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(54) **AUTONOMOUS VEHICLE, SYSTEM AND METHOD FOR STRUCTURAL OBJECT ASSESSMENT AND MANUFACTURE THEREOF**

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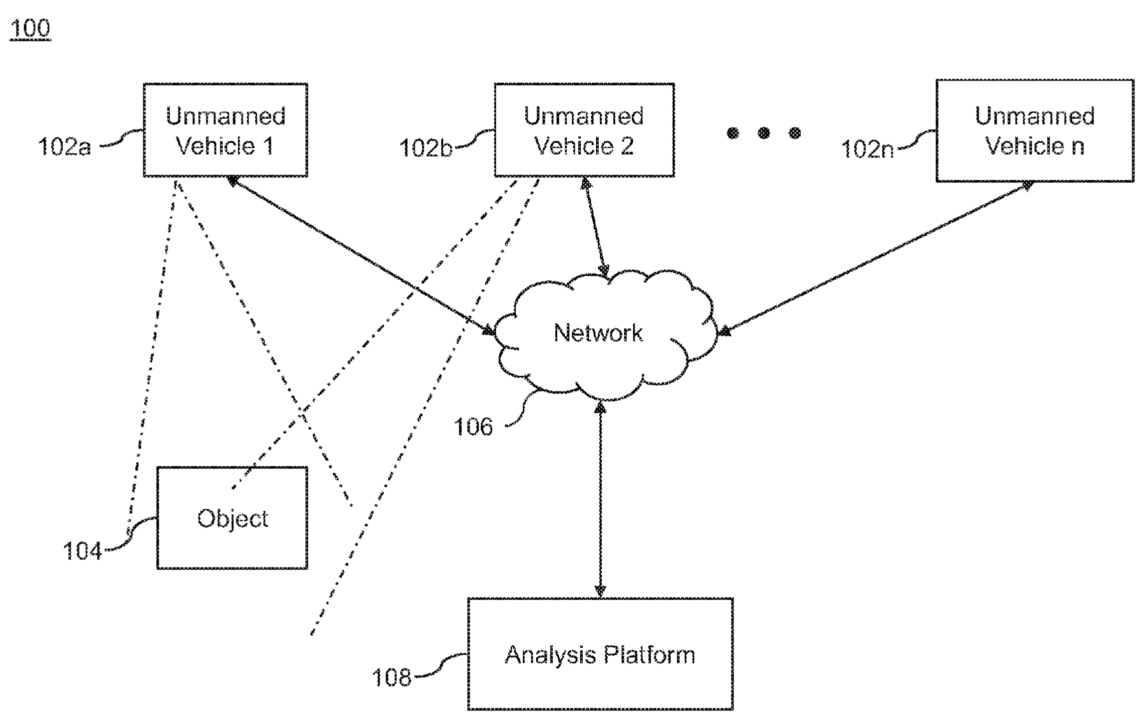
(57) **ABSTRACT**

Some embodiments are directed to an unmanned or optionally manned vehicle for inspecting an object. The unmanned or optionally manned vehicle includes a data collection unit that captures, via the unmanned or optionally manned vehicle, images of the object, wherein the images are combined to generate stereoscopic images and compares the stereoscopic images with pre-stored images for detecting structural parameters of the object. The unmanned or optionally manned vehicle also includes a location unit that determines location data associated with the detected structural parameters. The unmanned or optionally manned vehicle also includes a report generation unit that generates an inspection report based on the comparison of the stereoscopic images and the location data.



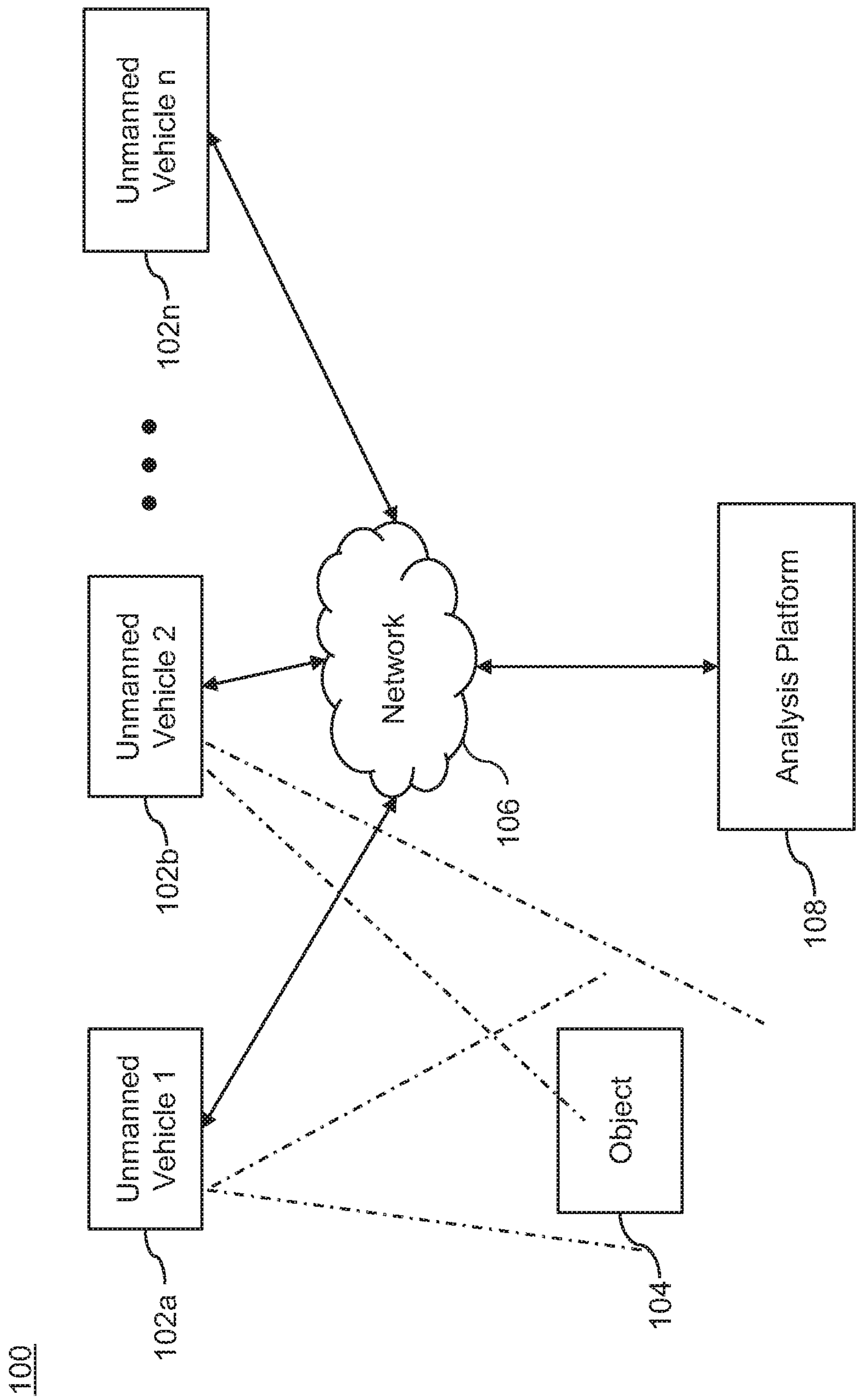

100
Unmanned Vehicle 1
102a
Unmanned Vehicle 2
102b
Unmanned Vehicle n
102n
Object
104
Network
106
Analysis Platform
108

FIG.1

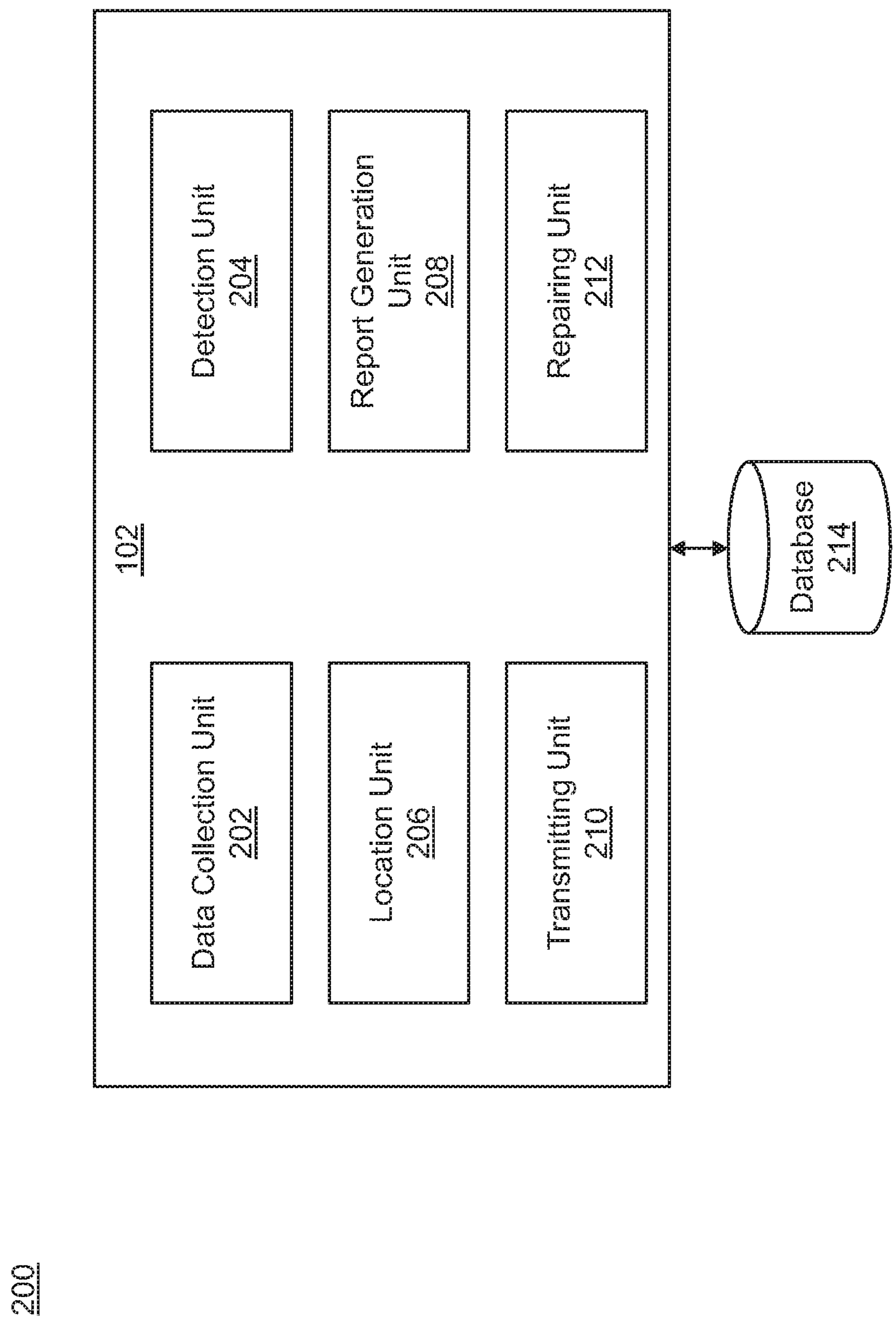

200
102
Data Collection Unit
202
Detection Unit
204
Location Unit
206
Report Generation Unit
208
Transmitting Unit
210
Repairing Unit
212
Database
214

FIG. 2

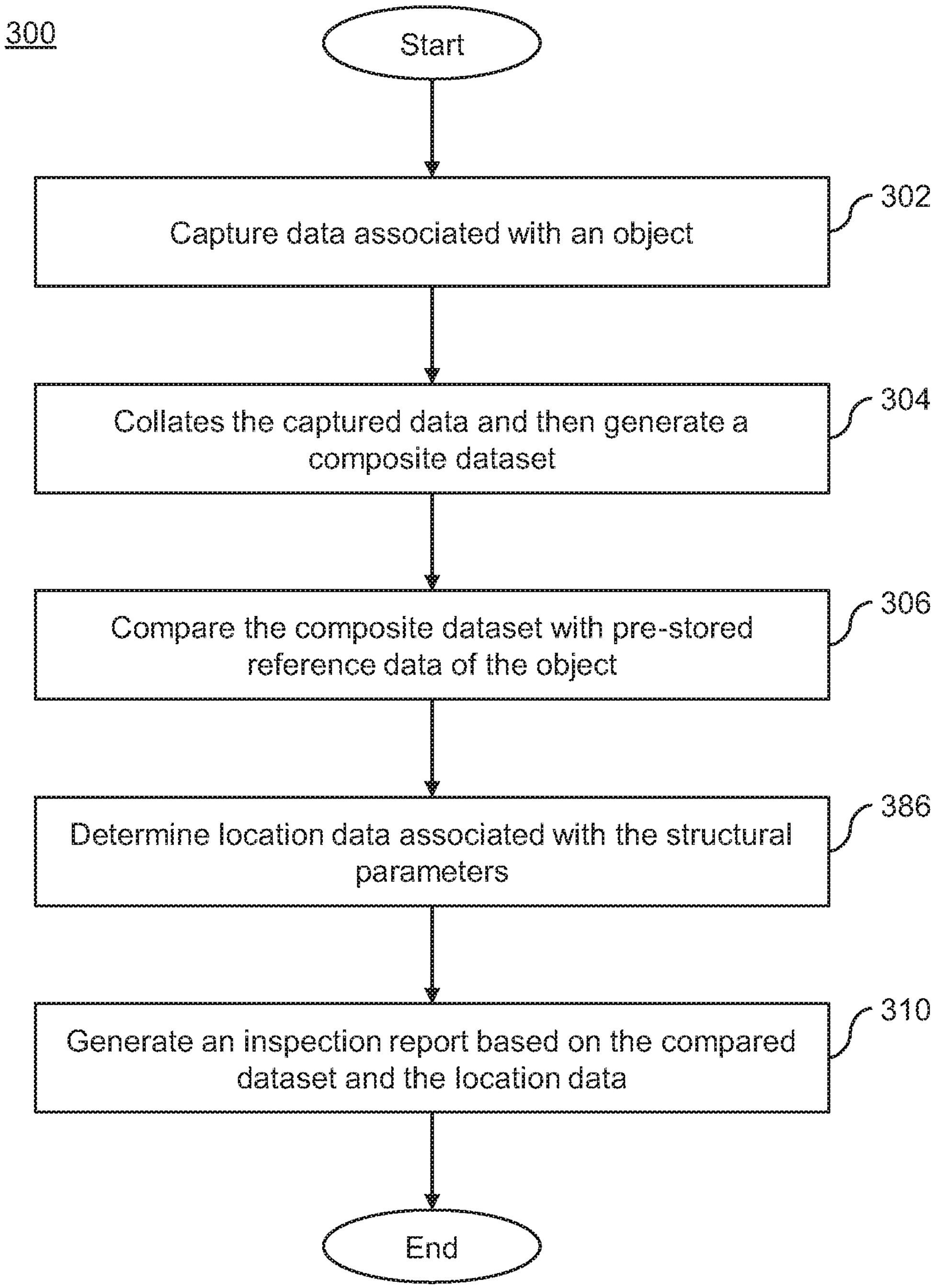

300
Start
Capture data associated with an object
302
Collates the captured data and then generate a composite dataset
304
Compare the composite dataset with pre-stored reference data of the object
306
Determine location data associated with the structural parameters
386
Generate an inspection report based on the compared dataset and the location data
310
End

FIG. 3

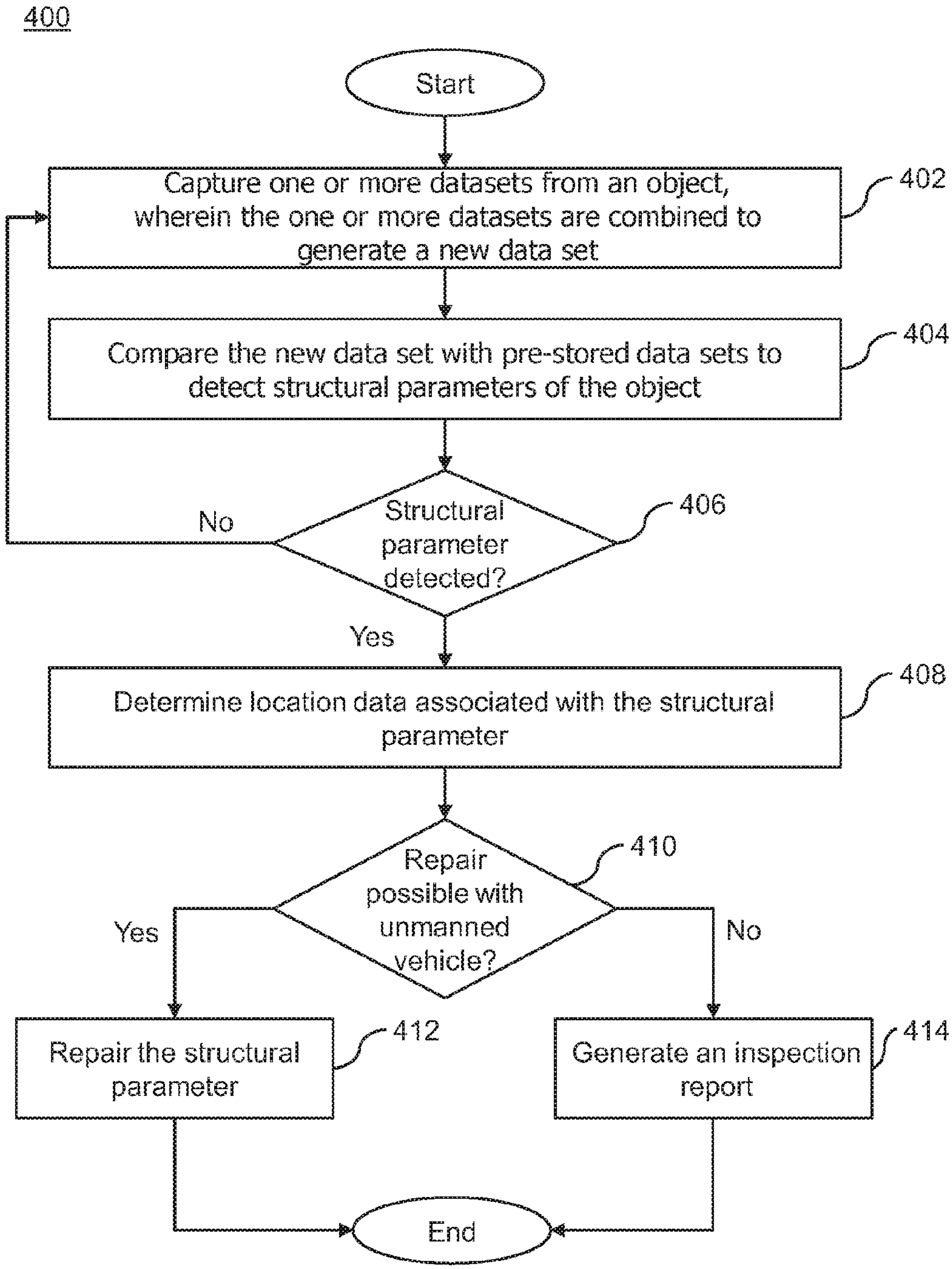

400
Start
Capture one or more datasets from an object, wherein the one or more datasets are combined to generate a new data set
402
Compare the new data set with pre-stored data sets to detect structural parameters of the object
404
Structural parameter detected?
406
No
Yes
Determine location data associated with the structural parameter
408
Repair possible with unmanned vehicle?
410
Yes
No
Repair the structural parameter
412
Generate an inspection report
414
End

FIG. 4

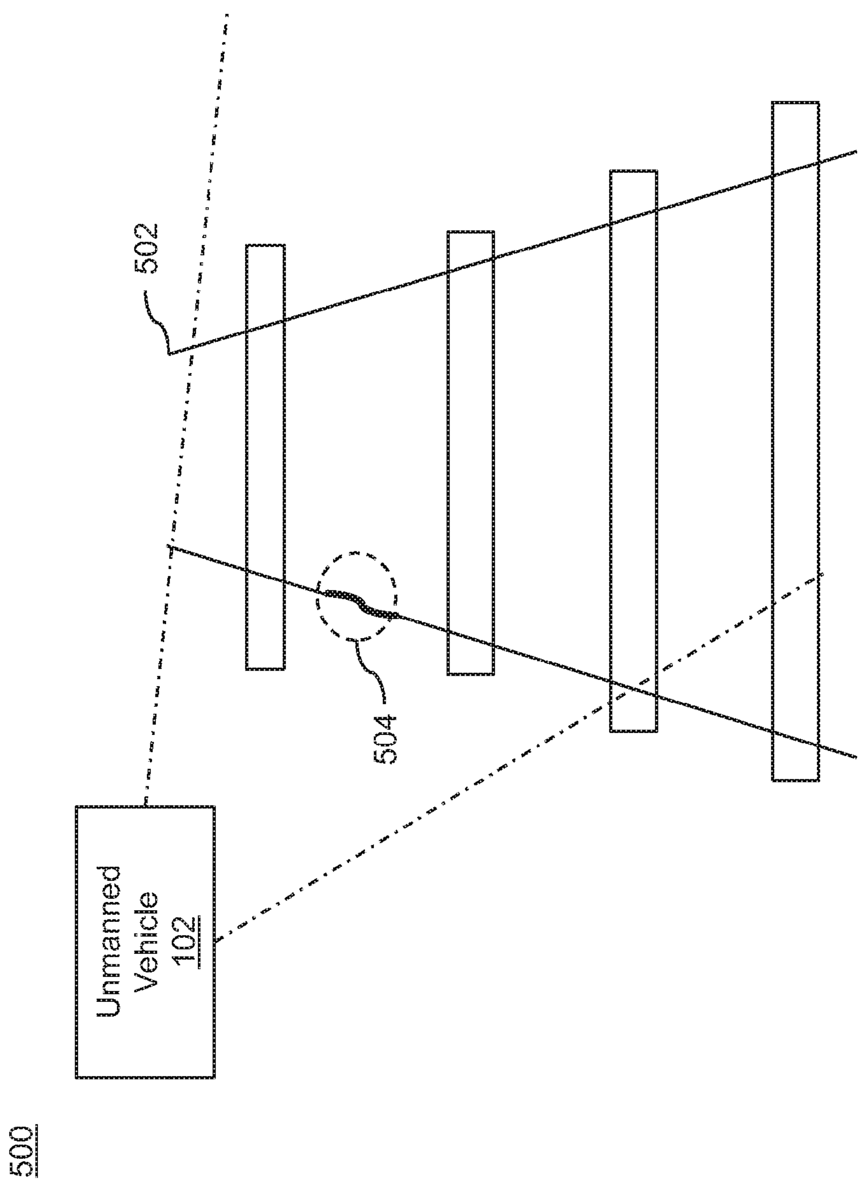


FIG. 5A

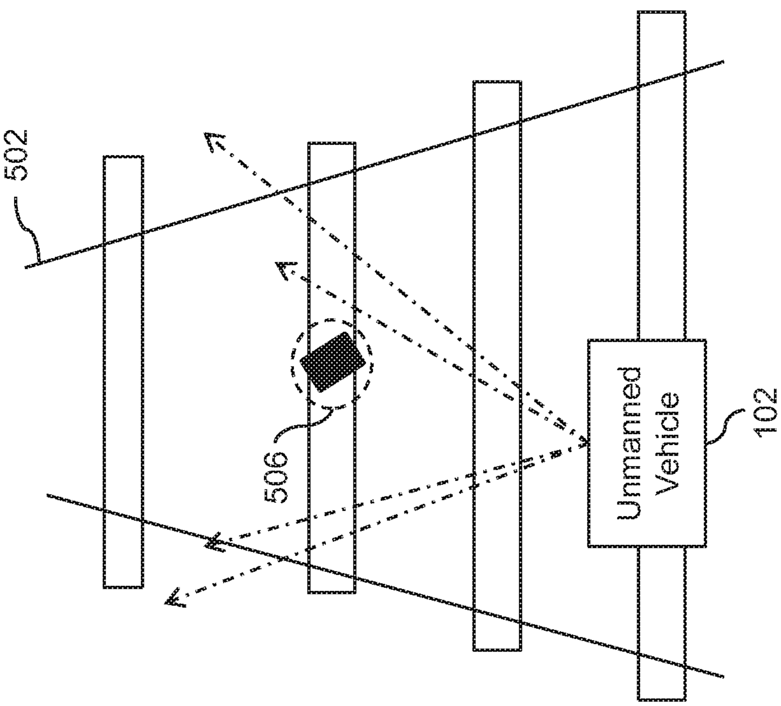


FIG. 5B

500

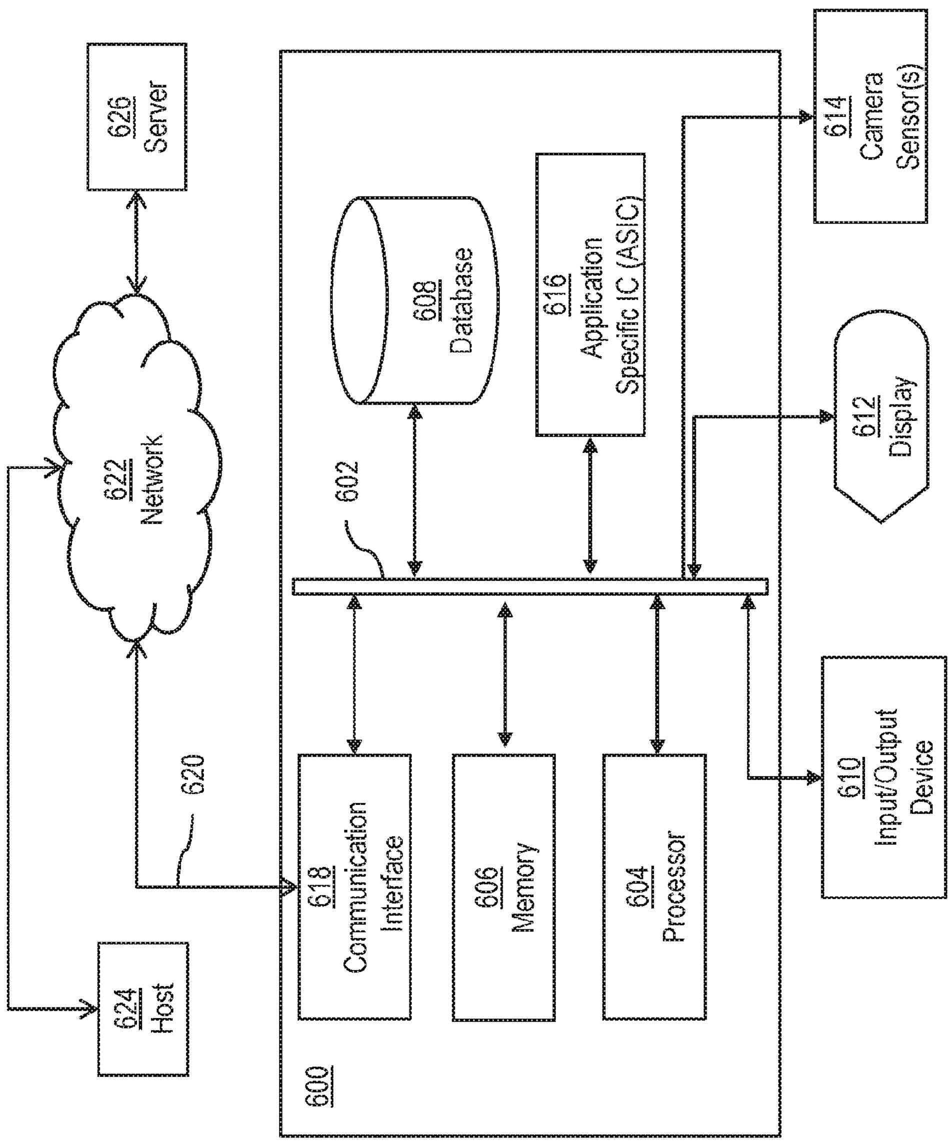

626
Server
622
Network
624
Host
620
600
618
Communication
Interface
606
Memory
604
Processor
602
608
Database
616
Application
Specific IC (ASIC)
614
Camera
Sensor(s)
612
Display
610
Input/Output
Device

FIG. 6

AUTONOMOUS VEHICLE, SYSTEM AND METHOD FOR STRUCTURAL OBJECT ASSESSMENT AND MANUFACTURE THEREOF

BACKGROUND

[0001] The disclosed subject matter relates to systems and methods for inspecting objects. More particularly, the disclosed subject matter relates to unmanned or optionally manned vehicles and systems, methods for inspecting objects, methods for inspecting objects by using one or more unmanned or optionally manned autonomous vehicles, and methods of manufacturing autonomous or semi-autonomous vehicles and systems.

[0002] An unmanned or optionally manned vehicle is a vehicle without a person on board that is capable of sensing its surrounding environment and navigating on its own. A semi-autonomous vehicle requires at least some degree of operator input, either directly (locally) or remotely (i.e., via an internet link, etc.). Either unmanned or optionally manned vehicle can operate in, but is not restricted to, air, water, land, and so forth, unmanned or optionally manned vehicle. Generally, the unmanned or optionally manned vehicle is used for enabling remote inspection of objects or structures that need constant monitoring. The objects and/or structures can include, but are not restricted to, commuter rail lines, dams, bridges, power lines or electrical power grids, and the like. The inspection of the objects and/or structures requires manual intervention. For example, some related inspection systems require a number of maintenance personnel for inspecting a commuter rail line. However, these inspection systems increase inspection time and expense. Further, it is difficult as well as dangerous for the maintenance personnel to perform the inspection when a train passes through the commuter rail line.

SUMMARY

[0003] The physical characteristics of the objects, such as commuter rail lines for railed vehicles, can be compromised by a number of degradation factors. One of the most primary sources of degradation to a commuter rail line is weather, such as, snow, rain, rust, sun exposure, solar wind/flares, pollution, etc. Further, seasonal changes and terrain changes (for example, frozen ground, erosion, etc.) can contribute to track instability. Also, improper/irregular maintenance can damage the objects such as a commuter rail lines, and can affect the commuter rail lines to various extents an in differing, often unpredictable ways. For example, during some times of the year it can be common for trees to shed leaves, which may in turn fall on the surface of the commuter rail lines, causing a reduction in friction between wheels of a train and the commuter rail line, and slippage of the wheels.

[0004] Further degradation factors can also affect a railed vehicle or its tracks, such as crooked ties, broken ties, missing ties, rail tie harnesses, and even the rails themselves. For example, during natural calamities such as earthquake, the rails and rail ties can be damaged and, may require a number of maintenance personnel to repair and/or replace them. However, maintenance personnel cannot always detect such damages to a commuter rail line for numerous reasons. Also, the damaged rails can result in the train derailing, which can lead to serious hazards to human health and safety.

[0005] Some related arts use static cameras for visual inspection of the objects and/or structures. However, the use of static cameras can have a limited field-of-view during inspection of large areas such as a spatially elongate commuter rail line, and also maintenance of the static cameras in remote areas can be difficult.

[0006] Some related arts use human piloted helicopters for the inspection of large objects and/or structures. However, use of these helicopters can also result in an increase in costs. Additionally, the practice of using the human piloted helicopters can be dangerous in some instances such as during storms, or rain.

[0007] It may therefore be beneficial to provide an unmanned or optionally manned vehicle, a system, and method of use and manufacture thereof that address at least one of the above issues. For example, it may be beneficial to provide an unmanned or optionally manned vehicle for inspecting objects and/or structures. It may also be beneficial to provide unmanned or optionally manned vehicle while also reducing manual inspection.

[0008] It may therefore be beneficial to provide an unmanned or optionally manned vehicle, a system, and method of use and manufacture thereof that address at least one of the above and/or other disadvantages. In particular, it may be beneficial to provide an unmanned or optionally manned vehicle, a system, and method for inspecting an object by using the unmanned or optionally manned vehicle, to eliminate the need to send maintenance personnel to inspect a commuter rail line. For example, it may be beneficial to configure an unmanned or optionally manned vehicle to inspect the object and determine structural parameters related to the object.

[0009] It may therefore be beneficial to provide an unmanned or optionally manned vehicle, a system, and method of use and manufacture thereof that address at least one of the above and/or other disadvantages. In particular, it may be beneficial to provide an unmanned or optionally manned vehicle, a system, and method for inspecting an object by using the unmanned or optionally manned vehicle, and to eliminate human errors while inspecting the commuter rail line.

[0010] Some embodiments are therefore directed to a method for inspecting an object by using an unmanned or optionally manned vehicle. The method can include capturing, by the at least one unmanned or optionally manned vehicle, one or more images of the object, wherein the one or more images are combined to generate one or more stereoscopic images; comparing the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters of the object; and determining location data associated with the one or more detected structural parameters, wherein the location data is used to generate an inspection report based on the comparison of the one or more stereoscopic images.

[0011] Some other embodiments are directed to an unmanned or optionally manned vehicle for inspecting an object. The unmanned or optionally manned vehicle can include a data collection unit that is configured to capture, via the unmanned or optionally manned vehicle, images of the object, wherein the images are combined to generate one or more stereoscopic images and compare the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters of the object. However, the data collection unit can also collect data in different forms and relating to different processes such as interferometry data (such as interference patterns or deviations therefrom), electrical characteristic data (voltages, currents, impedances, etc.), holographic imaging data, RADAR/SONAR data, etc. The unmanned or optionally manned vehicle can also include a location unit that is configured to determine location data associated with the one or more detected structural parameters being inspected. The unmanned or optionally manned vehicle can also include a report generation unit that is configured to generate an inspection report based on the data collected in the data collection unit, and could include a comparison of a particular data set to a known standard (such as a previous measurement), or could simply compare the collected data against a particular standard (such as a certain width, voltage, or periodicity must conform to a certain value, within a given threshold). A report can also include location data of the measured feature deviating from the known or standardized measured data set.

[0012] Yet other embodiments are directed to a system for inspecting an object. The system can include a data collection unit that is configured to capture, via the unmanned or optionally manned vehicle, images of the object, wherein the images are combined to generate one or more stereoscopic images and compare the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters of the object. However, the data collection unit can also collect data in different forms and relating to different processes such as interferometry data (such as interference patterns or deviations therefrom), electrical characteristic data (voltages, currents, impedances, etc.), holographic imaging data, RADAR/SONAR data, etc. The unmanned or optionally manned vehicle can also include a location unit that is configured to determine location data associated with the one or more detected structural parameters being inspected. The unmanned or optionally manned vehicle can also include a report generation unit that is configured to generate an inspection report based on the data collected in the data collection unit, and could include a comparison of a particular data set to a known standard (such as a previous measurement), or could simply compare the collected data against a particular standard (such as a certain width, voltage, or periodicity must conform to a certain value, within a given threshold). A report can also include location data of the measured feature deviating from the known or standardized measured data set. In a system including the unmanned or optionally manned vehicles, each of the unmanned or optionally manned vehicle can also include a communication unit that is in communication with each of the other of a plurality of unmanned or optionally manned vehicles for receiving a corresponding local inspection report and generating a global inspection report based on the received local inspection report.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The disclosed subject matter of the present application will now be described in more detail with reference to exemplary embodiments of the apparatus and method, given by way of example, and with reference to the accompanying drawings, in which:

[0014] FIG. **1** is an exemplary system for inspecting an object by using an unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0015] FIG. **2** illustrates components of the unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0016] FIG. **3** is a method for inspecting an object by using the unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0017] FIG. **4** is a method for inspecting an object by using the unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0018] FIG. **5**A is an exemplary environment for inspecting a commuter rail line by using an unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0019] FIG. **5**B is an exemplary environment for inspecting a commuter rail line by using an unmanned terrestrial railed vehicle in accordance with the disclosed subject matter.

[0020] FIG. **6** is a computer system that can be used to implement various exemplary embodiments of the disclosed subject matter.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0021] A few inventive aspects of the disclosed embodiments are explained in detail below with reference to the various figures. Exemplary embodiments are described to illustrate the disclosed subject matter, not to limit its scope, which is defined by the claims. Those of ordinary skill in the art will recognize a number of equivalent variations of the various features provided in the description that follows.

I. Unmanned or Optionally Manned Vehicle

[0022] FIG. **1** is an exemplary system **100** for inspecting an object by using the unmanned or optionally manned vehicle in accordance with the disclosed subject matter.

[0023] FIG. **1** illustrates the system **100** that includes unmanned or optionally manned vehicles **102***a-n*, hereinafter referred to as an unmanned or optionally manned vehicle **102**. The unmanned or optionally manned vehicle **102** and embodiments are intended to include or otherwise cover any type of unmanned or optionally manned vehicle, including an aerial vehicle, a terrestrial vehicle, a drone, a gyrocopter, an oceanic vehicle, etc. In some embodiments, the terrestrial vehicle can be, but is not restricted to, a railed vehicle, such as a miniature train that can ride on commuter rail lines, or could also be a wheeled vehicle that rides along one or both sides of a rail (or on one or more of the rails) to perform track inspection. In fact, embodiments are also intended to include or otherwise cover any type of unmanned or optionally manned vehicle that may stay geostationary in the sky, or fly at a considerable height near and/or above an object to be inspected. The unmanned terrestrial rail vehicle **102** is merely provided for exemplary purposes, and the various inventive aspects are intended to be applied to any type of unmanned or optionally manned vehicle.

[0024] In some embodiments, the unmanned or optionally manned vehicle **102** can be a single or multi-rail riding cart that rides on a terrestrial object. In some other embodiments, the unmanned or optionally manned vehicle **102** can be a wheeled terrestrial vehicle.

[0025] In some embodiments, the unmanned or optionally manned vehicle **102** can be manually controlled by an operator present at a base station. In some other embodiments, the unmanned or optionally manned vehicle **102** may be autonomously controlled based on a predetermined control strategy. In yet other embodiments, the unmanned or optionally manned vehicle **102** may be semi-autonomously controlled, which involves an operator entering and/or selecting one or more attributes and subsequent autonomous control of the unmanned or optionally manned vehicles **102** based on the entered and/or selected parameters. In fact, embodiments are intended to include or otherwise cover any type of techniques, including known, related art, and/or later developed technologies to control the unmanned or optionally manned vehicle **102**. In some other embodiments, the vehicle **102** may be a manned vehicle.

[0026] For operating purposes, the unmanned or optionally manned vehicle **102** and its components (not shown) can be powered by a power source to provide propulsion. The power source can be, but is not restricted to, a battery, a fuel cell, a photovoltaic cell, a combustion engine, fossil fuel, solar energy, electrical power supplied by the object **104**, and so forth. In fact, embodiments are intended to include or otherwise cover any type of power source to provide power to the unmanned or optionally manned vehicle for its operations.

[0027] In some embodiments, the unmanned or optionally manned vehicle **102** can have, but is not restricted to, rotors, propellers, and flight control surfaces that control movements and/or orientation of the unmanned or optionally manned vehicle **102**, and the like. In fact, embodiments are intended to include or otherwise cover any other component that may be beneficial to inspect objects by using the unmanned or optionally manned vehicle.

[0028] Further, in some embodiments, the unmanned or optionally manned vehicle **102** can also include, but is not restricted to, a processor (not shown), a memory (not shown), and the like. In some embodiments, the processor of the unmanned or optionally manned vehicle **102** can be a single core processor. In alternate embodiments, the processor can be a multi-core processor. Embodiments are intended to include or otherwise cover any type of processor, including known, related art, and/or later developed technologies to enhance capabilities of processing data and/or instructions. The memory can be used to store instructions that can be processed by the processor. Embodiments are intended to include or otherwise cover any type of memory, including known, related art, and/or later developed technologies to enhance capabilities of storing data and/or instructions.

[0029] In the exemplary system **100** as shown in FIG. **1**, the unmanned or optionally manned vehicle **102** inspects an object **104**. In some embodiments, the object **104** can be a terrestrial object, such as, but is not restricted to, a commuter rail line. In some other embodiments, the object **104** can be, but is not restricted to a dam, a bridge, a power grid, water towers, airports, power lines, fuel bunkers, water plants, cellular towers, and the like. In fact, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of object that covers a large area and needs constant and/or periodic inspection. Further, the object **104** can be any terrain, such as, but not restricted to rails, roads, runways, sidewalks, walking paths, and so forth.

[0030] In addition, the memory (not shown) of the unmanned or optionally manned vehicle **102** can store data used to inspect the object **104** and determine structural parameters of the object **104**. The data can include, but is not restricted to, images of the object, dimensions of the object, a name of the object, a type of the object, a geographical location of the unmanned or optionally manned vehicle **102**, and the like.

[0031] In some embodiments, the structural parameter of the object **104** can be, but is not restricted to, a break, a misalignment, a breach, a bend, a buckle, and the like. In some embodiments, the unmanned or optionally manned vehicle **102** can have more than one structural parameter. The structural parameters of the object **104** can occur due to various degradation factors, such as, but is not restricted to, environmental factors, for example, weather, improper maintenance, and so forth. In an exemplary scenario, structural parameters of a commuter rail line, such as a railroad, have occurred in rail ties, rail tie harness, or rails during rain.

[0032] The unmanned or optionally manned vehicle **102** may then determine the structural parameters of the object **104** by performing any form of detection capable of detecting breeches, such as by monitoring the reflected light of an LED, LASER, or the like. In some instances, the unmanned or optionally manned vehicle **102** may monitor electrical characteristics of the structural parameter by means of balanced electrical networks such as Wheatstone bridges or the like to determine regions of discontinuity. As previously mentioned, techniques of detecting interference patterns between one or more interferometers are also envisioned, as are methods of performing holographic image or video assessment and even structure or terrain SONAR/RADAR assessment. As previously mentioned, an unmanned or optionally manned vehicle could also generate stereoscopic images.

[0033] In some embodiments where stereoscopy is desired, the unmanned or optionally manned vehicle **102** can constantly capture images of the object **104**. These captured images of the object **104** could be two dimensional (2D) images. The 2D images may then be combined to generate 3-D stereoscopic images that give a perception of all three dimensions in high-quality detail to an observer or even a machine-learning or pattern detecting system. In particular, stereoscopy is a technique that is capable of creating a 3D image based on two or more differing perspectives of an object, causing a measure of depth of the object relative to its surroundings to be quantified. That is, in images or videos, the illusion of depth can be generated by presenting a different image for each eye of an observer. In some embodiments, the stereoscopic images can be generated to record and/or display 3D images of the object **104**. In some other embodiments, the stereoscopic images are generated for enhancing the illusion of depth in an image.

[0034] The stereoscopic images may be generated by using various stereoscopic techniques. In fact, embodiments of the present invention are intended to include or otherwise cover any type of stereoscopic techniques including known, related art, and/or later developed technologies to enhance illusion of depth.

[0035] In some embodiments, the unmanned or optionally manned vehicle **102** can generate the stereoscopic images of the object **104**. In some other embodiments, a fleet of unmanned or optionally manned vehicles **102** can be used to generate the stereoscopic images of the object **104**. In fact, embodiments of the present invention are intended to include or otherwise cover any number of unmanned or optionally manned vehicles **102** to generate the stereoscopic images of the object **104**. In some embodiments, the unmanned or optionally manned vehicle swarms can increase the resolution of the generated stereoscopic images by approximately 99% as opposed to a single unmanned or optionally manned vehicle **102** due to their separation. Generally, the 3D depth perception may increase with the separation of the collaborating unmanned or optionally manned vehicles **102**. Further, the stereoscopic images can be expanded and/or contracted in order to modify the degree of stereoscopic imaging based on a particular target, such as the object **104**. Therefore, a fleet of unmanned or optionally manned vehicles **102** may be used to provide 3D stereoscopic imaging for inspecting the object **104**. In addition, the fleet of unmanned or optionally manned vehicles **102** may also enable aerial inspection of the object **104**.

[0036] Further, the unmanned or optionally manned vehicle **102** may determine location data corresponding to the detected structural parameter of the object **104**. In some embodiments, the location data may include, but is not restricted to, latitude, longitude, and altitude. In alternate embodiments, the location data may include any other information that is required to determine the location of the detected structural parameter of the object **104**.

[0037] As further described below, the unmanned or optionally manned vehicle **102** can also employ numerous other technologies to assess the level of quality or degradation of a commuter rail line. In some embodiments, one or more interferometers can be used to accurately assess horizontal distances (such as track separation or deviations from the expected track separation within certain thresholds), vertical distances (such as deviation of the terrain from the vehicle, or even to "count" rail ties according to an algorithm), or at any angle in-between (such as to scan for cavities or breeches in either the rails, rail ties, tie spikes, or any other quantity of interest). These distances can be accurately determined by measuring the interference pattern of two electromagnetic waves traveling along orthogonal paths (one being a fixed, or "known" path distance and the other being a measured distance relative to the "known" distance), and measuring the interference pattern created when they coalesce. This technique can provide an almost arbitrarily determined precision in measuring distances.

[0038] Another means of detecting breeches or faults is to measure impedances between differing points along the rail. For example, a Wheatstone bridge is an incredibly sensitive network of (usually) four resistive elements, whereby the fourth element is the element being tested. In a calibrated, balanced network, the impedance of, voltage across, or current through the fourth resistor can be very accurately determined relative to the three "set" resistors whose values do not change appreciably. This network can be multiplied indefinitely (say, one between a point on the front-right track and a second point on the front-right track behind the first point). If the rail inspection vehicle crosses a point where a crack in the rail exists, the three set resistors will maintain the same value, while the fourth resistor (monitoring the 2 points on the rail) will suddenly go to infinity (open circuit). This impedance change could then be documented/reported. Circuits such as this could be arbitrarily stacked along horizontal and/or vertical axis of the rails, or even between the rails for greater precision.

[0039] Yet other capabilities to such an unmanned or optionally manned vehicle **102** can include using sonic or electromagnetic radiation (SONAR/RADAR) to evaluate the integrity of the track foundation, rail or rail tie health, or to scan for cavities, splits, cracks, or other breeches to any aspect of the rail line. For example, holes caused by erosion or routine wear can be readily detected with such a scheme and identified for later maintenance. Likewise, sinkholes that have not yet become visually obvious could be detected before they can cause problems.

[0040] A further ability of such an unmanned or optionally manned vehicle **102** is the capability to generate holographic images or videos of the rail line based on the interference patterns generated by one or more light sources (such as a laser) reflecting off of elements of the rail line such as ties, rails, tie spikes, etc. Such imaging could provide a complimentary or alternative means of assessing rail health, and could even be used to provide precision comparison between an expected image and a detected image.

[0041] Yet another ability of such an unmanned or optionally manned vehicle could be to perform non-ionizing millimeter-wave or sub-millimeter wave imaging. This could allow imagers to detect electromagnetically reflected waves from metallic objects (such as rails) through organic debris such as wood, bacteria, etc. that could be situated on the rails, and also to perform terrain assessment beneath the unmanned or optionally manned vehicle.

[0042] Moreover, the unmanned or optionally manned vehicle **102** may use the detected location data to generate an inspection report based upon the any of the aforementioned detection means of the object **104**. The unmanned or optionally manned vehicle **102** may then send the inspection report, through a communication network **106**, to an analysis platform **108**.

[0043] In some other embodiments, the communication network **106** may include a data network such as, but not restricted to, the Internet, Local Area Network (LAN), Wide Area Network (WAN), Metropolitan Area Network (MAN), etc. In certain embodiments, the communication network **106** can include a wireless network, such as, but not restricted to, a cellular network and may employ various technologies including Enhanced Data rates for Global Evolution (EDGE), General Packet Radio Service (GPRS), Global System for Mobile Communications (GSM), Internet protocol Multimedia Subsystem (IMS), Universal Mobile Telecommunications System (UMTS) etc. In some embodiments, the communication network **106** may include or otherwise cover networks or subnetworks, each of which may include, for example, a wired or wireless data pathway. The communication network **106** may include a circuit-switched voice network, a packet-switched data network, or any other network capable for carrying electronic communications. For example, the network may include networks based on the Internet protocol (IP) or Asynchronous Transfer Mode (ATM), and may support voice usage, for example, VoIP, Voice-over-ATM, or other comparable protocols used for voice data communications. In one implementation, the network includes a cellular telephone network configured to enable exchange of text or SMS messages.

[0044] Examples of the communication network **106** may include, but are not limited to, a Personal Area Network (PAN), a Storage Area Network (SAN), a Home Area Network (HAN), a Campus Area Network (CAN), a Virtual Private Network (VPN), an Enterprise Private Network

(EPN), Internet, a Global Area Network (GAN), and so forth. Embodiments are intended to include or otherwise cover any type of communication network, including known, related art, and/or later developed technologies to communicate with other unmanned or optionally manned vehicles **102** or the analysis platform **108**.

[0045] The analysis platform **108** can be, but is not restricted to, a base station. The base station can be a fixed base station or a mobile base station. In some other embodiments, the mobile base station may include, but is not restricted to, an unmanned or optionally manned aerial vehicle, an unmanned or optionally manned terrestrial vehicle, and the like. It may also be contemplated that the base station may be, but is not restricted to, an electronic device, such as a smartphone, a laptop, a remote control device, and the like. In fact, embodiments are intended to include or otherwise cover any type of base station, including known, related art, and/or later developed technologies to communicate with other unmanned or optionally manned vehicles **102**.

[0046] Further, the functioning of the unmanned or optionally manned vehicle **102** is described in more detail below in conjunction with FIG. **2**.

[0047] The unmanned or optionally manned vehicle **102** is configured to communicate with other companion unmanned or optionally manned vehicles **102**. In some embodiments, the unmanned or optionally manned vehicle **102** may communicate with other companion unmanned or optionally manned vehicles **102** through, but is not restricted to, a communication network such as the communication network **106** of the system **100**.

[0048] The unmanned or optionally manned vehicle **102** may also repair the detected structural parameters of the object **104**. In some embodiments, the unmanned or optionally manned vehicle **102** may include, but is not restricted to, a repairing equipment. In some exemplary scenarios, the repairing equipment may be, but is not restricted to, a welding machine, a hammer, a hoist, a saw, a drill machine, a wrench, or equipment such as electrical or electronic testing devices, and the like. In an exemplary scenario, the unmanned or optionally manned vehicle **102** could weld a breach or remove debris from the object **104** such as a railroad, without the need to alert a maintenance crew. In fact, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of repairing equipment, including known, related art, and/or later developed technologies to repair the structural parameters of the object **104**.

II. Functioning of the Unmanned or Optionally Manned Vehicle

[0049] FIG. **2** illustrates components of the unmanned or optionally manned vehicle **102**, in accordance with the disclosed subject matter. As discussed, the unmanned or optionally manned vehicle **102** can be configured to inspect the object **104** for determining structural parameters of the object **104**. In some exemplary scenarios, the inspection of object **104** may include, but is not restricted to, a track inspection, a rail tie inspection, debris removal, terrain inspection, a system of identifying and/or cataloguing faults, and so forth.

[0050] In some embodiments, the unmanned or optionally manned vehicle **102** can include, but is not restricted to, a data collection unit **202**, a detection unit **204**, a location unit **206**, a report generation unit **208**, a transmitting unit **210**, and a repairing unit **212**. In fact, embodiments of the disclosed subject matter are intended to include or otherwise any number of components in the unmanned or optionally manned vehicle **102** to inspect the objects **104**.

[0051] In some embodiments, the data collection unit **202** can be configured to capture images in addition to other forms of data of the object **104**. For example, the data collection unit **202** captures images of a commuter rail line from various perspectives. In some other embodiments, the data collection unit **202** can be configured to capture any form of data, videos and/or motion images of the object **104**. For example, in an embodiment, the data collection unit **202** captures a video of the commuter rail line. In some embodiments, the data collection unit **202** may include cameras to capture the images and/or videos of the object **104**. In fact, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of data collection unit **202**, including known, related art, and/or later developed technologies to capture images and/or videos of the object **104**. However, as mentioned above, the data collection unit **202** could also collect any information such as interferometry interference patents, holographic data or images, SONAR/RADAR data or images, of electrical network data (such as impedances, voltages, currents, etc.

[0052] Further, the captured data, images and/or videos can be stored in a database **214**. Embodiments are intended to include or otherwise cover any type of database, including known, related art, and/or later developed technologies to enhance capabilities of storing data, images and/or videos corresponding to the object **104** under inspection. In some other embodiments, the database **214** may store images of the object **104**.

[0053] In some embodiments, the detection unit **204** can be configured to generate stereoscopic images by using the captured images. The data collection unit **202** may use various stereoscopic photographic techniques that use the captured images to generate the stereoscopic images. These stereoscopic photographic techniques utilize binocularity of human vision. The images that are captured from slightly different angle by the unmanned or optionally manned vehicle **102** are combined to generate stereoscopic images to provide spatial depth and dimension. In some embodiments, the stereoscopic images can be three dimensional (3D) images.

[0054] In some further embodiments, one or more unmanned or optionally manned vehicles **102** (a swarm) can be used to record the angles, frequencies, and amplitudes of incoming photons to form a collective swarm “light field”. In this scenario, rather than directly imaging an objective, the general presence of light of different frequencies, amplitudes, and directions is recorded. This practice can culminate in recorded 3-dimensional light fields (one or more per unmanned or optionally manned vehicle). This information can then be collated and reconstructed later to perform selective zooming and focusing functions on any elements of the object **104** captured in the light field, and even to perform such functions as rotating a viewer perspective around an element of interest (even if the unmanned or optionally manned vehicles themselves never imaged the element from that angle). This capability is made possible because “all” of the light in the vicinity of the swarm is captured (without lensing or filtering that could obscure or exclude some light), allowing all light waves to be recorded and preferentially post-processed to identify features of interest without re-deploying the swarm for a "second look" at a feature of interest. That is, the same aggregated light field data could focus and zoom in on a feature very near to the swarm (with a second feature far from the swarm possibly blurred or obscured), while the same data set could be used to focus and zoom in on the second feature with the first feature possibly blurred or obscured. The result is two seemingly different images from different angles, magnifications, etc. derived from the same data set.

[0055] In addition, the data collection unit **202** can be configured to compare the generated data or images of the object **104** with the pre-stored data or other images of the object **104**. In some embodiments, the pre-stored information can be, but is not restricted to, images of the object **104** and its surroundings. In some embodiments, the compared information may be used to determine structural parameters of the object **104**.

[0056] In some embodiments, the detection unit **204** can be configured to detect and/or determine the structural parameters of the object **104**. The structural parameters may be, but is not restricted to, a break, a misalignment, a breach, a bend, a buckle, and so forth, of an object. For example, structural parameters of a commuter rail line can include, but is not restricted to, rail tie degradation, a rail spike degradation, changes in rail separation, a rail breach detection, and the like.

[0057] The detection unit **204** can be configured to perform an optical inspection of the object **104**. The optical inspection can be carried out parallel to the track of the rails for track surface inspection, down at the ground for tie inspection, or can be performed at different angles between the tracks of the railroads for inspection inside the tracks, tie spikes, and so forth. In some embodiments, the optical inspection may be performed to detect structural parameters such as, but is not restricted to, broken, misaligned or compromised ties of an object, for example, a commuter rail ties. In alternate embodiments, the optical inspection may be performed to detect structural parameters such as, but is not restricted to, tie wear, tie securing fixture health (for example, railroad spike oxidation, etc.), and so forth. In some embodiments, the optical inspection may be performed by using optical scanners that can be configured to determine discontinuities and/or irregularities in the object **104**, for example, individual rail ties. In fact, embodiments of the disclosed subject matter can include or otherwise cover any element to perform optical inspection of the object **104**. The optical detection techniques are used to detect bumps or dips within a certain tolerance in the tracks, ties, spikes, and so forth.

[0058] In some other embodiments, the detection unit **204** can perform an optical inspection to detect breaches in the object **104**, such as in a rail. The optical inspection can be configured to detect structural parameters, such as, but is not restricted to, cracks or voids in a metal that may be used to support or guide the object **104**, such as a commuter rail line. The detection unit **204** may use optical sensors (horizontal, vertical, or a combination thereof) to image the rail, which can be used to determine discontinuities and/or irregularities in the object **104**. In an exemplary scenario, the optical sensors emit optical signals and then based on the reflection of the optical signals, from the object **104**, structural parameters are detected. This may be accomplished by using one, two, or three dimensional optical imaging. In some embodiments, the detection unit **204** can perform an optical inspection by using ranging tones of the optical signals to detect distance of the unmanned or optionally manned vehicle **102** from the ground for terrain assessment, or tie counting, or a combination thereof. The optical signals are also used to determine tie length by using a timer that compares changes in the optical signals on a tie, for example, one second between ties, or 0.25 seconds per tie, etc.

[0059] In an exemplary scenario, the optical sensors can be calibrated to detect a certain amount of reflected light, and when the reflected light exceeds a threshold amount, an alert is generated and a structural parameter is detected. In some embodiments, the optical sensors can also be configured to work at an orientation or angle, or in collaboration with each other in order to detect the breach in the object **104**. In addition, the detection unit **204** may be configured to estimate the structural parameters of the object **104** based on the optical inspection.

[0060] The detection unit **204** can also be configured to perform impedance check of the object **104** for electrical detection of faults. In some exemplary scenario, the detection unit **204** can detect rail breach, such as electrical breach, a mechanical breach, or a combination thereof. In some embodiments, the impedance check may be performed based on a change in resistance in a balanced resistive or capacitive network such as, but is not restricted to, a Wheatstone bridge. The Wheatstone bridges can be included in the unmanned or optionally manned vehicle **102** to determine resistance between two unmanned or optionally manned vehicle wheels on a track, resistance between two different unmanned or optionally manned vehicle wheels on a track, or resistance between two points (for example, top to bottom, left to right that is parallel to the rail) on a wheel of the unmanned or optionally manned vehicle.

[0061] In some exemplary scenario, a Wheatstone bridge is connected to a rail and an unmanned or optionally manned vehicle **102** is set and/or attached to the track of the rail, thereby creating a closed loop, unmanned or optionally manned vehicle. When the unmanned or optionally manned vehicle **102** passes over the breach, a resistance in a fourth resistor of the Wheatstone bridge becomes infinite as no current flows through the breach, which enables detection of the breach in the rail. Similarly, in case, of a non-infinite but change in resistance at the fourth resistor, a contamination on the railway track is detected.

[0062] In some exemplary scenario, multiple Wheatstone bridges are positioned between each of the permutation railed vehicle's wheels and also aligned top to bottom along each wheel in order to detect electrical fault between two points that could signal a rail fault. In some embodiments, one or more balanced impedance bridges can be employed between electrical contacts of the unmanned or optionally manned vehicle **102**. In some other embodiments, a stack of Wheatstone bridges can be used to determine electrical structural parameters (for example, from top to bottom) of the object **104** with finer resolution. In alternate embodiments, the detection unit **204** can detect the structural parameters by using vertical (top to bottom) rail impedance detection techniques or by using horizontal (left to right) rail impedance detection techniques.

[0063] The detection unit **204** can also be configured to determine bending or buckling by checking distances in lengths of the object **104**. In some embodiments, the detection unit **204** can use laser interferometers to determine bending or buckling in the object **104**. In some exemplary scenario, a laser interferometer is attached to each of the rail, which may have a fixed first arm terminating inside of the unmanned or optionally manned vehicle **102** and a second arm terminating on the rail. When a length of the second arm changes, an interference pattern is detected, which can indicate bending or buckling in the object **104** such as the rail track. In some embodiments, interferometers can also be placed in a 90 degree rotated position to monitor the distance between the unmanned or optionally manned vehicle **102** and the terrain (terrain assessment, or tie counting, or both). A timer can be used to compare a change in optical signals in order to determine even tie lengths.

[0064] However, usage of two laser interferometers to detect the structural parameters is for illustration purposes and may include any suitable number of laser interferometers that may be beneficial. Additionally, non-optical interferometers such as millimeter-wave, infra-red, or any other frequency could also be employed in order to detect the structural parameters of the object **104**.

[0065] The unmanned or optionally manned vehicle **102** can then measure a vertical distance to the ground for determining voids or dips. In case, distance between the rail arm and unmanned or optionally manned vehicle **102** changes, an interference pattern is generated. The generated interference pattern is analyzed to determine the structural parameters of the rail.

[0066] In addition, the detection unit **204** is also configured to generate holographic images based on the generated interference pattern. The holographic images can be created by using optical radiation such as laser beams that interfere with each other, causing an interference pattern to be imprinted on a recording medium (not shown). The interference pattern is encoded and often (but not always) requires a light source of a particular frequency, such as laser, in order to view its content.

[0067] Further, the detection unit **204** is also configured to determine integrity of the ground below a rail. In some exemplary scenario, the ground below the rail may be structurally unsound due to weather conditions and natural events such as rain or snow, mudslides, earthquakes and the like. The ground may also have terrain anomalies, for example, voids or gaps such as developing sinkholes, faults, and the like. These terrain anomalies can be detected by using SONAR or RADAR systems deployed on the unmanned or optionally manned vehicle **102**. The sonar or radar systems can be used for short range or long range monitoring of the rails, ties, terrain integrity (underground sinkholes, for example, that could collapse under the weight of a train), debris identification, etc.

[0068] In some embodiments, after detecting the structural parameters of the object **104**, the data collection unit **202** may capture precise data, images and/or videos in order to record the structural parameters of the object **104**. In alternate embodiments, first the detection unit **204** detects a structural parameter of the object **104** and then the data collection unit **202** captures the images and/or videos to record the structural parameter.

[0069] In some other embodiments, the detection unit **204** detects the structural parameters by using more than one technique, as described above.

[0070] In some embodiments, the location unit **206** can be configured to determine location data of the detected structural parameters of the object **104**. The location data may include, but is not restricted to, latitude, longitude, and altitude. In alternate embodiments, the location data may include any other information that is required to determine the location of the detected structural parameter of the object **104**. The location unit **206** can be, but is not restricted to, a navigation device such as a Global Positioning System (GPS), or other location sensing devices. In fact, embodiments of the disclosed subject matter are intended or otherwise include any type of navigation devices to determine location of the structural parameters of the object **104** under inspection.

[0071] In some embodiments, the report generation unit **208** can be configured to generate an inspection report. The report generation unit **208** may use the compared stereoscopic images along with the determined location data of the structural parameters of the object **104** in order to generate an inspection report. In some embodiments, the report generation unit **208** of the unmanned or optionally manned vehicle **102** can generate a local inspection report. In alternate embodiments, the inspection report may also include, but is not restricted to, a type of structural parameter, a type of detection technique used to determine the structural parameter, and the like.

[0072] The transmitting unit **210** can be configured to transmit the inspection report to the analysis platform **108**. In some embodiments, the transmitting unit **210** can transmit the inspection report to the analysis platform **108** through the communication network **106**. The transmitting unit **210** can use communication methods that can include radio communications based on any frequency spectrum (e.g., Very High Frequency (VHF) or Ultra-High Frequency (UHF)) and any supporting infrastructure (e.g., satellites, cell phone towers, etc.). In fact, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of techniques, including known, related art, and/or later developed technologies to transmit the inspection report to the analysis platform **108**. In alternate embodiments, the transmitting unit **210** can transmit the inspection report to other companion unmanned or optionally manned vehicles **102**. The inspection report can be generated in any format.

[0073] The repairing unit **212** can be configured to repair the structural parameters of the object **104**. In some embodiments, the unmanned or optionally manned vehicle **102** can have repairing equipment such as, but is not restricted to, a welding machine, a hammer, a hoist, a saw, a drill machine, a wrench, or equipment such as electrical or electronic testing devices, and the like. In fact, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of repairing equipment, including known, related art, and/or later developed technologies to repair the structural parameters of the object **104**.

III. Operation of the Unmanned or Optionally Manned Vehicle

[0074] FIG. **3** is a flowchart of a procedure **300** for inspecting an object by using an unmanned or optionally manned vehicle in accordance with the disclosed subject matter. In some embodiments, the unmanned or optionally manned vehicle can be an unmanned terrestrial railed vehicle. This flowchart is merely provided for exemplary purposes, and embodiments are intended to include or otherwise cover any methods or procedures for inspecting an object by using an unmanned or optionally manned vehicle.

[0075] In accordance with the flowchart of FIG. 3, the unmanned or optionally manned vehicle 102 captures data associated with the object, such as the object 104 at step 302. In some embodiments, the data can include, but is not restricted to, data, images and/or videos, sound light, or any other form of data associated with the objects. In some other embodiments, the captured data can include, but is not restricted to, individual images, holographic or interferometric data, electrical characteristic data, individual light-field data sets, SONAR/RADAR data, millimeter-wave imaging data, terrain feature data (such as elevation), etc. In some embodiments, the unmanned or optionally manned vehicle 102 may include cameras, sensors, or any other media to capture data from the object 104.

[0076] At step 304, the unmanned or optionally manned vehicle 102 collates the data captured by the unmanned or optionally manned vehicle 102 and then generate a composite data set. In some embodiments, the data set could be a compiled stereoscopic image, but could also include holograms, terrain maps, or other sets of data. In some exemplary scenarios, the unmanned or optionally manned vehicle 102 combines the captured images and generates stereoscopic or holographic images of the object 104.

[0077] At step 306, the unmanned or optionally manned vehicle 102 compares the composite data set with pre-stored reference data of the object. In some exemplary scenarios, the data is compared with pre-stored images in order to determine structural parameters of the object 104. In some embodiments, the pre-stored data can be, but is not restricted to, images of the object 104 and its surroundings, data from any of the previously mentioned means such as microwave or SONAR/RADAR reflections, digital communication throughput, and the like. The structural parameters may be, but is not restricted to, a break, a misalignment, a breach, a bend, a buckle, and so forth of the object 104.

[0078] In some embodiments, the unmanned or optionally manned vehicle 102 can determine the structural parameters of the object by using, but is not restricted to, an optical inspection, an impedance check, interferometry, SONAR and/or RADAR systems, and the like. In fact, embodiments of the disclose subject matter are intended to include or otherwise cover any type of techniques and/or systems to determine the structural parameters of the object.

[0079] Further, at step 308, the unmanned or optionally manned vehicle 102 determines location data for the detected structural parameters of the object. As discussed, the location data may include, but is not restricted to, latitude, longitude, and altitude of a location at which the structural parameter of the object is determined. In alternate embodiments, the location data may include any other information that is required to determine the location of the detected structural parameter of the object 104. The unmanned or optionally manned vehicle 102 may include, but is not restricted to, a navigation device such as a Global Positioning System (GPS), or other like devices to determine the location data.

[0080] Next, at step 310, the unmanned or optionally manned vehicle 102 generates an inspection report. The unmanned or optionally manned vehicle 102 uses the compared dataset, i.e., stereoscopic images, along with the determined location data of the structural parameters of the object 104 in order to generate the inspection report.

[0081] Further, the inspection report may be transmitted to the analysis platform 108 that can be, but is not restricted to, a companion unmanned or optionally manned vehicle, a base station, an electronic device, for example, a desktop, a mobile device, and the like. The inspection report may be analyzed in order to take necessary actions.

[0082] FIG. 4 is a flowchart of a procedure 400 for inspecting an object by using an unmanned or optionally manned vehicle in accordance with the disclosed subject matter. This flowchart is merely provided for exemplary purposes, and embodiments are intended to include or otherwise cover any methods or procedures for inspecting an object by using an unmanned or optionally manned vehicle.

[0083] In accordance with the flowchart of FIG. 4, the unmanned or optionally manned vehicle 102 captures data from the object, such as images of the object 104 at step 402. In some embodiments, the unmanned or optionally manned vehicle 102 may include cameras to capture the data, images and/or videos of the object 104. Further, the unmanned or optionally manned vehicle 102 combines the captured data and generates, for example, stereoscopic, holographic, topological, or any other data sets (including images) of the object 104 based on the data collected by the data collection unit 202.

[0084] At step 404, the unmanned or optionally manned vehicle 102 compares the collected data sets with pre-stored data sets in order to determine structural parameters of the object. In some embodiments, the pre-stored data sets can be, but are not restricted to, images of the object 104 and its surroundings. The structural parameters may be, but is not restricted to, a break, a misalignment, a breach, a bend, a buckle, and so forth of an object.

[0085] In some embodiments, the unmanned or optionally manned vehicle 102 can determine the structural parameters of the object by using, but is not restricted to, optical inspection, impedance check, laser interferometry, SONAR and/or RADAR systems, and the like. In fact, embodiments of the disclose subject matter are intended to include or otherwise cover any type of techniques and/or systems to determine the structural parameters of the object.

[0086] Further, at step 406, the unmanned or optionally manned vehicle 102 determines whether a structural parameter of the object is detected. In case, the unmanned or optionally manned vehicle 102 determines that a structural parameter is detected, then the procedure 400 proceeds to a step 408. In case, the unmanned or optionally manned vehicle 102 determines that a structural parameter is not detected, then the procedure 400 returns to the step 402 and continues capturing and comparing the images.

[0087] Next, at the step 408, the unmanned or optionally manned vehicle 102 determines location data for the detected structural parameters of the object. As discussed, the location data may include, but is not restricted to, latitude, longitude, and altitude. In alternate embodiments, the location data may include any other information that is required to determine the location of the detected structural parameter of the object 104. The unmanned or optionally manned vehicle 102 may include, but is not restricted to, a navigation device such as a Global Positioning System (GPS), or other location sensing devices to determine the location data.

[0088] Further, at step 410, the unmanned or optionally manned vehicle 102 determines whether repairing of the structural parameter is possible with the unmanned or optionally manned vehicle 102. In case, it is determined that the repairing of the structural parameter is possible, that means the unmanned or optionally manned vehicle **102** can repair the structural parameters, then the procedure **400** proceeds to a step **412** and repairs the structural parameter of the object with the unmanned or optionally manned vehicle **102**.

[0089] In case, it is determined that the repairing of the structural parameter is not possible, that means the unmanned or optionally manned vehicle **102** cannot repair the structural parameters, then the procedure **400** proceeds to a step **414**. At the step **414**, the unmanned or optionally manned vehicle **102** generates an inspection report and transmits it to the analysis platform **108**.

IV. Exemplary Embodiments

[0090] FIG. **5**A illustrates an exemplary scenario illustrating an unmanned or optionally manned vehicle inspecting a commuter rail line in accordance with the disclosed subject matter. In FIG. **5**, the unmanned or optionally manned vehicle **102** is used to inspect the commuter rail line **502**. The unmanned or optionally manned vehicle **102** captures data from the commuter rail line **502**. In some instances, this data can be combined with previously stored data (such as images, etc.) to generate new data sets, including stereoscopic images, holographic images, terrain maps, etc. as previously discussed.

[0091] Further, the unmanned or optionally manned vehicle **102** can compare captured data with data stored in either a local or remote database, such as the database **214** in order to determine structural parameters of the commuter rail line **502**. As shown, the commuter rail line **502** has a bend **504**. The unmanned or optionally manned vehicle **102** can detect the structural parameters by using laser interferometric techniques. The unmanned or optionally manned vehicle **102** can then determine location data corresponding to the detected bend (or buckle) **504**. The location data and collected data from the commuter rail line **502** may then used to generate an inspection report.

[0092] FIG. **5**B illustrates an exemplary scenario illustrating an unmanned or optionally manned vehicle inspecting a commuter rail line in accordance with the disclosed subject matter. In FIG. **5**B, the unmanned terrestrial railed vehicle **102** is deployed on the commuter rail line **502** for to inspection purposes. The unmanned terrestrial railed vehicle **102** captures data from the commuter rail line **502** and can combine the captured data to generate secondary data sets.

[0093] Further, the unmanned terrestrial railed vehicle **102** can then compare the secondary data sets with data sets stored in a local or remote database, such as the database **214** in order to determine structural parameters of the commuter rail line **502**. In some embodiments, the secondary data sets can be in the form of stereoscopic images, holographic images, interferometry patterns, electrical parameters, topological maps, and the like. As shown, the commuter rail line **502** has broken ties **506**. The unmanned terrestrial railed vehicle **102** detects the structural parameters by using laser interferometric techniques. The unmanned terrestrial railed vehicle **102** then determines location data corresponding to the detected the broken ties **506**. The location data and the collected data (such as, for example, stereoscopic images) of the commuter rail line **502** can then be used to generate an inspection report.

[0094] However, one unmanned or optionally manned vehicle **102** shown in the exemplary embodiment is for illustration purposes only, and the various embodiments are intended to include or otherwise cover any number of unmanned or optionally manned vehicles that may be beneficial.

V. Other Exemplary Embodiments

[0095] Similarly, in another exemplary scenario, the unmanned or optionally manned vehicle **102** can capture data from the commuter rail line **502** and combine the captured data to generate secondary data sets. Further, the unmanned or optionally manned vehicle **102** can compare the secondary data set(s) with data stored in a database, such as the database **214** in order to determine structural parameters of the commuter rail line **502**. The unmanned or optionally manned vehicle **102** can then determine an extent of bending, buckling, cracking, or debris (etc.) over the commuter rail line **502**. The unmanned or optionally manned vehicle **102** may also determine location data corresponding to (for example) the detected debris **504**. The location data and the secondary data set(s) of the commuter rail line **502** can then be used to generate an inspection report. The unmanned or optionally manned vehicle **102** can also determine if the debris can be removed by the unmanned or optionally manned vehicle **102**. If so, the unmanned or optionally manned vehicle **102** may remove the debris from the commuter rail line **502** by using debris removal equipment deployed on the unmanned or optionally manned vehicle **102**. If not, the breech, location, and any collected data (images, video, etc.) can be catalogued and provided to an inspection/maintenance team for future assessment.

[0096] FIG. **6** illustrates a computer system **600** upon which an embodiment of the invention may be implemented. Although, the computer system **600** is depicted with respect to a particular device or equipment, it is contemplated that other devices or equipment (e.g., network elements, servers, etc.) within FIG. **6** can deploy the illustrated hardware and components of the system **600**. The computer system **600** is programmed (e.g., via computer program code or instructions) to inspect the objects by using one or more unmanned or optionally manned vehicles described herein and includes a communication mechanism such as a bus **602** for passing information between other internal and external components of the computer system **600**. Information (also called data) is represented as a physical expression of a measurable phenomenon, typically electric voltages, but including, in other embodiments, such phenomena as magnetic, electromagnetic, pressure, chemical, biological, molecular, atomic, sub-atomic and quantum interactions. For example, north and south magnetic fields, or a zero and non-zero electric voltage, represent two states (0, 1) of a binary digit (bit). Other phenomena can represent digits of a higher base. A superposition of multiple simultaneous quantum states before measurement represents a quantum bit (qubit). A sequence of one or more digits constitutes digital data that is used to represent a number or code for a character. In some embodiments, information called analog data is represented by a near continuum of measurable values within a particular range. The computer system **600**, or a portion thereof, constitutes a means for performing one or more steps for inspecting the objects by using one or more unmanned or optionally manned vehicles.

[0097] A bus **602** includes one or more parallel conductors of information so that information is transferred quickly among devices coupled to the bus **602**. One or more processors **604** for processing information are coupled with the bus **602**.

[0098] The processor (or multiple processors) **604** performs a set of operations on information as specified by computer program code related to inspect the objects by using one or more unmanned or optionally manned vehicles. The computer program code is a set of instructions or statements providing instructions for the operation of the processor **604** and/or the computer system **600** to perform specified functions. The code, for example, may be written in a computer programming language that is compiled into a native instruction set of the processor **604**. The code may also be written directly using the native instruction set (e.g., machine language). The set of operations include bringing information in from the bus **602** and placing information on the bus **602**. The set of operations also typically include comparing two or more units of information, shifting positions of units of information, and combining two or more units of information, such as by addition or multiplication or logical operations like OR, exclusive OR (XOR), and AND. Each operation of the set of operations that can be performed by the processor is represented to the processor by information called instructions, such as an operation code of one or more digits. A sequence of operations to be executed by the processor **604**, such as a sequence of operation codes, constitute processor instructions, also called computer system instructions or, simply, computer instructions. The processors **604** may be implemented as mechanical, electrical, magnetic, optical, chemical, or quantum components, among others, alone or in combination.

[0099] The computer system **600** also includes a memory **606** coupled to the bus **602**. The memory **606**, such as a Random Access Memory (RAM) or any other dynamic storage device, stores information including processor instructions for storing information and instructions to be executed by the processor **604**. The dynamic memory **606** allows information stored therein to be changed by the computer system **600**. RAM allows a unit of information stored at a location called a memory address to be stored and retrieved independently of information at neighboring addresses. The memory **606** is also used by the processor **604** to store temporary values during execution of processor instructions. The computer system **600** also includes a Read Only Memory (ROM) or any other static storage device coupled to the bus **602** for storing static information, including instructions, that is not changed by the computer system **600**. Some memory is composed of volatile storage that loses the information stored thereon when power is lost. Also coupled to the bus **602** is a non-volatile (persistent) storage device **608**, such as a magnetic disk, a solid state disk, optical disk or flash card, for storing information, including instructions, that persists even when the computer system **600** is turned off or otherwise loses power.

[0100] Information, including instructions for inspecting the objects by using one or more unmanned or optionally manned vehicles is provided to the bus **602** for use by the processor **604** from an external input device **610**, such as a keyboard containing alphanumeric keys operated by a human user, a microphone, an Infrared (IR) remote control, a joystick, a game pad, a stylus pen, a touch screen, or a sensor. The sensor detects conditions in its vicinity and transforms those detections into physical expression compatible with the measurable phenomenon used to represent information in the computer system **600**. Other external devices coupled to the bus **602**, used primarily for interacting with humans, include a display **612**, such as a Cathode Ray Tube (CRT), a Liquid Crystal Display (LCD), a Light Emitting Diode (LED) display, an organic LED (OLED) display, active matrix display, Electrophoretic Display (EPD), a plasma screen, or a printer for presenting text or images, and a pointing device **616**, such as a mouse, a trackball, cursor direction keys, or a motion sensor, for controlling a position of a small cursor image presented on the display **612** and issuing commands associated with graphical elements presented on the display **612**, and one or more camera sensors **614** for capturing, recording and causing to store one or more still and/or moving images (e.g., videos, movies, etc.) which also may comprise audio recordings. Further, the display **612** may be a touch enabled display such as capacitive or resistive screen. In some embodiments, for example, in embodiments in which the computer system **600** performs all functions automatically without human input, one or more of the external input device **610**, and the display device **612** may be omitted.

[0101] In the illustrated embodiment, special purpose hardware, such as an ASIC **616**, is coupled to the bus **602**. The special purpose hardware is configured to perform operations not performed by the processor **604** quickly enough for special purposes. Examples of ASICs include graphics accelerator cards for generating images for the display **612**, cryptographic boards for encrypting and decrypting messages sent over a network, speech recognition, and interfaces to special external devices, such as robotic arms and medical scanning equipment that repeatedly perform some complex sequence of operations that are more efficiently implemented in hardware.

[0102] The computer system **600** also includes one or more instances of a communication interface **618** coupled to the bus **602**. The communication interface **618** provides a one-way or two-way communication coupling to a variety of external devices that operate with their own processors, such as printers, scanners and external disks. In general, the coupling is with a network link **620** that is connected to a local network **622** to which a variety of external devices with their own processors are connected. For example, the communication interface **618** may be a parallel port or a serial port or a Universal Serial Bus (USB) port on a personal computer. In some embodiments, the communication interface **618** is an Integrated Services Digital Network (ISDN) card, a Digital Subscriber Line (DSL) card, or a telephone modem that provides an information communication connection to a corresponding type of a telephone line. In some embodiments, the communication interface **618** is a cable modem that converts signals on the bus **602** into signals for a communication connection over a coaxial cable or into optical signals for a communication connection over a fiber optic cable. As another example, the communications interface **618** may be a Local Area Network (LAN) card to provide a data communication connection to a compatible LAN, such as Ethernet or an Asynchronous Transfer Mode (ATM) network. In one embodiment, wireless links may also be implemented. For wireless links, the communication interface **618** sends or receives or both sends and receives electrical, acoustic or electromagnetic signals, including infrared and optical signals that carry information streams, such as digital data. For example, in wireless handheld devices, such as mobile telephones like cell phones, the communication interface **618** includes a radio band electromagnetic transmitter and receiver called a radio transceiver. In certain embodiments, the communication interface **618** enables connection to the communication network **106** for inspecting the objects by using one or more unmanned or optionally manned vehicles. Further, the communication interface **618** can include peripheral interface devices, such as a thunderbolt interface, a Personal Computer Memory Card International Association (PCMCIA) interface, etc. Although a single communication interface **618** is depicted, multiple communication interfaces can also be employed.

[0103] The term "computer-readable medium" as used herein refers to any medium that participates in providing information to the processor **604**, including instructions for execution. Such a medium may take many forms, including, but not limited to, computer-readable storage medium (e.g., non-volatile media, volatile media), and transmission media. Non-transitory media, such as non-volatile media, include, for example, optical or magnetic disks, such as the storage device **608**. Volatile media include, for example, the dynamic memory **606**. Transmission media include, for example, twisted pair cables, coaxial cables, copper wire, fiber optic cables, and carrier waves that travel through space without wires or cables, such as acoustic waves, optical or electromagnetic waves, including radio, optical and infrared waves. Signals include man-made transient variations in amplitude, frequency, phase, polarization or other physical properties transmitted through the transmission media. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a USB flash drive, a Blu-ray disk, a CD-ROM, CDRW, DVD, any other optical medium, punch cards, paper tape, optical mark sheets, any other physical medium with patterns of holes or other optically recognizable indicia, a RAM, a PROM, an EPROM, a FLASH-EPROM, an EEPROM, a flash memory, any other memory chip or cartridge, a carrier wave, or any other medium from which a computer can read. The term computer-readable storage medium is used herein to refer to any computer-readable medium except transmission media.

[0104] Logic encoded in one or more tangible media includes one or both of processor instructions on a computer-readable storage media and special purpose hardware, such as ASIC **616**.

[0105] The network link **620** typically provides information communication using transmission media through one or more networks to other devices that use or process the information. For example, the network link **620** may provide a connection through the local network **622** to a host computer **624** or to ISP equipment operated by an Internet Service Provider (ISP).

[0106] A computer called a server host **626**, connected to the Internet, hosts a process that provides a service in response to information received over the Internet. For example, the server host **626** hosts a process that provides information representing video data for presentation at the display **612**. It is contemplated that the components of the computer system **600** can be deployed in various configurations within other computer systems, e.g., the host **624** and the server **626**.

[0107] At least some embodiments of the invention are related to the use of the computer system **600** for implementing some or all of the techniques described herein. According to one embodiment of the invention, those techniques are performed by the computer system **600** in response to the processor **604** executing one or more sequences of one or more processor instructions contained in the memory **606**. Such instructions, also called computer instructions, software and program code, may be read into the memory **606** from another computer-readable medium such as the storage device **608** or the network link **620**. Execution of the sequences of instructions contained in the memory **606** causes the processor **604** to perform one or more of the method steps described herein. In alternative embodiments, hardware, such as the ASIC **616**, may be used in place of or in combination with software to implement the invention. Thus, embodiments of the invention are not limited to any specific combination of hardware and software, unless otherwise explicitly stated herein.

[0108] Various forms of computer readable media may be involved in carrying one or more sequence of instructions or data or both to the processor **604** for execution. For example, instructions and data may initially be carried on a magnetic disk of a remote computer such as the host **624**. The remote computer loads the instructions and data into its dynamic memory and sends the instructions and data over a telephone line using a modem. A modem local to the computer system **600** receives the instructions and data on a telephone line and uses an infra-red transmitter to convert the instructions and data to a signal on an infra-red carrier wave serving as the network link **620**. An infrared detector serving as the communication interface **618** receives the instructions and data carried in the infrared signal and places information representing the instructions and data onto the bus **602**. The bus **602** carries the information to the memory **606** from which the processor **604** retrieves and executes the instructions using some of the data sent with the instructions. The instructions and data received in the memory **606** may optionally be stored on the storage device **608**, either before or after execution by the processor **604**.

VI. Alternative Embodiments

[0109] While certain embodiments of the invention are described above, and FIGS. **1-6** disclose the best mode for practicing the various inventive aspects, it should be understood that the invention can be embodied and configured in many different ways without departing from the spirit and scope of the invention.

[0110] For example, embodiments are disclosed above in the context of an unmanned or optionally manned vehicle. However, embodiments are intended to include or otherwise cover any type of unmanned or optionally manned vehicle, including, an unmanned aerial vehicle, an unmanned terrestrial vehicle, a drone, a gyrocopter, etc. In fact, embodiments are intended to include or otherwise cover configurations of the unmanned or optionally manned vehicle.

[0111] Embodiments are disclosed above in the context of inspecting commuter rail lines. However, embodiments are intended to cover any object such as, but is not restricted to, water towers, pylons, bridges, airports including both tarmac/runway and control tower inspections), power lines, fuel bunkers, power plants, incarceration facilities, damns, water plants, Amplitude Modulation (AM)/Frequency Modulation (FM) towers, and so forth.

[0112] Exemplary embodiments are intended to include or otherwise cover any type of structural parameters of the objects disclosed above.

[0113] Exemplary embodiments are intended to include or otherwise cover light field imaging for detecting structural parameters of the object.

[0114] Exemplary embodiments are also intended to cover any additional or alternative components of the unmanned or optionally manned vehicle disclosed above. Exemplary embodiments are further intended to cover omission of any component of the unmanned or optionally manned vehicle disclosed above.

[0115] Embodiments are disclosed above in the context of inspecting commuter rail lines. However, embodiments are intended to cover any unmanned non-rail guided terrestrial vehicles, single rail guided unmanned or optionally manned vehicles, multi-rail guided unmanned or optionally manned vehicles, and so forth.

[0116] Embodiments are also intended to include or otherwise use unmanned aerial vehicles for inspection of roads, sidewalks, pathways, and so forth.

[0117] Embodiments are also intended to include or otherwise use unmanned oceanic vehicles for inspecting bridges, piers, and so forth.

[0118] Embodiments are also intended to include or otherwise cover the inspection of objects for parcel delivery by using the stereoscopic images. The reason can be beneficial because 3D depth perception increases with the separation of the collaborating unmanned or optionally manned vehicle. By employing two or more unmanned or optionally manned vehicles, a fleet of unmanned or optionally manned vehicles can increase the precision of a target location for parcel delivery.

[0119] Embodiments are also intended to include or otherwise use stereoscopic images for accurately estimating payload delivery targets, for example, parcels, weapons, and the like.

[0120] Embodiments are also intended to include or otherwise use stereoscopic images for accurately locating assets, for example, missing persons, errant vehicles, and the like.

[0121] Embodiments are also intended to include or otherwise use stereoscopic images for ascertaining structural assets or defects (such as breaches, leaks, etc.) and for surveying entities such as cell towers, wind turbines, water towers, pylons, bridges, airports (both tarmac/runway and control tower inspections), power lines, fuel bunkers, power plants, incarceration facilities, damns, water plants, AM/FM towers, etc.

[0122] Exemplary embodiments are also intended to include and/or otherwise use unmanned or optionally manned vehicle swarms to selectively transmit and/or receive optical signals in order to capture extremely precise holographic images.

[0123] Exemplary embodiments are also intended to include and/or otherwise a v-formation of the unmanned or optionally manned vehicle swarm or a fleet of unmanned or optionally manned vehicles, which can cause each of the unmanned or optionally manned vehicles to be well separated. The separation of the unmanned or optionally manned vehicles can allow each of the unmanned or optionally manned vehicles to individually receive and mutually combine images of the objects. However, embodiments of the disclosed subject matter are intended to include or otherwise cover any type of formation that may be beneficial.

[0124] Embodiments are also intended to include or otherwise cover methods of manufacturing the unmanned or optionally manned vehicle disclosed above. The methods of manufacturing include or otherwise cover processors and computer programs implemented by processors used to design various elements of the unmanned or optionally manned vehicle disclosed above.

[0125] Exemplary embodiments are intended to cover all software or computer programs capable of enabling processors to implement the above operations, designs and determinations. Exemplary embodiments are also intended to cover any and all currently known, related art or later developed non-transitory recording or storage mediums (such as a CD-ROM, DVD-ROM, hard drive, RAM, ROM, floppy disc, magnetic tape cassette, etc.) that record or store such software or computer programs. Exemplary embodiments are further intended to cover such software, computer programs, systems and/or processes provided through any other currently known, related art, or later developed medium (such as transitory mediums, carrier waves, etc.), usable for implementing the exemplary operations of the unmanned or optionally manned vehicles disclosed above.

[0126] While the subject matter has been described in detail with reference to exemplary embodiments thereof, it will be apparent to one skilled in the art that various changes can be made, and equivalents employed, without departing from the scope of the invention. All related art references discussed in the above Background section are hereby incorporated by reference in their entirety.

1. A method for inspecting a static object by using at least one unmanned or optionally manned vehicle, the method comprising:

capturing, by the at least one unmanned or optionally manned vehicle, one or more images of the static object, wherein the one or more images are combined to generate one or more stereoscopic images;

comparing the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters of the static object, each of the one or more structural parameters being a structural change to the static object itself; and

determining location data of a location of the structural change at which the one or more structural parameters is detected, wherein the location data is used to generate an inspection report of the static object based on the one or more structural parameters detected in the comparison of the one or more stereoscopic images indicating the location of the structural change at which the one or more structural parameters is detected.

2. The method of claim **1**, wherein the one or more images are captured by activating at least one camera disposed on the at least one unmanned or optionally manned vehicle.

3. The method of claim **1**, wherein the one or more structural parameters comprise at least one of a break, a misalignment, a breach, a bend, and a buckle of the static object.

4. The method of claim **1**, further comprising:

performing, by the at least one unmanned or optionally manned vehicle, optical inspection of the static object; and

estimating the one or more structural parameters based on the optical inspection.

5. (canceled)

6. The method of claim 1, further comprising:

performing, by the at least one unmanned or optionally manned vehicle, impedance check of the static object; and

estimating the one or more structural parameters based on the impedance check on the static object.

7. The method of claim 1, further comprising:

performing, by the at least one unmanned or optionally manned vehicle, interferometric inspection on the static object; and

estimating the one or more structural parameters based on the interferometric inspection.

8. The method of claim 7, wherein the one or more stereoscopic images are generated based on the interferometric inspection.

9. The method of claim 1, further comprising:

performing, by the at least one unmanned or optionally manned vehicle, an inspection of the static object and surrounding of the static object by using at least one of a sonar system and a radar system; and

estimating the one or more structural parameters based on the inspection performed on the static object.

10. The method of claim 1, wherein the inspection of the static object is conducted in at least one of a fully unmanned mode, a semi-unmanned mode, or a manual mode.

11. The method of claim 1, further comprising:

transmitting the inspection report to an analysis platform.

12. The method of claim 1, further comprising:

repairing the one or more detected structural parameters using the at least one unmanned or optionally manned vehicle.

13. An unmanned or optionally manned vehicle for inspecting a static object, the unmanned or optionally manned vehicle comprising:

a data collection unit that is configured to:

capture, by the at least one unmanned or optionally manned vehicle, one or more images of the static object, wherein the one or more images are combined to generate one or more stereoscopic images; and

compare the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters of the static object, each of the one or more structural parameters being a structural change to the static object itself;

a location unit that is configured to determine location data of a location of the structural change at which the one or more structural parameters is detected; and

a report generation unit that is configured to generate an inspection report of the static object based on the one or more structural parameters detected in the comparison of the one or more stereoscopic images and the location data indicating the location of the structural change at which the one or more structural parameters is detected.

14. The unmanned or optionally manned vehicle of claim 13, wherein the one or more images are captured by activating at least one camera disposed on the at least one unmanned or optionally manned vehicle.

15. The unmanned or optionally manned vehicle of claim 13, further comprising a detection unit that is configured to:

perform, by the at least one unmanned or optionally manned vehicle, optical inspection on the static object; and

estimate one or more structural parameters based on the optical inspection performed on the static object.

16. The unmanned or optionally manned vehicle of claim 15, wherein the detection unit that is further configured to:

perform, by the at least one unmanned or optionally manned vehicle, inspection on the static object by using at least one of a sonar system, and a radar system; and

estimate one or more structural parameters based on the inspection performed on the static object.

17. The unmanned or optionally manned vehicle of claim 13, further comprising a transmitting unit that is configured to:

transmit the inspection report to an analysis platform.

18. The unmanned or optionally manned vehicle of claim 13, further comprising a repairing unit that is configured to:

repair the one or more detected structural parameters using the at least one unmanned or optionally manned vehicle.

19. A system for inspecting a static object, the system comprising:

a plurality of unmanned or optionally manned vehicles, wherein each of the plurality of unmanned or optionally manned vehicles includes:

a data collection unit that is configured to:

capture, by at least one of the unmanned or optionally manned vehicles, one or more images of the static object, wherein the one or more images are combined to generate one or more stereoscopic images; and

compare the one or more stereoscopic images with one or more pre-stored images for detecting one or more structural parameters, each of the one or more structural parameters being a structural change to the static object itself;

a location unit that is configured to determine location data of a location of the structural change at which the one or more structural parameters is detected;

a report generation unit that is configured to generate a local inspection report of the static object based on the one or more structural parameters detected in the comparison of the one or more images and the location data indicating the location of the structural change at which the one or more structural parameters is detected; and

a communication unit that is in communication with each of the other plurality of unmanned or optionally manned vehicles for receiving a corresponding local inspection report and generating a global inspection report based on the received local inspection report.

20. The system of claim 19, wherein at least one of the plurality of unmanned or optionally manned vehicles includes a repairing unit that is configured to:

repair the one or more detected structural parameters, wherein the at least one unmanned or optionally manned vehicle comprises a repairing tool.

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