taken to include any collection of systems or sub-systems that individually or jointly execute a set, or multiple sets, of instructions to perform one or more computer functions.

The computer system 900 may include a processor 902 e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both. The processor 902 may be a component in a variety of systems. For example, the processor 902 may be part of a standard personal computer or a workstation. The processor 902 may be one or more general processors, digital signal processors, application specific integrated circuits, field programmable gate arrays, servers, networks, digital circuits, analog circuits, combinations thereof, or other now known or later developed devices for analysing and processing data The processor 902 may implement a software program, such as code generated manually (i.e., programmed).

The computer system 900 may include a memory 904, such as a memory 904 that can communicate via a bus 908. The memory 904 may be a main memory, a static memory, or a dynamic memory. The memory 904 may include, but is not limited to computer readable storage media such as various types of volatile and non-volatile storage media, including but not limited to

random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic tape or disk, optical media and the like. In one example, the memory 904 includes a cache or random access memory for the processor 902. In alternative examples, the memory 904 is separate from the processor 902, such as a cache memory of a processor, the system memory, or other memory. The memory 904 may be an external storage device or database for storing data. Examples include a hard drive, compact disc ("CD"), digital video disc ("DVD"), memory card, memory stick, floppy disc, universal serial bus ("USB") memory device, or any other device operative to store data. The memory 904 is operable to store instructions executable by the processor 902. The functions, acts or tasks illustrated in the figures or described may be performed by the programmed processor 902 executing the instructions stored in the memory 904. The functions, acts or tasks are independent of the particular type of instructions set, storage media, processor or processing strategy and may be performed by software, hardware, integrated circuits, firm-ware, micro-code and the like, operating alone or in combination. Likewise, processing strategies may include multiprocessing, multitasking, parallel processing and the like.

As shown, the computer system 900 may or may not further include a display unit 910, such as a liquid crystal display (LCD), an organic light emitting diode (OLED), a flat panel display, a solid state display, a cathode ray tube (CRT), a projector, a printer or other now known or later developed display device for outputting determined information. The display 910 may act as an interface for the user to see the functioning of the processor 902, or specifically as an interface with the software stored in the memory 904 or in the drive unit 916.

Additionally, the computer system 900 may include an input device 912 configured to allow a user to interact with any of the components of system 900. The input device 912 may be a number pad, a keyboard, or a cursor control device, such as a mouse, or a joystick, touch screen display, remote control or any other device operative to interact with the computer system 900.

The computer system 900 may also include a disk or optical drive unit 916. The disk drive unit 916 may include a computer-readable medium 922 in which one or more sets of instructions 924, e.g. software, can be embedded. Further, the instructions 924 may embody one or more of the methods or logic as described. In a particular example, the instructions 924 may reside completely, or at least partially, within the memory 904 or within the processor 902 during execution by the computer system 900. The memory 904 and the processor 902 also may include computer-readable media as discussed above.

The present invention contemplates a computer-readable medium that includes instructions 924 or receives and executes instructions 924 responsive to a propagated signal so that a device connected to a network 926 can communicate voice, video, audio, images or any other data over the network 926. Further, the instructions 924 may be transmitted or received over the network 926 via a communication port or interface 920 or using a bus 908. The communication port or interface 920 may be a part of the processor 902 or may be a separate component. The communication port 920 may be created in software or may be a physical connection in hardware. The communication port 920 may be configured to connect with a network 926, external media, the display 910, or any other components in system 900, or combinations thereof. The connection with the network 926 may be a physical connection, such as a wired Ethernet connection or may be established wirelessly as discussed later. Likewise, the additional connections with other components of the system 900 may be physical connections or may be established wirelessly. The network 926 may alternatively be directly connected to the bus 908.

The network 926 may include wired networks, wireless networks, Ethernet AVB networks, or combinations thereof. The wireless network may be a cellular telephone network, an 802.11, 802.16, 802.20, 802.1Q or WiMax network. Further, the network 926 may be a public network, such as the Internet, a private network, such as an intranet, or combinations thereof, and may utilize a variety of networking protocols now available or later developed including, but not limited to TCP/IP based networking protocols.

In an alternative example, dedicated hardware implementations, such as application specific integrated circuits, programmable logic arrays and other hardware devices, can be constructed to implement various parts of the system 900.

Applications that may include the systems can broadly include a variety of electronic and computer systems. One or more examples described may implement functions using two or more specific interconnected hardware modules or devices with related control and data signals that can be communicated between and through the modules, or as portions of an application-specific integrated circuit. Accordingly, the present system encompasses software, firmware, and hardware implementations.

The system described may be implemented by software programs executable by a computer system. Further, in a non-limited example, implementations can include distributed processing, component/object distributed processing, and parallel processing. Alternatively, virtual computer system processing can be constructed to implement various parts of the system.

The system is not limited to operation with any particular standards and protocols. For example, standards for Internet and other packet switched network transmission (e.g., TCP/IP, UDP/IP, HTML, HTTP) may be used. Such standards are periodically superseded by faster or more efficient equivalents having essentially the same functions. Accordingly, replacement standards and protocols having the same or similar functions as those disclosed are considered equivalents thereof.

At least by virtue of aforesaid, the present invention proves advantageous at least by doing away with the requirement of helicopters and link-walks for monitoring and surveying the pipeline, thereby requiring a minimum extent of human-involvement and altogether eliminating physical and life threatening difficulties to human during helicopter monitoring and line walks. In addition, virtual-marking of ROU is possible irrespective of the pipeline markers presence, thereby facilitating identification of ROU in large homogeneous areas such dense forests, agri fields, water bodies, forest areas etc. Addition marking of risk zone and possibility of varying the extent of RoU buffer is possible for further analysis.

The present invention further facilitates wide coverage of pipeline and corresponding RoU, an ease of change-analysis and exception marking for a particular portion of the pipeline or RoU, identification of pipeline route including bends, and near real time alert generations in case of exception generation through depicting images. Further, virtual marking of various turning points like river & canal crossings, rail crossings, roads crossings, settlements and also marking of risk zones, different RoU buffers etc., along the RoU is possible for predicting possibility of current and future risks/threats. Further, the present invention makes data available for frequent reference and operation by substantial number of people, thereby reducing the possibility of human error.

Further, the present subject matter facilitates automatic or manual panning of images, a bird-eye viewing, comparison of images – either automatic and manual, identification of bends, and overall a user-friendly and intuitive web-enabled tool for accessing information related to a terrain neighboring the pipeline.

While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

The drawings and the forgoing description give examples of embodiments. Those

skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein.

Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.

We claim:

1. A method of generating an aerial representation of terrain around a pipeline laid for transportation of substances, the method comprising:

acquiring (step 102) remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline;

processing (step 104) said data for representing said region' surface at least in terms of geographical position coordinates (GPS); and

creating (step 106) a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

2. The method as claimed in claim 1, wherein said acquisition comprises capturing a high resolution data through at least one of: satellites, manned aerial vehicles and unmanned aerial vehicles (UAV) based on sensitiveness of the region

3. The method as claimed in claim 1 and 2, wherein said high resolution data represents microwave data collected under overcast weather conditions through satellites and optical data collected under non-overcast weather conditions through said satellites or said manned or unmanned aerial vehicles.

4. The method as claimed in claim 1, wherein said zone denotes a right of use (ROU) based zone associated with said pipeline, said ROU being defined by at least one of:

a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground ; and

a second zone neighbouring said pipeline and defined by about 50 to 250 meters on either side of said pipeline above the ground.

5. The method as claimed in claim 1, wherein said acquisition comprises acquiring said data at least once in month, based on the sensitiveness associated with said region.

6. The method as claimed in claim 1, wherein said processing comprises applying at least a digital photogrammetric technique to the acquired data and thereafter executing an ortho-rectification process.

7. The method as claimed in claim 6, wherein said application of digital photogrammetric technique comprises using a digital elevation model (DEM) of said region's surface.

8. The method as claimed in claim 1, further comprising applying image-enhancement techniques to said model based on ascertaining said acquired data as at least one of an optical data or a microwave data.

9. The method as claimed in claim 1, wherein said pipeline is rendered within the model based on GPS coordinates of said pipeline.

10. A method of rendering information about a pipeline laid for transportation of substances, said method comprising:

digitally displaying (step 602) at least one of:

a pipeline running across a region; and

the region' surface,

said region defining a pre-defined neighbourhood of said pipeline;

comparing (step 604) said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface;

receiving (step 606) a field -information about said at least one site from at least designated entity associated to said at least one site; and

rendering (step 608) said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface.

11. The method as claimed in claim 10, wherein said region defining said pre-defined neighbourhood denotes an ROU in respect of said pipeline, said ROU being defined by at least one of:

a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground; and

a second type of zone neighbouring said pipeline and defined by about 500 meters or more at either side of said pipeline above the ground.

12. The method as claimed in claim 10, wherein said digital display further comprises displaying land use, drainage, a railway-track, a water body, and physical infrastructure along said pipeline's corridor.

13. The method as claimed in claim 10, wherein said pre-stored data relates to an earlier display of said pipeline and said region's surface.

14. The method as claimed in claims 10 to 11, wherein said modifications at said at least one site relate to changes in terrain associated with said at least one site within the ROU.

15. The method as claimed in preceding claims, wherein said modifications are reported as a type of change with respect to said at least one site in a GIS file format to one or more field personnel manning the pipeline at a geographical location corresponding to said at least one site.

16. The method as claimed in claim 15, wherein said field information as received comprises geo-tagged photographic and field-observations captured by said personnel through a mobile or aerial device.

17. The method as claimed in claim 15, wherein said field information is received from said field personnel in real-time or in an offline state

18. The method as claimed in claim 15, further comprising:

receiving input from said field personnel to modify an information as associated with said digitally displayed pipeline and said region's surface.

19. The method as claimed in claim 10, wherein said rendering of information comprises displaying said information at an appropriate geo-location or chainage over said displayed region's surface.

20. The method as claimed in claim 10, further comprising automatically changing a current display of said pipeline and said regions' surface based on traversing the length of the displayed pipeline.

21. The method as claimed in claim 10, further comprising: annotating the displayed pipeline and the displayed region's surface based on information received from said user.

22. A system (200) for generating an aerial representation of terrain around a pipeline laid for transportation of substances, the system comprising:

an acquisition module (202) for acquiring aerial data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline;

a processing module (204) for processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS) coordinates; and

a generation module (206) for creating a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface..

23. A system (700) for rendering information about a pipeline laid for transportation of substances, said system comprising:

a first processor (702) for digitally displaying at least one of:

a pipeline running across a region; and

the region' surface,

said region defining a pre-defined neighbourhood of said pipeline;

a comparator (704) for comparing said display with pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface;

a receiver (706) for receiving a field -information about said at least one site from at least designated entity physically present at said at least one site; and

a second processor (708) for rendering said information at said at least one site as a part of said digitally displayed pipeline and/or said displayed surface.

Dated this 18th day of May, 2016

Method and System of generating and rendering information about a space-representation of terrain around a pipeline

ABSTRACT

The present subject matter describes a method and system (200, 700) of generating an aerial representation of terrain around a pipeline laid for transportation of substances. The method as executed by the system (200, 700) comprises acquiring remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline; processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS); and creating a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

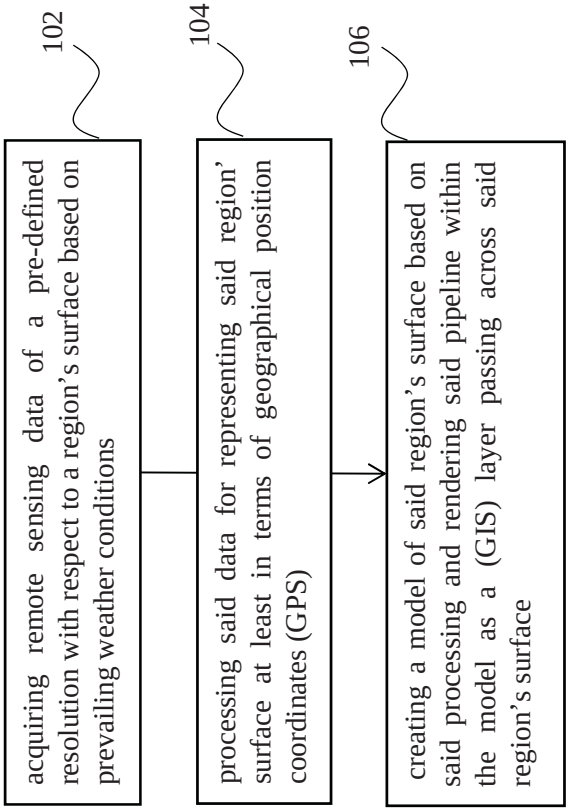
102
104
106
acquiring remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions
processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS)
creating a model of said region's surface based on said processing and rendering said pipeline within the model as a (GIS) layer passing across said region's surface

Figure 1

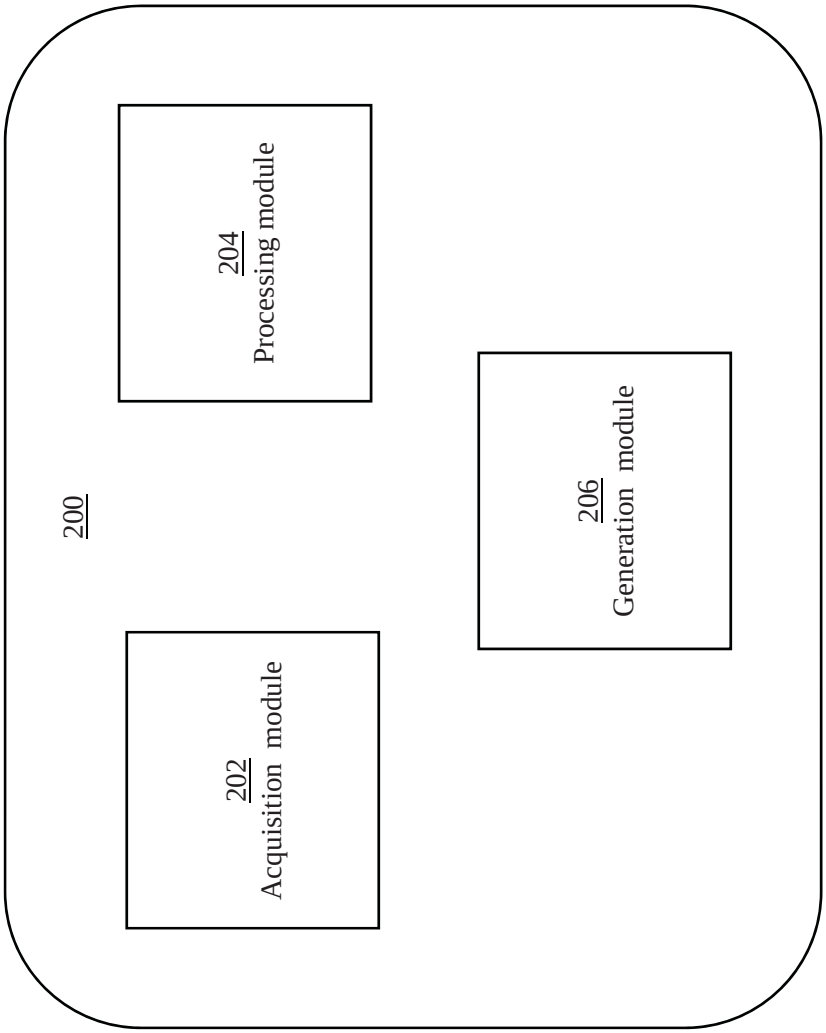
200
204
Processing module
206
Generation module
202
Acquisition module

Figure 2

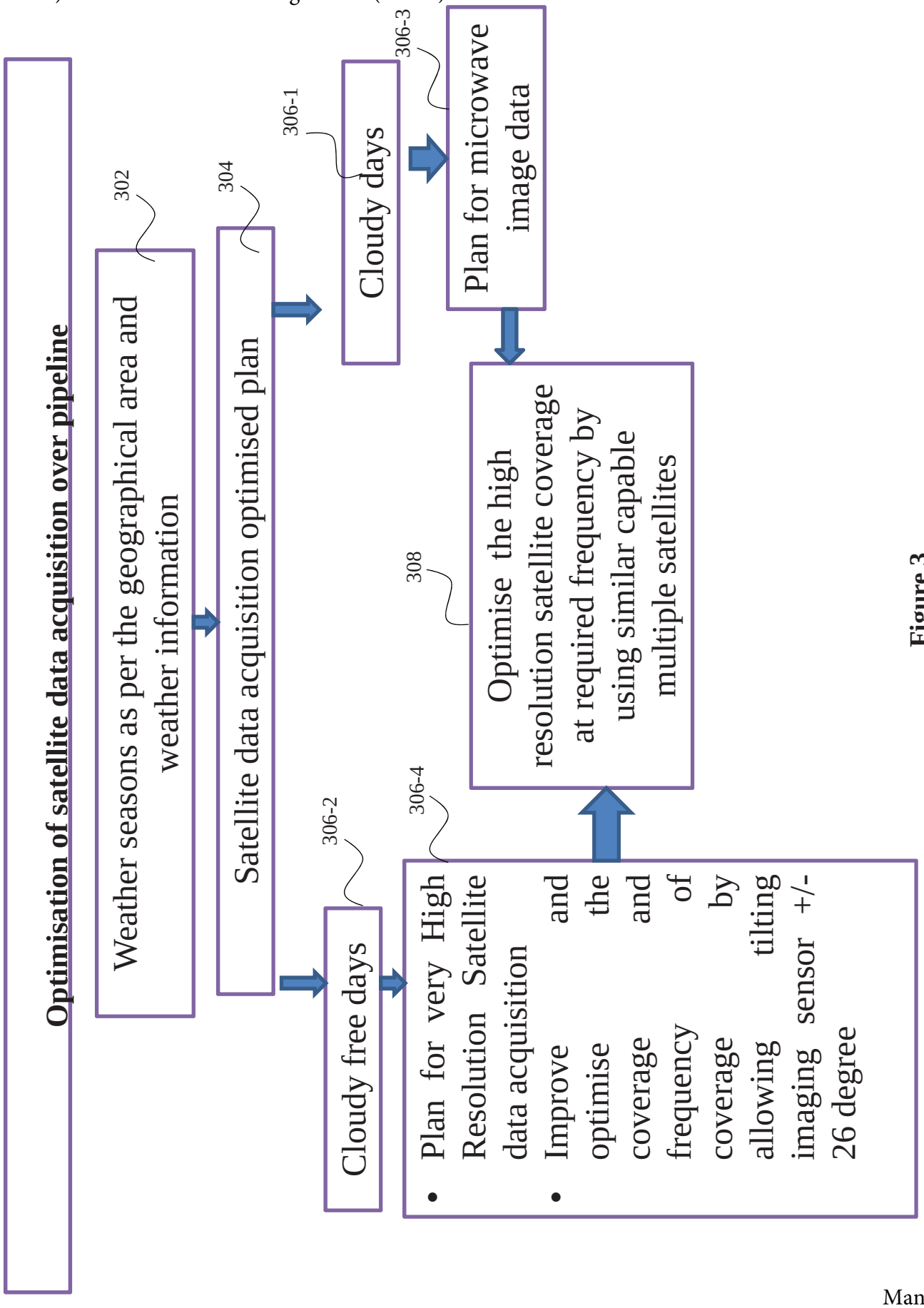

Figure 3

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LEXORBIS

Very resolution satellite data procurement and processing for ortho-rectification
402
Procure the Very resolution satellite data from satellite data supplier
Product type : standard ortho-kit with RPCs
404
Ortho-rectification satellite image
Inputs : Image data with RPC, accurate Control points, and DEM
Method: Digital photogrammetric techniques
406
Apply Image enhancements using image processing techniques for better interpretability. For microwave image data apply speckle noise removal/ suppression techniques.
408
Upload the ortho-rectified image data alongside a representation of pipeline to web-application and publish for visualisation and analysis.

Figure 4

Pipeline GIS database

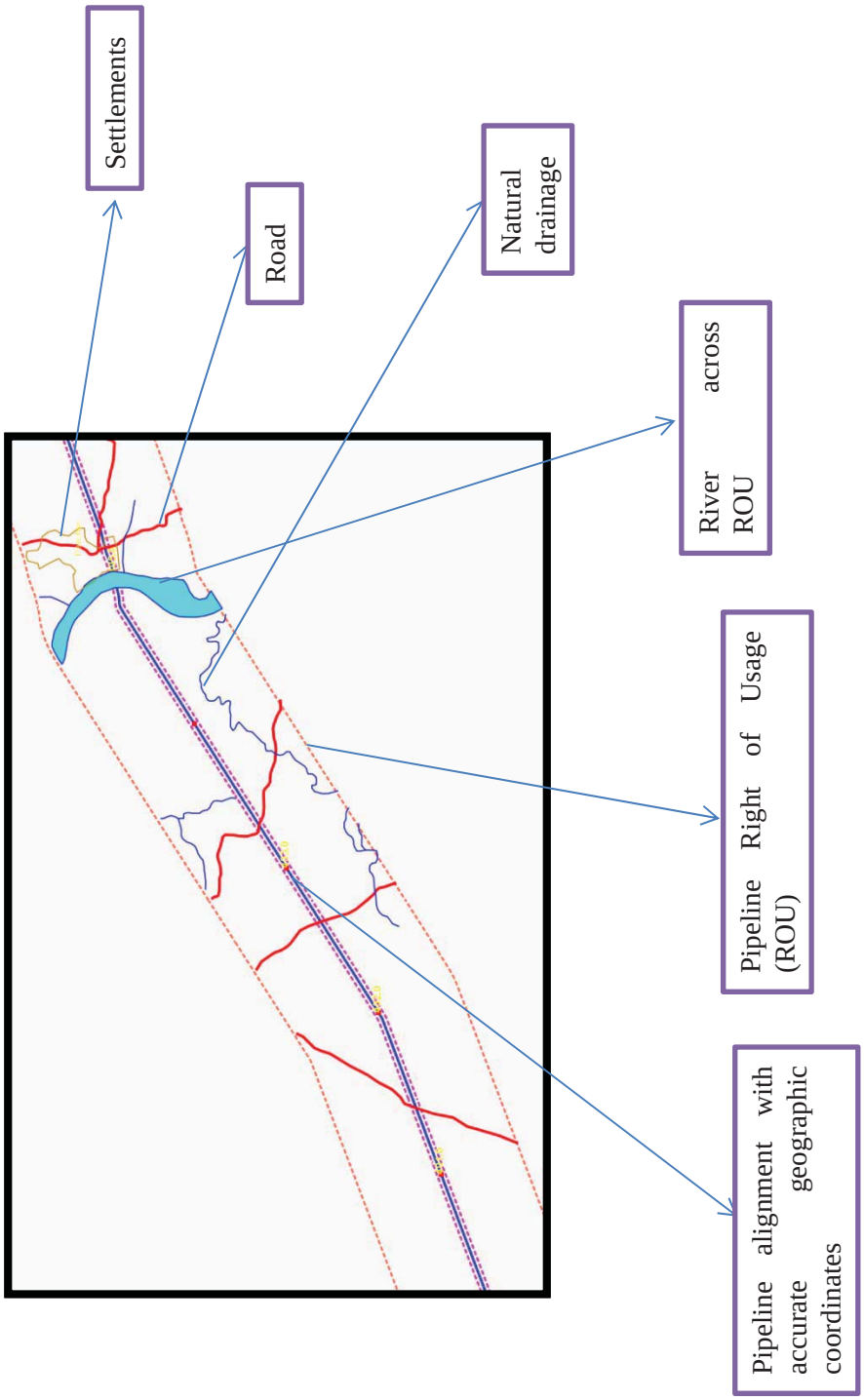

Figure 5

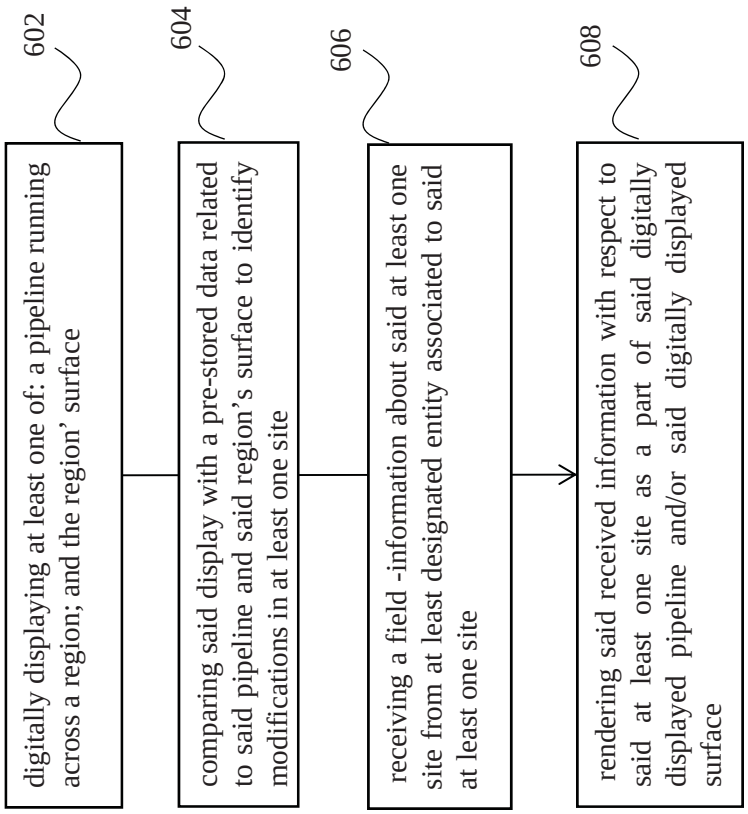
602
digitally displaying at least one of: a pipeline running across a region; and the region' surface
604
comparing said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site
606
receiving a field -information about said at least one site from at least designated entity associated to said at least one site
608
rendering said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface

Figure 6

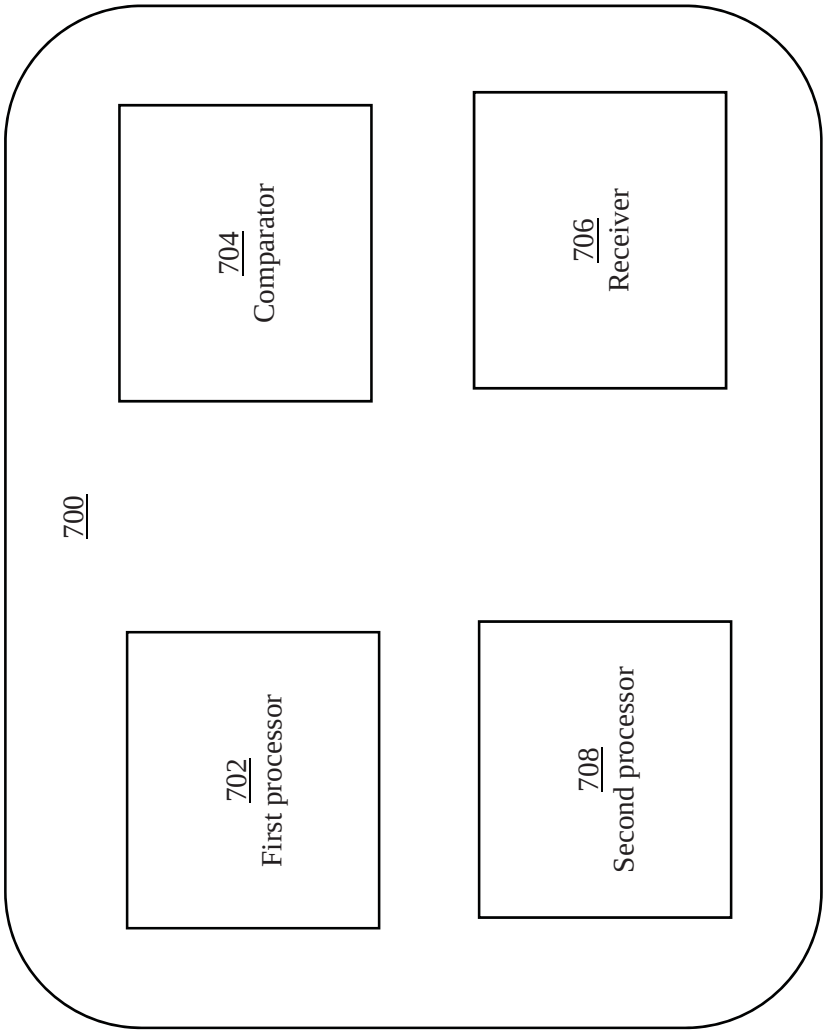
700
704
Comparator
706
Receiver
702
First processor
708
Second processor

Figure 7

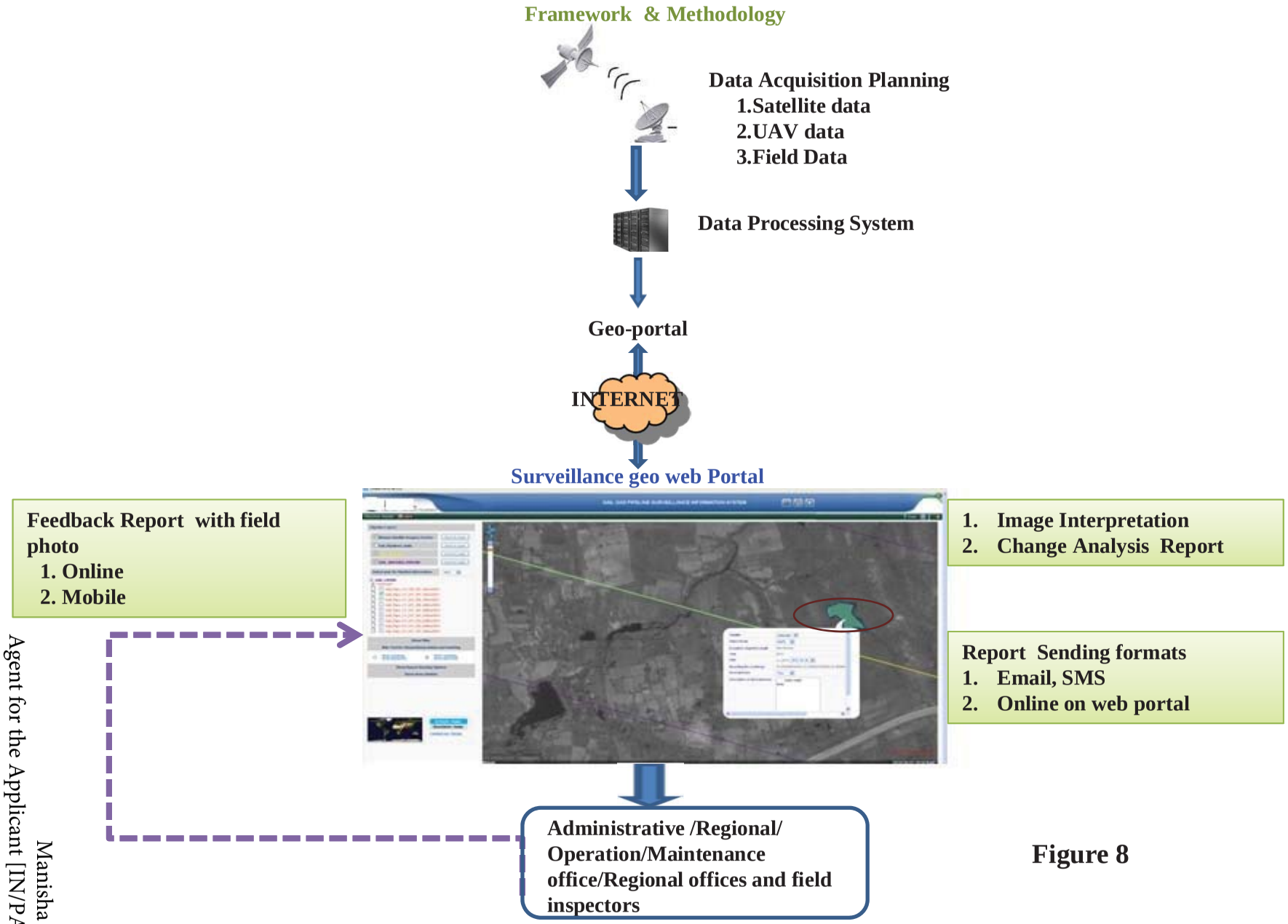
Framework & Methodology
Data Acquisition Planning
1.Satellite data
2.UAV data
3.Field Data
Data Processing System
Geo-portal
INTERNET
Surveillance geo web Portal
Feedback Report with field photo
1. Online
2. Mobile
1. Image Interpretation
2. Change Analysis Report
Report Sending formats
1. Email, SMS
2. Online on web portal
Administrative /Regional/ Operation/Maintenance office/Regional offices and field inspectors

Figure 8

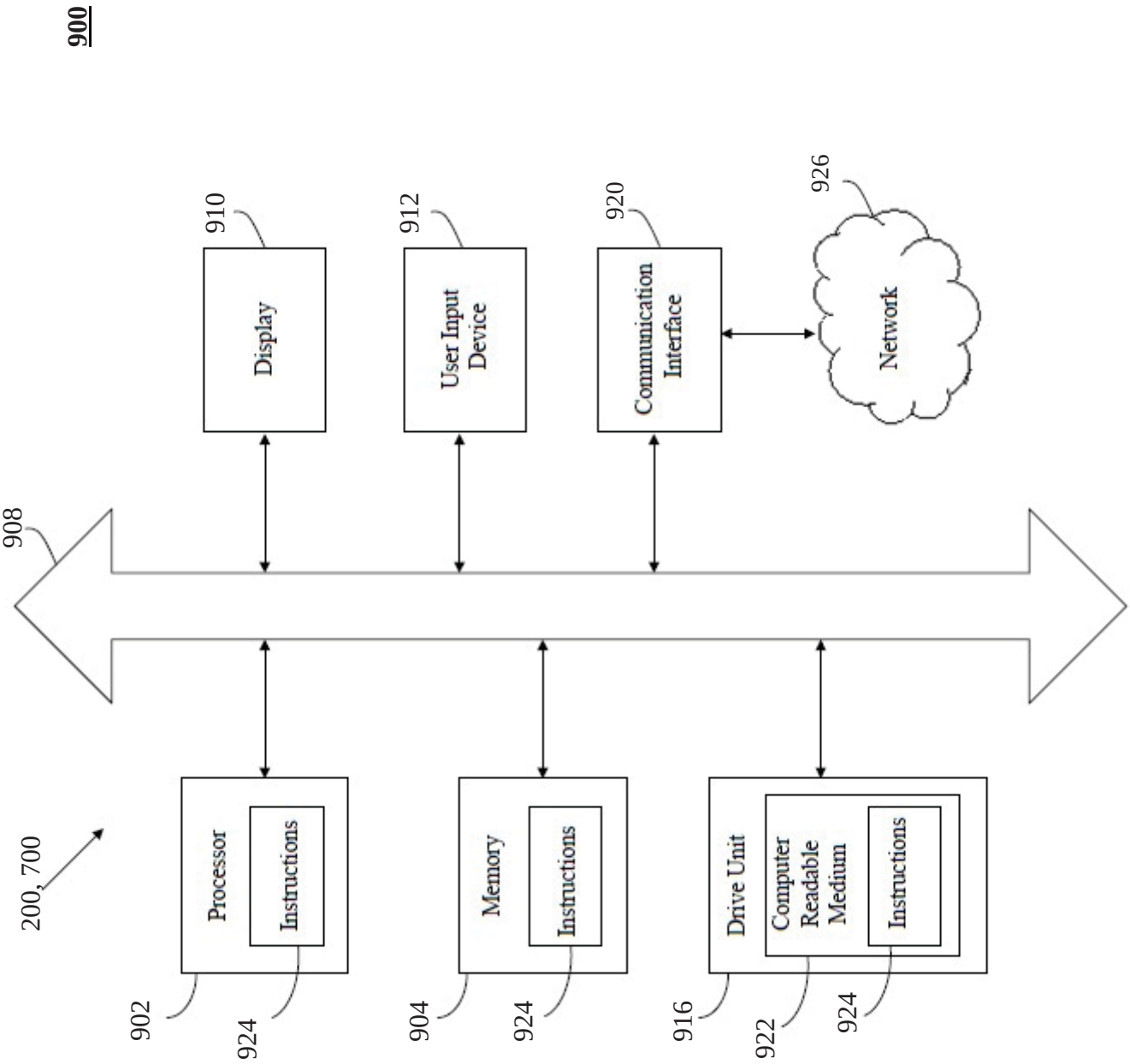
900
910
Display
912
User Input Device
920
Communication Interface
926
Network
908
200, 700
Processor
Instructions
902
924
Memory
Instructions
904
924
Drive Unit
Computer Readable Medium
Instructions
916
922
924

Figure 9

We claim:

1. A method of generating an aerial representation of terrain around a pipeline laid for transportation of substances, the method comprising:

acquiring (step 102) remote sensing data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline;

processing (step 104) said data for representing said region' surface at least in terms of geographical position coordinates (GPS); and

creating (step 106) a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

2. The method as claimed in claim 1, wherein said acquisition comprises capturing a high resolution data through at least one of: satellites, manned aerial vehicles and unmanned aerial vehicles (UAV) based on sensitiveness of the region.

3. The method as claimed in claim 1 and 2, wherein said high resolution data represents microwave data collected under overcast weather conditions through satellites and optical data collected under non-overcast weather conditions through said satellites or said manned or unmanned aerial vehicles.

4. The method as claimed in claim 1, wherein said zone denotes a right of use (ROU) based zone associated with said pipeline, said ROU being defined by at least one of:

a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground; and

a second zone neighbouring said pipeline and defined by about 50 to 250 meters on either side of said pipeline above the ground.

5. The method as claimed in claim 1, wherein said acquisition comprises acquiring said data at least once in month, based on the sensitiveness associated with said region.

6. The method as claimed in claim 1, wherein said processing comprises applying at least a digital photogrammetric technique to the acquired data and thereafter executing an ortho-rectification process.

7. The method as claimed in claim 6, wherein said application of digital photogrammetric technique comprises using a digital elevation model (DEM) of said region's surface.

8. The method as claimed in claim 1, wherein the method comprises applying image-enhancement techniques to said model based on ascertaining said acquired data as at least one of an optical data or a microwave data.

9. The method as claimed in claim 1, wherein said pipeline is rendered within the model based on GPS coordinates of said pipeline.

10. A method of rendering information about a pipeline laid for transportation of substances, said method comprising:

digitally displaying (step 602) at least one of:

a pipeline running across a region; and

the region' surface, said region defining a pre-defined neighbourhood of said pipeline;

comparing (step 604) said display with a pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface;

receiving (step 606) a field -information about said at least one site from at least designated entity associated to said at least one site; and

rendering (step 608) said received information with respect to said at least one site as a part of said digitally displayed pipeline and/or said digitally displayed surface.

11. The method as claimed in claim 10, wherein said region defining said pre-defined neighbourhood denotes an ROU in respect of said pipeline, said ROU being defined by at least one of:

a first type of zone neighbouring said pipeline and defined by about 15 to 25 meters on either side of said pipeline above the ground; and

a second type of zone neighbouring said pipeline and defined by about 500 meters or more at either side of said pipeline above the ground.

12. The method as claimed in claim 10, wherein said digital display comprises displaying land use, drainage, a railway-track, a water body, and physical infrastructure along said pipeline's corridor.

13. The method as claimed in claim 10, wherein said pre-stored data relates to an earlier display of said pipeline and said region's surface.

14. The method as claimed in claims 10 to 11, wherein said modifications at said at least one site relate to changes in terrain associated with said at least one site within the ROU.

15. The method as claimed in preceding claims, wherein said modifications are reported as a type of change with respect to said at least one site in a GIS file format to one or more field personnel manning the pipeline at a geographical location corresponding to said at least one site.

16. The method as claimed in claim 15, wherein said field information as received comprises geo-tagged photographic and field-observations captured by said personnel through a mobile or aerial device.

17. The method as claimed in claim 15, wherein said field information is received from said field personnel in real-time or in an offline state.

18. The method as claimed in claim 15, wherein the method comprises:

receiving input from said field personnel to modify an information as associated with said digitally displayed pipeline and said region's surface.

19. The method as claimed in claim 10, wherein said rendering of information comprises displaying said information at an appropriate geo-location or chainage over said displayed region's surface.

20. The method as claimed in claim 10, wherein the method comprises automatically changing a current display of said pipeline and said regions' surface based on traversing the length of the displayed pipeline.

21. The method as claimed in claim 10, wherein the method comprises: annotating the displayed pipeline and the displayed region's surface based on information received from said user.

22. A system (200) for generating an aerial representation of terrain around a pipeline laid for transportation of substances, the system comprising:

an acquisition module (202) for acquiring aerial data of a pre-defined resolution with respect to a region's surface based on prevailing weather conditions, wherein said region defines a zone around a pipeline;

a processing module (204) for processing said data for representing said region' surface at least in terms of geographical position coordinates (GPS) coordinates; and

a generation module (206) for creating a model of said region's surface based on said processing and rendering said pipeline within the model as a geographical information system (GIS) layer passing across said region's surface.

23. A system (700) for rendering information about a pipeline laid for transportation of substances, said system comprising:

a first processor (702) for digitally displaying at least one of:

a pipeline running across a region; and

the region' surface, said region defining a pre-defined neighbourhood of said pipeline;

a comparator (704) for comparing said display with pre-stored data related to said pipeline and said region's surface to identify modifications in at least one site with respect to at least one of: said displayed pipeline and surface;

a receiver (706) for receiving a field -information about said at least one site from at least designated entity physically present at said at least one site; and

a second processor (708) for rendering said information at said at least one site as a part of said digitally displayed pipeline and/or said displayed surface.

Dated this the 18th Day of May 2016

Manisha Singh
Agent for the Applicant [IN/PA-740]
LEXORBIS
/Digitally Signed/