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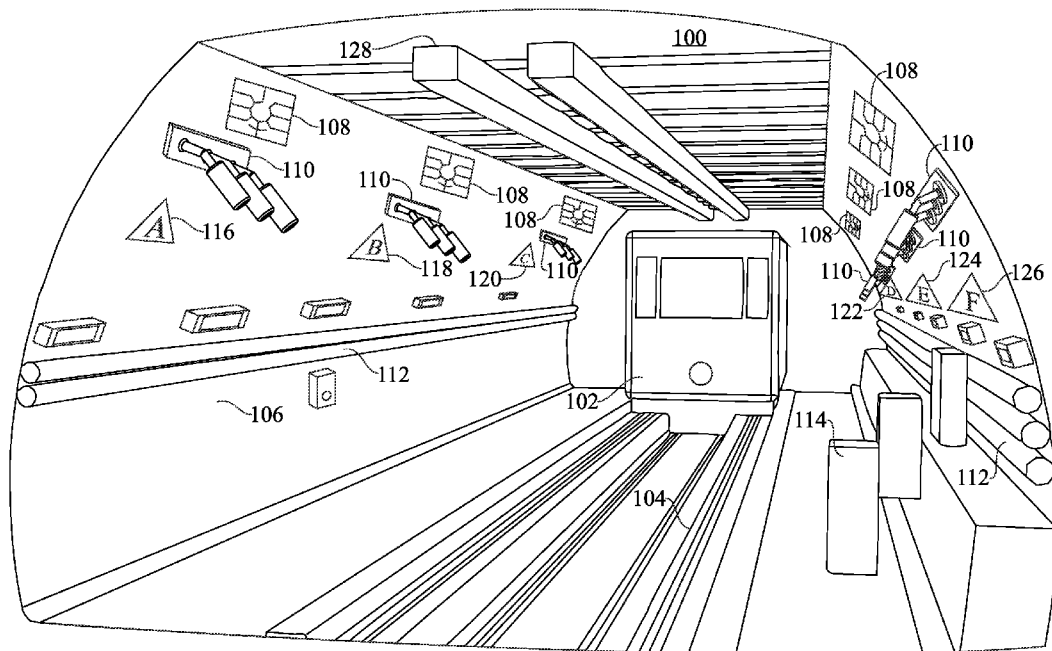


FIG. 1

(57) Abstract: A system and method for performing safety inspections of and/or emergency response activities within a particular site. Proximity data loaders are installed at and associated with a particular section within a site and store a three-dimensional (3D) point cloud, data set specific to the associated particular section. 3D image capture devices are installed at a different location within the site for capturing real-time 3D images. An augmented reality (AR) device worn by a user is configured for receiving the 3D point cloud data set from the proximity data loader as a user traverses the site and a real-time AR view of the site is displayed. The real-time AR view is a combination of at least one 3D image generated using the 3D point cloud data set and at least one real-time 3D image of the site from at least one of the 3D image capture devices.



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AUGMENTED REALITY SAFETY INSPECTION PLATFORM

Cross-Reference to Related Applications

[0001] This PCT application claims the benefit of U.S. Provisional Patent Application Serial No. 63/440,127, filed January 20, 2023, which is hereby incorporated by reference herein in its entirety.

Field of the Invention

[0002] The present invention relates generally to the field of safety inspections systems, and more particularly, to a system and method that facilitates using virtual reality environments with respect to performing safety inspections of a particular site.

Background of the Invention

[0002] Emergency preparedness with respect to buildings, site locations and other infrastructure involves various technical, operational and organizational measures that prevent a dangerous situation that has occurred from developing into an accidental event, or which prevent or reduce the harmful effects of accidental events that have occurred and may be ongoing. For example, tunnels are integral to the system of public roads and railways, vital to the economy, and critical to improve mobility for the general population. Governments and communities often bear significant social, economic, and environmental costs because of loss of service and rerouted traffic in the event of a tunnel emergency. As such, lengthy detours from tunnel closures can cause significant social, economic, and environmental hardships on nearby communities because of traffic detours, rerouting of hazardous cargo through neighborhoods, and ensuing gridlock, noise and pollution. Tunnels remain in service for extended periods of time, sometime beyond their intended service life. Tunnels that are not adequately maintained usually need more costly and extensive repairs. Structural, civil, and functional systems deteriorate at accelerated levels because of the harsh tunnel environment. Many tunnels have complicated functional systems such as lighting, ventilation, drainage, fire detection and alarms, fire suppression, communication and traffic control and these systems must be kept in good working order to minimize death and injury during an emergency such as a vehicle collision, derailment, fire, flood, earthquake, or criminal act.

[0003] For example, efficient emergency response is key to preventing major losses in tunnel fires. Conformance to prescriptive regulations dominates existing practice in the area of emergency preparedness. A successful emergency response to tunnel fires and other infrastructure emergencies is dependent on many parties collaborating under serious time constraints and harsh and unsafe conditions. Safety becomes a matter of controlling critical processes necessary to keep the system in a safe state and prevent the loss of life. Efficient decision-making in situations of major uncertainty is vital, to achieve safety goals. As such, efficient emergency preparedness for any type of infrastructure is a matter that needs attention in the early design phases and continuous improvements during the operational phase. Enhancing the ability to perform safety inspections and emergency responses for different physical sites is an area for further deployment of various technologies and associated devices.

[0004] Accordingly, there is need for a system and method for that facilitates using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure.

Summary of the Invention

[0005] The present invention is directed to providing a system and method that facilitates using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure.

[0006] In a first implementation of the invention, an augmented reality safety inspection platform is provided that facilitates using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure. The system comprising: a plurality of proximity data loaders, each proximity data loader of the plurality of proximity data loaders installed at and associated with a particular section within a site and storing a three-dimensional (3D) point cloud data set specific to the particular section associated therewith; a plurality of 3D image capture devices, each 3D image capture device installed at a different location within the site for capturing real-time 3D images of the site; an augmented reality (AR) device configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site while wearing the augmented reality device and displaying a real-time AR view of the site; and wherein the real-time AR view comprises a combination of at least one 3D image generated using

the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices.

[0007] In a second aspect, a method is provided that facilitates using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure. The method comprising: (i) collecting a plurality of point cloud data sets specific to a site, each point cloud data set associated with a particular section of the facility or site; (ii) storing each point cloud data set collected in a proximity data loader located proximate to the particular section of the facility or site associated therewith; (iii) receiving the point cloud data set stored from the proximity data loader located proximate to the particular section of the facility or site; (iv) generating at least one 3D image using the point cloud data set received; and (v) rendering a real-time view on an AR device of the facility or site comprising a combination of at least the real-time image with the at least one 3D image generated associated with the particular section of the facility or site.

[0008] In a third aspect, a user device is provided and configured for using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure. The user device comprising at least a processor, a display and a memory storing instructions that when executed cause the processor to perform operations comprising (i) collecting a plurality of point cloud data sets specific to a site, each point cloud data set associated with a particular section of the facility or site; (ii) storing each point cloud data set collected in a proximity data loader located proximate to the particular section of the facility or site associated therewith; (iii) receiving at least one real-time video image associated with at least a particular section of the facility or site; (iv) receiving the point cloud data set stored from the proximity data loader located proximate to the particular section of the facility or site; (v) generating at least one 3D image using the point cloud data set received; and (vi) rendering a real-time view on an AR device of the facility or site comprising a combination of at least the real-time image with the at least one 3D image generated associated with the particular section of the facility or site.

[0009] In a fourth aspect, an augmented reality safety inspection application (alternatively referred to herein as an “app”) may be executed on the augmented reality safety inspection platform and/or the user device for executing operations that provide for using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure. The operations comprising (i) collecting a plurality of point

cloud data sets specific to a site, each point cloud data set associated with a particular section of the facility or site; (ii) storing each point cloud data set collected in a proximity data loader located proximate to the particular section of the facility or site associated therewith; (iii) receiving at least one real-time video image associated with at least a particular section of the facility or site; (iv) receiving the point cloud data set stored from the proximity data loader located proximate to the particular section of the facility or site; (v) generating at least one 3D image using the point cloud data set received; and (vi) rendering a real-time view on an AR device of the facility or site comprising a combination of at least the real-time image with the at least one 3D image generated associated with the particular section of the facility or site.

[0010] In another aspect, at least one of the 3D image capture devices is a 3D holographic projection camera.

[0011] In another aspect, at least one of the 3D image capture devices is configured with a 3D motion detector and video recorder.

[0012] In another aspect, the augmented reality safety inspection platform further comprises at least one terrestrial scanner configured to scan the site for creating the three-dimensional (3D) point cloud data set specific to the particular section associated therewith.

[0013] In another aspect, the site is a tunnel.

[0014] In another aspect, the site is a building.

[0015] In another aspect, the user is a first responder responding to a real-time emergency at a site.

[0016] In another aspect, a first responder responding to the real-time emergency at a site remains external to the site while wearing the AR device.

[0017] In another aspect, the real-time AR view displays a plurality of levels of a site.

[0018] In another aspect, the user may suppress one or more levels of the plurality of levels from being displayed.

[0019] In another aspect, the user may make one or more features shown in the real-time AR view transparent.

[0020] In another aspect, the augmented reality safety inspection platform further comprises a mobile command center communicatively coupled with the user through the AR device worn thereby.

[0021] In another aspect, the mobile command center collects georeferenced data for identifying and locating any threat within a site.

[0022] In another aspect, the user remotely activates one or more safety systems within a site using the real-time AR view of the site displayed as the user traverses the site.

[0023] The methods and systems described herein can be implemented by data processing systems, such as one or more smartphones, tablet computers, desktop computers, laptop computers, smart watches, wearable, audio accessories, on-board computer, and other data processing systems and other consumer electronic devices. The methods and systems described herein can also be implemented by one or more data processing systems which execute executable computer program instructions, stored in one or more non-transitory machine-readable media that cause the one or more data processing systems to perform the one or more methods described herein when the program instructions are executed. Thus, the embodiments described herein can include methods, data processing systems, and non-transitory machine-readable media.

[0024] The above summary does not include an exhaustive list of all embodiments in this disclosure. All systems and methods can be practiced from all suitable combinations of the various aspects and embodiments summarized above, and also those disclosed in the detailed description below.

[0025] These and other objects, features, and advantages of the present invention will become more readily apparent from the attached drawings and the detailed description of the preferred embodiments, which follow.

Brief Description of the Drawings

[0026] The preferred embodiments of the invention will hereinafter be described in conjunction with the appended drawings provided to illustrate and not to limit the invention, where like designations denote like elements, and in which:

[0027] FIG. 1 presents an exemplary site configured with an augmented reality safety inspection system in accordance with an embodiment;

[0028] FIG. 2 an illustrative AR device configured in accordance with an embodiment;

[0029] FIG. 3 presents an illustrative user AR device view created in accordance with an embodiment;

[0030] FIG. 4 presents a high-level block diagram of a cloud network services architecture for providing augmented reality safety inspections in accordance with an embodiment;

[0031] FIG. 5 presents an illustrative block diagram for conducting augmented reality safety inspections and how the user's AR device engages and views the user augmented reality views created in accordance with an embodiment;

[0032] FIG. 6 presents illustrative an augmented reality safety inspection platform in accordance with an embodiment;

[0033] FIG. 7 presents an illustrative user device configured in accordance with an embodiment;

[0034] FIG. 8 a flowchart of illustrative operations for using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure in accordance with an embodiment; and

[0035] FIG. 9 presents an illustrative architecture for an augmented reality safety inspection app in accordance with an embodiment.

[0036] Like reference numerals refer to like parts throughout the several views of the drawings.

Detailed Description

[0037] The following detailed description is merely exemplary in nature and is not intended to limit the described embodiments or the application and uses of the described embodiments. As used herein, the word "exemplary" or "illustrative" means "serving as an example, instance, or illustration." Any implementation described herein as "exemplary" or "illustrative" is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to make or use the embodiments of the disclosure and are not intended to limit the scope of the disclosure, which is defined by the claims. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background,

brief summary or the following detailed description. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0038] As shown throughout the figures, the present invention is directed toward a system and method that facilitates using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site or other infrastructure. More particularly, the system comprises a plurality of proximity data loaders and each proximity data loader of the plurality of proximity data loaders installed at and associated with a particular section within a site and stores a 3D point cloud data set specific to the particular section associated therewith. Further, a plurality of 3D image capture devices is employed with each 3D image capture device installed at a different location within the site for capturing real-time 3D images of the site. An AR device worn by a user is configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site (or is proximate thereto) while wearing the augmented reality device and displaying a real-time AR view of the site. In accordance with the principles of the disclosed embodiments, the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices. Importantly, the augmented reality safety inspection system and method of the disclosed embodiments provides an advantageous improvement of practical applications such as safety inspection systems, emergency first responder systems, location-based systems and platforms, extended reality platforms, extended reality devices, and extending reality applications.

[0039] To provide further context for the subject disclosure, a high-level discussion of virtual reality, augmented reality, mixed reality, and extended reality will now be discussed. Virtual reality (VR) or augmented reality (AR) environments have existed for a number of years. VR or AR may refer to simulated environments featuring computer graphics that a user can interact with in a way that is more immersive than merely watching a television or computer screen. Past VR environments have included large pod-like or cockpit-like stations, where a user would sit down inside the station and be able to interact with a panoramic graphical interface that represented some 3-dimensional world. The user would typically utilize some external set of controllers, such as a

joystick or interactive glove, in order to move around in the VR environment. Other implementations of VR have included VR goggles, which are head-mounted devices that a user only needs to wear over their eyes. The user can then see the equivalent of a panoramic view that they could have seen in the immersive, pod-like stations, but the goggles enable the user to be more mobile and does not require such a large hardware implementation. The user may manipulate the environment seen through the goggles by using some external device, like a joystick or some other controller. AR implementations attempt to blend computer graphics and other images with a user's actual surroundings, such that the user may perceive that their surroundings have been augmented. To achieve this, AR smart eyeglasses that the user may wear typically provide transparent or substantially transparent lenses, so that the user can still see their actual surroundings while viewing other objects at the same time. Companies such as Google, Microsoft, Qualcomm, Epson, Nreal, Rokid, and Lenovo market a variety of AR hardware devices. Other companies such as Apple and Meta have also announced work in the area of AR hardware devices. Modern day smartphones may also include AR capability via their camera systems, allowing the user to point the device at their surroundings and then data overlays occur via their smartphone screen, offering AR capabilities similar to the AR smart eyeglasses.

[0040] Augmented reality technology involves modifying a view of a real-world environment (also referred to as a "scene") to enhance the viewer's perception. This can be done, for example, by presenting various AR elements to a user such that the AR elements are incorporated into the user's experience of a scene. By incorporating these AR elements, the user's experience of the scene may thereby become enhanced. Examples of these AR elements include computer-generated data, text, images, sounds, haptics, or the like. AR technology may take the form of electronic devices, including wearable devices (e.g., smart eyeglasses), mobile devices (e.g., smartphones), tablets, or laptop computers. These AR devices may perform a variety of AR functions. For example, a pair of smart eyeglasses may include a transparent display capable of presenting various visual AR elements. When a user wears the smart eyeglasses, the display may be positioned in between the user's eyes and the scene that the user is viewing. In this way, the AR elements presented on the display of the smart eyeglasses may be overlaid on top of and/or incorporated into the user's view of the scene. AR can use "markers" or data-based triggers, for instance geolocation, to know where to include AR elements in the user's display. By providing these AR functionalities, AR devices may facilitate social interactions. For example, an AR device may display biographical information about various people that a user might encounter. An AR device may use markers/geolocation or scan a person's face, determine identification information related to the person, and thereafter

display some data about that person, such as his name, profession, age, interests, and/or contact information.

[0041] In mixed reality (MR), digital and real-world objects are co-existing and may interact with each other in real-time. This immersive technology (sometimes also referred to as hybrid reality) requires an MR headset and typically more processing power than VR or AR applications. Mixed reality does not exclusively take place in either the physical world or virtual world but is a hybrid of AR and VR. To further highlight the difference, AR takes place in the physical world, with information or objects added virtually like an overlay and VR immerses the user in a fully virtual world without the intervention of the physical world. Mixed reality is a blend of physical and digital worlds, unlocking natural and intuitive three-dimensional (3D) human, computer, and environmental interactions. This new reality is based on advancements in computer vision, graphical processing, display technologies, input systems, and cloud computing. As such, AR and VR capabilities are blended, bringing together the physical and digital world to produce an environment where physical and digital objects co-exist and interact in real-time. There are many practical applications of mixed reality, including design, entertainment, military training, and remote working. There are also different display technologies used to facilitate the interaction between users and mixed reality applications.

[0042] Extended reality (XR) is a term referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables and includes representative forms such as AR, VR, and MR, and the areas interpolated among them. The levels of virtuality range from partially sensory inputs to immersive virtuality such that XR is a superset which includes the entire spectrum from the "complete real" to the "complete virtual" in conceptual terms. Still, its connotation lies in the extension of human experiences, especially relating to the senses of existence (represented by VR) and the acquisition of cognition (represented by AR).

[0043] As used herein, the term "extended reality (XR)" is an umbrella term for all immersive technologies including, but not limited to, augmented reality (AR), virtual reality (VR), and mixed reality (MR). XR refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables and includes representative forms such as AR, VR, and MR, and the areas interpolated among them. The levels of virtuality range from partially sensory inputs to immersive virtuality such that XR is a superset which includes the entire spectrum from "the complete real" to "the complete virtual" in conceptual terms. XR's connotation lies in the extension of human experiences especially relating to the senses of existence

(represented by VR) and the acquisition of cognition (represented by AR). To that end, as used herein: (i) augmented reality (AR): in an augmented reality, virtual information and objects are overlaid over the real world such that the experience enhances the real world with digital details (e.g., images, text, and animation). An individual may access this user experience through AR glasses or via screens, tablets, or smartphones, for example. In this way, users are not isolated from the real world and may still interact and see what is going on in front of them; (ii) virtual reality (VR): in contrast to AR, a VR experience fully immerses the individual in a simulated digital environment. An individual uses a VR headset or head-mounted display to engage with a 360-degree view of an artificial world that manipulates their brain into believing they are performing or engaging in a particular activity (e.g., walking on the moon, stepping into a castle or whatever environment is created by the VR developers); and (iii) mixed reality (MR): in mixed reality, digital and real world objects co-exist and may interact with one another in real-time. A user employs a MR headset to engage the MR environment that, for example, may place digital objects in a room where the user is standing and give that user the ability to control (e.g., spin) the objects and/or interact with the digital objects in almost any way possible. While the disclosed embodiments herein focus on an AR environment and application it will be understood that the principles described herein are equally applicable to XR, VR, and MR, and the areas interpolated among them.

[0044] To further illustrate and detail the aforementioned operational aspects of the disclosed embodiments, we now turn our attention to FIGs. 1, 2 and 3 that will be discussed together. More particularly, FIG. 1 presents an exemplary site 100 configured with an augmented reality safety inspection system in accordance with an embodiment, FIG. 2 shows an illustrative AR device 200 configured in accordance with an embodiment, and FIG. 3 presents an illustrative user AR device view 300 created in accordance with an embodiment. As shown, the site 100 comprises a railroad tunnel 106 through which railcar 102 traverses over tracks 104. Of course, the site 100 may be any type of infrastructure including, but not limited to, buildings, homes and malls, to name just a few. The augmented reality safety inspection system comprises a plurality of proximity data loaders 108 and each proximity data loader 108 of the plurality of proximity data loaders is installed at and associated with a particular section within the site 100 (e.g., section A 116, section B 118, section C 120, section D 122, section E 124, and section F 126) and stores a 3D point cloud data set specific to the particular section associated therewith. Illustratively, each proximity data loader 108 comprises at least one proximity data loader for storing the 3D point cloud data. As will be appreciated, a point cloud is a 3D visualization made up of thousands or even millions of

georeferenced points. Point clouds provide high-resolution data without the distortion sometimes present in 3D mesh models. Point clouds are datasets that represent objects or space. These points represent the X, Y, and Z geometric coordinates of a single point on an underlying sampled surface. Point clouds are a means of collating a large number of single spatial measurements into a dataset that can then represent a whole. Point clouds are most commonly generated using 3D laser scanners and LiDAR (light detection and ranging) technology and techniques. Here, each point represents a single laser scan measurement. These scans are then stitched together, creating a complete capture of a scene, using a process called “registration”. In an embodiment, the augmented reality safety inspection system herein further comprises at least one terrestrial scanner (not shown) configured to scan the site for creating the 3D point cloud data set specific to the particular section associated therewith. Such terrestrial scanners are commercially available from companies such as Trimble, Riegl, and Topcon. Further, a plurality of 3D image capture devices 110 is employed with each 3D image capture device 110 installed at a different location within the site for capturing real-time 3D images of the site. Illustratively, the 3D image capture devices 110 are placed to ensure that all or substantially all of the site 100 may be visually covered for observation. In an embodiment, at least one of the 3D image capture devices is a 3D holographic projection camera. In another aspect, at least one of the 3D image capture devices is configured with a 3D motion detector and video recorder. Such 3D holographic projection cameras and 3D motion detectors and video recorders are commercially available from companies such as Basler, Vzense, and Nerian Vision Technologies.

[0045] In accordance with the principles of the disclosed embodiments, an AR device is worn by a user which is configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site (or is proximate thereto) while wearing the augmented reality device and displaying a real-time AR view of the site. In accordance with the principles of the disclosed embodiments, the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices. Turning our attention to FIG. 2, an illustrative AR device 200 is shown configured in accordance with an embodiment. The illustrative AR device 200 shown having an eyeglass configuration comprising control unit 202 that may be located anywhere in or on the physical frame of the AR device 200. Of course, other configurations for the AR device 200 (e.g., a first responder helmet) may be utilized as well consistent with the principles of the disclosed embodiments. The control unit 202 provides functionality including, but not limited, interfacing with the augmented

reality safety inspection platform 600 (see, FIGs. 4, 5, and 6), the augmented reality safety inspection app 900 (see, FIG. 9), the user device(s) 700 (see, FIGs. 4, 5, and 7), and the plurality of proximity data loaders 108. The control unit 202 further comprises processor 206, image generation and control unit 204, Global Positioning System (GPS) module 208, left display 210, right display 212, and power source 214 (e.g., a battery). The processor 206 may be a microcontroller and include both general and special purpose microprocessors and may be the sole processor or one of multiple processors of the device. Further, the processor 206 may comprise one or more central processing units (CPUs) and may include, be supplemented by, or incorporated in, one or more application-specific integrated circuits (ASICs) and/or one or more field programmable gate arrays (FPGAs). The left display 210 and the right display 212 may be configured using a transparent liquid crystal display (LCD), a heads-up display (HUD) or other suitable display. In accordance with the principles of the disclosed embodiments, when a user wearing the AR device 200 is traversing the site 100 (traversing includes both being inside the site or external to the site at any particular time) and is proximate to one of the proximity data loaders 108, the 3D point cloud data set stored therein is received the AR device 200 and a real-time time AR view of the site 100 is displayed. More particularly, in accordance with the principles of the disclosed embodiments, the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices. For example, FIG. 3 presents one such illustrative user AR device view 300 created in accordance with an embodiment for display on the AR device 200. The rendered user AR device view 300 will show the site's (e.g., the site 100) internal features and may include multiple levels. In an embodiment, the user may suppress one or more levels of the plurality of levels from being displayed in the user AR device view 300 and/or make one or more of the features shown in the user AR device view 300 transparent in nature. Thus, the generated user AR device view 300 may comprise transparent features (e.g., a transparent wall) to allow users (e.g., a first responder) to obtain a visual of any threats within the site 100, for example. These transparent features will also allow for the user to view multiple and different angles/perspectives of the site. Further, in an embodiment, the user may remotely activate one or more safety systems within the site as a function of the real-time time user AR device view 300 displayed as the user traverses the site. For example, the user may activate water supply line 116 electrical line 112 and/or control box 114 (each as shown in FIG. 1) depending upon their real-time interaction with user AR device view 300 and current observed conditions at the site 100.

[0046] Turning our attention to FIG. 4, a high-level block diagram of a cloud network services architecture 400 is shown for use with an augmented reality safety inspection platform 600 in accordance with an embodiment. As will be detailed herein below, the cloud 402 facilitates the delivery of augmented reality safety inspection services to a plurality of users (e.g., comprised by user 410-1, 410-2, 410-3 through 410-N) that are offered by and through the augmented reality safety inspection platform 600 using an augmented reality safety inspection app 900, as will be detailed herein below, on user device 700. The user device 700 provides various users (e.g., user 410-1 through user 410-N) with real-time access to augmented reality safety inspection services in accordance with the disclosed embodiments herein. For example, one or more of the users may be an emergency first responder that is responding to a real-time emergency at a site. In an embodiment, the augmented reality safety inspection processing, offered by and through the cloud network services architecture 400 and the augmented reality safety inspection platform 600 will be facilitated by the augmented reality safety inspection app 900 (see, FIG. 9), as will be detailed herein below, executing on the user device 700 (see, FIG. 7). The user device 700 provides the various users (e.g., user 410-1 through user 410-N) with real-time access to augmented reality safety inspection services in accordance with the disclosed embodiments herein.

[0047] As noted above, the cloud 402 comprises at least server(s) 404, the access point(s) 406 and the database(s) 408. In an embodiment, mobile command center network 412 is hosted and provided by and through cloud 402 at the direction of a mobile command center that may be situated at the site 100 in support of the safety inspection activities including, but not limited to, technical operations. The mobile command center network 412 (as deployed by the mobile command center, for example) is communicatively coupled with at least the proximity data loaders 108, the plurality of 3D image capture devices 110 and each AR device 200 as worn by each user. Illustratively, the mobile command center network 412 may be any secure network type and may include mobile networks configured within, on or proximate to the site 100. In an embodiment, using the mobile command center network 412, the on-site mobile command center is able to collect georeferenced data for identifying and locating any threat within the site that may be conveyed to the user through their respective AR device 200. Further, one or more users may deploy their respective AR device 200 while within the mobile command center. Cloud, cloud service, cloud server and cloud database are broad terms and are to be given their ordinary and customary meaning to one of ordinary skill in the art and includes, without limitation, any database, data repository or storage media which store content typically associated with and managed by users, emergency service platforms (e.g., emergency service platforms 418) and third-party content

providers (e.g., third-party content providers 416) in the context of augmented reality safety inspection services, to name just a few. For example, one emergency service platform 418 may be an emergency 911 system. A cloud service may include one or more cloud servers and cloud databases that provides for the remote storage of content as hosted by a third-party service provider or operator. A cloud server may include an HTTP/HTTPS server sending and receiving messages in order to provide web-browsing interfaces to client web browsers as well as web services to send data to integrate with other interfaces (e.g., as executed on the user device 700). The cloud server may be implemented in one or more servers and may send and receive content in a various forms and formats, user supplied and/or created information/content and profile/configuration data that may be transferred from or stored in a cloud database (e.g., the databases 408).

[0048] A cloud database may include one or more physical servers, databases or storage devices as dictated by the cloud service's storage requirements. The cloud database may further include one or more well-known databases (e.g., an SQL database) or a fixed content storage system to store content, user profile information, configuration information, administration information and any other information necessary to execute the cloud service. In various embodiments, one or more networks providing computing infrastructure on behalf of one or more users may be referred to as a cloud, and resources may include, without limitation, data center resources, applications (e.g., software-as-a-service or platform-as-a-service) and management tools.

[0049] Turning our attention to FIG. 5., an illustrative block diagram 500 for conducting augmented reality safety inspections and how the user's AR device engages and views the user augmented reality views created in accordance with an embodiment. More particularly, each of users 410-1, 410-2, 410-3, and 410-N is wearing a respective AR device 200 which communicates, for example, with the augmented reality safety inspection platform 600, a respective user device 700 associated with each user, and the mobile command center network 412 over the communications links 436. Illustratively, each user is executing the augmented reality safety inspection app 900 on their respective user device 700, as detailed herein. Each of these users is experiencing an AR environment and a user AR view (i.e., user AR view 502 (illustratively comprising the user AR device view 300 as detailed above), user AR view 504, user AR view 506, and user AR view 508) in accordance with the principles of the disclosed embodiments, which is generated as a function of the augmented reality safety inspection system configured within the site 100, as detailed previously. Thus, the real-time AR views (i.e., user AR view 502, user AR view 504, user AR view 506, and user AR view 508) comprise a combination of at least one 3D image

generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices. It will be noted that in various embodiments the user may either be within the site 100 or external to the site 100 when receiving the user AR view on their respective AR device 200.

[0050] Turning our attention to FIG. 6, an illustrative configuration for the augmented reality safety inspection platform 600 is shown. More particularly, the augmented reality safety inspection platform 600 comprises processor 602 for executing program code (e.g., augmented reality safety inspection app 900) and communications interface 614 for managing communications to and from the augmented reality safety inspection platform 600, memory 606, data storage 610, and/or read-only memory (ROM) 608 for storing program code and data, and power source 618 for powering the augmented reality safety inspection platform 600. The memory 606 is coupled to the bus 604 for storing computer-readable instructions to be executed by the processor 602 (e.g., execution of the augmented reality safety inspection app 900). Database manager 612 is used to manage the delivery and storage of content, data, and other information in the augmented reality safety inspection platform database(s) 420, database(s) 408 and across third-party content providers, for example. The augmented reality safety inspection platform database(s) 420 may store and provide information including, but not limited, to user IDs 422, user profiles 424, AR device information 426, 3D point cloud data and information 428, site-specific information 430, and hardware tracking and inventory information 432. As will be detailed further herein below, the operations performed by for the augmented reality safety inspection platform 600 in combination with the augmented reality safety inspection app 900, for example, provide for using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site, facility or other infrastructure in accordance with the disclosed embodiments.

[0051] Website manager 620 is used to deliver and manage content, data, and other information across one or more websites that may be utilized to access and use the augmented reality safety inspection platform 600, for example. Further, the operations provided by and through the augmented reality safety inspection app 900 may be offered through a web-based application. As will be discussed in greater detail herein below, the augmented reality safety inspection app 900, as stored in data storage 610, when executed by the processor 602 will enable access by a plurality of users (e.g., user 410-1, 410-2, 410-3 through 410-N) to the augmented reality safety inspection platform 600 for the processing of, for example, the user IDs 422, user profiles 424, AR device information 426, 3D point cloud data and information 428, site-specific information 430, and hardware tracking and inventory information 432. Location-based services manager 622 facilitates

the delivery of location-based services (e.g., GPS tracking) either independently or on user device 700. This allows the augmented reality safety inspection platform 600 to register the exact location of the user and their AR device 200 and/or the user device 700, for example, as the tracking subjects and/or users roams from one location to another location such that the services offered via the augmented reality safety inspection processing hereunder may be delivered and/or tailored to a current location. AR device manager 630 and on-site hardware and device manager 626 facilitates the management of such AR devices 200 and/or user devices 700, and the management of the devices comprised by the augmented reality safety inspection system (e.g., plurality of proximity data loaders 108 and the plurality of 3D image capture devices 110).

[0052] In an embodiment, the augmented reality safety inspection processing provided through the execution of the augmented reality safety inspection app 900 may also include a web-based delivery platform and/or accessing and interfacing any number of websites using website manager 620 for procuring information and data that can be used in the augmented reality safety inspection platform 600. The term “website” in the context herein is used in a conventional and broadest sense and is located on at least one server containing web pages stored thereon and is operational in a 24-hour/7-day typical fashion. Further, as shown in the cloud network services architecture 400, the plurality of users (i.e., the user 410-1 through user 410-N) may alternatively utilize well-known Internet 434 for access to augmented reality safety inspection platform 600 by and through a web browser on the user device 700, for example. The augmented reality safety inspection platform 600 may also include one or more input/output devices 616 that enable user interaction with the user device 700 (e.g., camera, display, keyboard, mouse, speakers, microphone, buttons, etc.). The input/output devices may include peripherals, such as an NFC device (e.g., NFC tag reader), camera, printer, scanner (e.g., a QR-code scanner), touchscreen display, etc. For example, the input/output devices 616 may include a display device such as a cathode ray tube (CRT), plasma monitor, liquid crystal display (LCD) monitor or organic light-emitting diode (OLED) monitor for displaying information to the user, a keyboard, and a pointing device such as a mouse or a trackball by which the user can provide input to the user device 700 or an associated display device 624, for example, that may also be managed by graphical user interface generator 628.

[0053] The communications interface 614 is used to facilitate communications across the communications links 436 (see, FIG. 4) within the cloud network services architecture 400. This may take the form, for example, of a wide area network connection that communicatively couples the augmented reality safety inspection platform 600 with the access points 406 (see, FIG. 4) which may be a cellular communications service. Similarly, communications managed by the

communications interface 614 may take the form, for example, of a local Wi-Fi network interface or Ethernet interface the communicatively couples the augmented reality safety inspection platform 600 with the Internet 434, local area network (LAN) 414, and ultimately the user device 700. In the instant embodiment, the augmented reality safety inspection app 900 and/or the communications interface 614 may include a communications stack for facilitating communications over the respective communications link 436. Electronic communications by and through augmented reality safety inspection platform 600 between the various systems, networks, devices, users, entities, and/or individuals are facilitated by the communications links 436 in accordance with any number of well-known communications protocols and methods (e.g., wireless communications).

[0054] Turning our attention briefly to FIG. 7, an illustrative user device 700 is shown for use with, illustratively, the augmented reality safety inspection platform 600 and the AR device 200 in accordance with an embodiment. The user device 700 typically includes bus 702 and processor 704 coupled to the bus 702 for executing operations and processing information. As will be appreciated, a “user device” in the context herein may comprise a wide variety of devices such as any type of hardware device, XR device, mobile devices, smartphones, laptop computers, desktop computers, tablets, kiosks, and wearable devices, to name just a few, that execute applications (e.g., a mobile application) in accordance with the principles of the disclosed embodiments herein. For example, the execution of the augmented reality safety inspection app 900 as will be discussed in much greater detail herein below. The processor 704, as powered by power source 712, may include both general and special purpose microprocessors, and may be the sole processor or one of multiple processors of the device. This is equally applicable to the processor 602 of FIG. 6. Further, the processor 704 (or the processor 602) may comprise one or more central processing units (CPUs) and may include, be supplemented by, or incorporated in, one or more application-specific integrated circuits (ASICs) and/or one or more field programmable gate arrays (FPGAs).

[0055] The user device 700 may also include memory 706 coupled to the bus 702 for storing computer-readable instructions to be executed by the processor 704. The memory 706 may also be utilized for storing temporary variables or other intermediate information during the execution of the instructions by the processor 704. The user device 700 may also include ROM 708 or other static storage device coupled to the bus 702. Further, data storage device 710, such as a magnetic, optical, or solid-state device may be coupled to the bus 702 for storing information and instructions for the processor 704 including, but not limited to, the augmented reality safety inspection app 900. Data storage device 710 (or the data storage device 610) and the memory 706 (and the memory

606) may each comprise a non-transitory computer readable storage medium and may each include high-speed random access memory, such as dynamic random access memory (DRAM), static random access memory (SRAM), double data rate synchronous dynamic random access memory (DDR RAM), or other random access solid state memory devices, and may include non-volatile memory, such as one or more magnetic disk storage devices such as internal hard disks and removable disks, magneto-optical disk storage devices, optical disk storage devices, flash memory devices, semiconductor memory devices, such as erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), compact disc read-only memory (CD-ROM), digital versatile disc read-only memory (DVD-ROM) disks, or other non-volatile solid state storage devices.

[0056] The user device 700 may also include one or more communications interface 716 for communicating with other devices via a network (e.g., a wireless communications network) or communications protocol (e.g., Bluetooth®). For example, such communication interfaces may be a receiver, transceiver, or modem for exchanging wired or wireless communications in any number of well-known fashions. For example, the communications interface 716 (or the communications interface 614) may be an integrated services digital network (ISDN) card or modem/router used to facilitate data communications of various well-known types and formats. Further, illustratively, the communications interface 716 (or the communications interface 614) may be a LAN card used to provide data communication connectivity to a comparable LAN. Wireless communication links may also be implemented. The GPS transceiver 718 and antenna 720 facilitate delivery of location-based services in order to register the exact location of the user device 700, for example, as the user roams from one location to another location. As will be understood, the application herein will be able to track individual users and their location (and proximities to other locations) upon the launching of the application thereby enabling the well understood GPS location features of the user device 700 (e.g., a smartphone).

[0057] As will be appreciated, the functionality of the communications interface 716 (or the communications interface 614) is to send and receive a variety of signals (e.g., electrical, optical, or other signals) that transmit data streams representing various data types. The user device 700 may also include one or more input/output devices 714 that enable user interaction with the user device 700 such as a camera, display, keyboard, mouse, speakers, microphone, buttons, etc. The input/output devices 714 (or I/O devices 616) may include peripherals, such as an NFC device (e.g., NFC reader), camera, printer, scanner (e.g., QR-code scanner), touchscreen display, etc. For example, the input/output devices 714 (or the I/O devices 616) may include a display device such

as a cathode ray tube (CRT), plasma monitor, liquid crystal display (LCD) monitor or organic light-emitting diode (OLED) monitor for displaying information to the user, a keyboard, and a pointing device such as a mouse or a trackball by which the user can provide input to the user device 700 or an associated display device, for example.

[0058] Turning our attention to FIG. 8, a flowchart of illustrative operations 800 for using augmented reality environments for performing safety inspections of and/or emergency response activities within a particular site, facility or other infrastructure in accordance with an embodiment. More particularly, at step 802, collecting a plurality of point cloud data sets specific to a site, each point cloud data set associated with a particular section of the facility or site. At step 804, storing each point cloud data set collected in a proximity data loader located proximate to the particular section of the facility or site associated therewith. At step 806, receiving at least one real-time video image associated with at least a particular section of the facility or site and at step 808, receiving the point cloud data set stored from the proximity data loader located proximate to the particular section of the facility or site. At step 810, generating at least one 3D image using the point cloud data set received and at step 812, rendering a real-time view on an AR device of the facility or site comprising a combination of at least the real-time image with the at least one 3D image generated associated with the particular section of the facility or site.

[0059] Turning our attention to FIG. 9, an illustrative architecture for the operation of the augmented reality safety inspection app 900 is presented in accordance with an embodiment. As will be appreciated, the architecture may be used, illustratively, in conjunction with the cloud network services architecture 400, the augmented reality safety inspection platform 600, the mobile command center network 412, the AR device(s) 200 and/or the user device(s) 700 for launching and executing the augmented reality safety inspection app 900 and its associated operations. As shown, the architecture for the operations of the augmented reality safety inspection app 900 provides several interfaces and engines used to perform a variety of functions such as the collection, aggregation, manipulation, processing, analyzing, verification, authentication, and display of applicable real-time information and data that are useful to realize the delivery of the augmented reality safety inspection operations of the disclosed embodiments. More particularly, data display interface module 918 and communications module 912 are used to facilitate the input/output and display of electronic data and other information to, illustratively, the users (e.g., user 410-1 through user 410-N) employing the user device 700 (e.g., a touch screen of the user device 700) and executing the augmented reality safety inspection app 900. The data collection module 906 facilitates data gathering from the plurality of users and other third parties. The location-based

services module 920 provides for the delivery of location-based services in order for the geographic locations of the users to be identified and displayed (e.g., GPS locations) including with the site boundary areas, as detailed previously. The communications module 912 will also facilitate communications by and through the augmented reality safety inspection platform 600, for example.

[0060] Execution engine 902 may be employed to deliver the augmented reality safety inspection services herein through the execution of the augmented reality safety inspection app 900. In such delivery, the execution engine 902 will operate and execute, as further detailed herein below, with at least the following program modules: graphical user interface module 904, data collection module 906, on-site hardware and device module 908, user profile module 910, communications module 912, augmented reality safety inspection system operations module 914, 3D point cloud data administration and management module 916, data display interface module 918, location-based services module 920, AR device module 922, user AR view administration and management module 924, user device module 926, mobile command center network module 928, and real-time images administration and management module 930. Further, in an embodiment, the graphical user interface module 904, data display interface module 918, and the communications module 912 are used to facilitate the input/output and display of electronic data and other information (e.g., a graphical user interface) to, illustratively, the users (e.g., user 410-1 through user 410-N) employing their respective AR device 200 and/or user device 700 (e.g., a touch screen) and executing the augmented reality safety inspection app 900. The data collection module 906 facilitates augmented reality safety inspection services information collection from the plurality of users (e.g., user 410-1 through user 410-N). The data collection module 906 may also be used to collect a variety of augmented reality safety inspection services information from other virtual and/or electronic sources accessible via the Internet 434 and individual third party websites hosted thereon. The operations executed by each and every of the foregoing modules are, for example, as discussed throughout this disclosure.

[0061] Those skilled in the art will appreciate that the present disclosure contemplates the use of systems configurations and/or computer instructions that may perform any or all of the operations involved in the augmented reality safety inspection services herein. The disclosure of computer instructions that include, for example, the augmented reality safety inspection app 900 and the augmented reality safety inspection platform 600 instructions is not meant to be limiting in any way. Those skilled in the art will readily appreciate that stored computer instructions and/or systems configurations may be configured in any way while still accomplishing the various goals, features, and advantages according to the present disclosure. The terms “program,” “application,”

“software application,” and the like as used herein, are defined as a sequence of instructions designed for execution on a computer system. A “program,” “computer program,” “application,” or “software application” may include a subroutine, a function, a procedure, an object method, an object implementation, an executable application, an applet, a servlet, a source code, an object code, a shared library/dynamic load library, and/or other sequence of instructions designed for execution on a computer system. Accordingly, the applications and programs, for example, may be written using any number of programming languages and/or executed on compatible platforms including, but not limited to, JavaScript, PHP (PHP: Hypertext Preprocessor), WordPress, Drupal, Laravel, React.js, Angular.js, and Vue.js. Computer readable program instructions for carrying out operations of the disclosed embodiments may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like, and conventional procedural programming languages, such as the “C” programming language or similar programming languages. The computer readable program instructions (e.g., non-transitory computer readable mediums) may execute entirely on one or more standalone computers, partly on one or more standalone computers, as a stand-alone software package, partly on one or more standalone computers and partly on one or more remote computers, partly on one or more standalone computers and partly on one or more distributed computing environments (such as a cloud environment), partly on one or more remote computers and partly on one or more distributed computing environments, entirely on one or more remote computers or servers, or entirely on one or more distributed computing environments. Standalone computers, remote computers, and distributed computing environments may be connected to each other through any type of network or combination of networks, including LANs, wide area networks (WANs), through the Internet (e.g., using an Internet Service Provider), or the connection may be made to external computers.

[0062] Devices or system modules that are in at least general communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices or system modules that are in at least general communication with each other may communicate directly or indirectly through one or more intermediaries. Moreover, it is understood that any system components described or named in any embodiment or claimed herein may be grouped or sub-grouped (and accordingly implicitly renamed) in any combination or sub-combination as those skilled in the art can imagine as suitable for the particular application, and

still be within the scope and spirit of the claimed embodiments of the present invention. For an example of what this means, if the invention was a controller of a motor and a valve and the embodiments and claims articulated those components as being separately grouped and connected, applying the foregoing would mean that such an invention and claims would also implicitly cover the valve being grouped inside the motor and the controller being a remote controller with no direct physical connection to the motor or internalized valve, as such the claimed invention is contemplated to cover all ways of grouping and/or adding of intermediate components or systems that still substantially achieve the intended result of the invention. A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention.

[0063] As is well-known to those skilled in the art, many careful considerations and compromises typically must be made when designing for the optimal manufacture of a commercial implementation of any system, and in particular, the embodiments of the present invention. A commercial implementation in accordance with the spirit and teachings of the present invention may be configured according to the needs of the particular application, whereby any aspect(s), feature(s), function(s), result(s), component(s), approach(es), or step(s) of the teachings related to any described embodiment of the present invention may be suitably omitted, included, adapted, mixed and matched, or improved and/or optimized by those skilled in the art, using their average skills and known techniques, to achieve the desired implementation that addresses the needs of the particular application.

[0064] Those of skill in the art will appreciate that where appropriate, some embodiments of the disclosure may be practiced in network computing environments with many types of computer system configurations, including personal computers, handheld devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. Where appropriate, embodiments may also be practiced in distributed computing environments where tasks are performed by local and remote processing devices that are linked (either by hardwired links, wireless links, or by a combination thereof) through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices. "Software" may refer to prescribed rules to operate a computer. Examples of software may include code segments in one or more computer-readable languages; graphical and/or textual instructions; applets; pre-compiled code; interpreted code; compiled code; and computer programs. A network is a collection of links

and nodes (e.g., multiple computers and/or other devices connected together) arranged so that information may be passed from one part of the network to another over multiple links and through various nodes. Examples of networks include the Internet, the public switched telephone network, wireless communications networks, computer networks (e.g., an intranet, an extranet, a local area network, or a wide area network), wired networks, and wireless networks.

[0065] Aspects of the present invention are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general-purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. The flowchart and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

[0066] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks. Further, although process steps, method steps, algorithms or the like may be described in a sequential order, such

processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously.

[0067] It will be readily apparent that the various methods and algorithms described herein may be implemented by, e.g., appropriately programmed general purpose computers and computing devices. Typically, a processor (e.g., a microprocessor) will receive instructions from a memory or like device, and execute those instructions, thereby performing a process defined by those instructions. Further, programs that implement such methods and algorithms may be stored and transmitted using a variety of known media. When a single device or article is described herein, it will be readily apparent that more than one device/article (whether or not they cooperate) may be used in place of single device/article. Similarly, where more than one device or article is described herein (whether or not they cooperate), it will be readily apparent that a single device/article may be used in place of the more than one device or article. The functionality and/or the features of a device may be alternatively embodied by one or more other devices which are not explicitly described as having such functionality/features. Thus, other embodiments of the present invention need not include the device itself.

[0068] The term "social media" as referred to herein implies interactive computer-mediated technologies that facilitate the creation and sharing of information, ideas, career interests and other forms of expression via virtual communities and networks. The variety of stand-alone and built-in social media services currently available introduces challenges of definition; however, there are some common features such as social media are typically interactive Internet-based applications. User-generated content, such as text posts or comments, digital photos or videos, and data generated through all online interactions, is the lifeblood of social media. Users create service-specific profiles for the website or app that are designed and maintained by the social media organization. Social media facilitate the development of online social networks by connecting a user's profile with those of other individuals or groups. Users usually access social media services via web-based technologies on desktops and laptops or download services that offer social media functionality to their mobile devices (e.g., smartphones and tablets). As users engage with these electronic services, they create highly interactive platforms through which individuals, communities, and organizations can share, co-create, discuss, participate and modify user-generated content or pre-made content posted online. Some of the most popular social media websites, with over 100 million registered users, include Facebook (and its associated Facebook

Messenger), YouTube, WeChat, Instagram, Twitter, Tumblr, Telegram, Reddit, LinkedIn, Snapchat, and Pinterest.

[0069] The term "computer-readable medium" as used herein refers to any medium that participates in providing data (e.g., instructions) which may be read by a computer, a processor or a like device. Such a medium may take many forms, including but not limited to, non-volatile media, non-transitory media, volatile media, and transmission media. Non-volatile media include, for example, optical or magnetic disks and other persistent memory. Volatile media include dynamic random-access memory (DRAM), which typically constitutes the main memory. Transmission media include coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to the processor. Transmission media may include or convey acoustic waves, light waves and electromagnetic emissions, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media and non-transitory media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, a RAM, a PROM, an EPROM, a FLASH-EEPROM, removable media, flash memory, a "memory stick", any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read. Various forms of computer readable media may be involved in carrying sequences of instructions to a processor. For example, sequences of instruction may be delivered from RAM to a processor, may be carried over a wireless transmission medium, and/or may be formatted according to numerous formats, standards or protocols, such as Bluetooth, 4G, 5G, etc.

[0070] As noted above, in some embodiments the method(s) described above may be executed or carried out by a computing system including a non-transitory computer-readable storage medium, also described herein as a storage machine, that holds machine-readable instructions executable by a logic machine (i.e., a processor or programmable control device) to provide, implement, perform, and/or enact the above-described methods, processes and/or tasks. When such methods and processes are implemented, the state of the storage machine may be changed to hold different data. For example, the storage machine may include memory devices such as various hard disk drives, CD, or DVD devices. The logic machine may execute machine-readable instructions via one or more physical information and/or logic processing devices. For example, the logic machine may be configured to execute instructions to perform tasks for a computer program. The logic machine may include one or more processors to execute the machine-readable instructions. The computing system may include a display subsystem to display a graphical user interface (GUI),

or any visual element of the methods or processes described above. For example, the display subsystem, storage machine, and logic machine may be integrated such that the above method may be executed while visual elements of the disclosed system and/or method are displayed on a display screen for user consumption. The computing system may include an input subsystem that receives user input. The input subsystem may be configured to connect to and receive input from devices such as a mouse, keyboard, or gaming controller. For example, a user input may indicate a request that certain task is to be executed by the computing system, such as requesting the computing system to display any of the above-described information or requesting that the user input updates or modifies existing stored information for processing. A communication subsystem may allow the methods described above to be executed or provided over a computer network. For example, the communication subsystem may be configured to enable the computing system to communicate with a plurality of personal computing devices. The communication subsystem may include wired and/or wireless communication devices to facilitate networked communication. The described methods or processes may be executed, provided, or implemented for a user or one or more computing devices via a computer program product such as via an application programming interface (API).

[0071] Thus, the steps of the disclosed method(s) and the associated discussion herein above can be defined by the computer program instructions stored in a memory and/or data storage device and controlled by a processor executing the computer program instructions. Accordingly, by executing the computer program instructions, the processor executes an algorithm defined by the disclosed method. For example, the computer program instructions can be implemented as computer executable code programmed by one skilled in the art to perform the illustrative operations defined by the disclosed methods. Further, it will be appreciated that any flowcharts, flow diagrams, state transition diagrams, pseudo code, program code and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer, machine, or processor, whether or not such computer, machine or processor is explicitly shown. One skilled in the art will recognize that an implementation of an actual computer or computer system may have other structures and may contain other components as well, and that a high-level representation of some of the components of such a computer is for illustrative purposes.

[0072] Since many modifications, variations, and changes in detail can be made to the described preferred embodiments of the invention, it is intended that all matters in the foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a

limiting sense. Thus, the scope of the invention should be determined by the appended claims and their legal equivalents.

What is claimed is:

1. An augmented reality safety inspection system comprising:

a plurality of proximity data loaders, each proximity data loader of the plurality of proximity data loaders installed at and associated with a particular section within a site and storing a three-dimensional (3D) point cloud data set specific to the particular section associated therewith;

a plurality of 3D image capture devices, each 3D image capture device installed at a different location within the site for capturing real-time 3D images of the site;

an augmented reality (AR) device configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site while wearing the augmented reality device and displaying a real-time time (AR) view of the site; and

wherein the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices.

2. The augmented reality safety inspection system of claim 1, wherein at least one of the 3D image capture devices is a 3D holographic projection camera.

3. The augmented reality safety inspection system of claim 1, wherein at least one of the 3D image capture devices is configured with a 3D motion detector and video recorder.

4. The augmented reality safety inspection system of claim 1, wherein the augmented reality safety inspection system further comprises:

at least one terrestrial scanner configured to scan the site for creating the three-dimensional (3D) point cloud data set specific to the particular section associated therewith.

5. The augmented reality safety inspection system of claim 1, wherein the site is a tunnel.

6. The augmented reality safety inspection system of claim 1, wherein the user is a first responder responding to a real-time emergency at the site.

7. The augmented reality safety inspection system of claim 6, wherein the first responder responding to the real-time emergency at the site remains external to the site while wearing the AR device.
8. The augmented reality safety inspection system of claim 1, wherein the site is a building.
9. The augmented reality safety inspection system of claim 1, wherein the real-time AR view displays a plurality of levels of the site.
10. The augmented reality safety inspection system of claim 9, wherein the user may suppress one or more levels of the plurality of levels from being displayed.
11. The augmented reality safety inspection system of claim 1, wherein the user may make one or more features shown in the real-time AR view transparent.
12. The augmented reality safety inspection system of claim 1, further comprises:
a mobile command center communicatively coupled with the user through the AR device worn thereby.
13. The augmented reality safety inspection system of claim 12, wherein the mobile command center collects georeferenced data for identifying and locating any threat within the site.
14. The augmented reality safety inspection system of claim 1, wherein the user remotely activates one or more safety systems within the site using the real-time time (AR) view of the site displayed as the user traverses the site.
15. An augmented reality safety inspection system comprising:
a plurality of proximity data loaders, each proximity data loader of the plurality of proximity data loaders installed at and associated with a particular section within a site and storing a three-dimensional (3D) point cloud data set specific to the particular section associated therewith, wherein the 3D point cloud data set is created from a scan of the site by a terrestrial scanner;

a plurality of 3D image capture devices, each 3D image capture device installed at a different location within the site for capturing real-time 3D images of the site, wherein at least one of the 3D image capture devices is a 3D holographic projection camera;

an augmented reality (AR) device configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site while wearing the augmented reality device and displaying a real-time time (AR) view of the site; and

wherein the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices.

16. The augmented reality safety inspection system of claim 15, wherein at least one of the 3D image capture devices is configured with a 3D motion detector and video recorder.

17. The augmented reality safety inspection system of claim 15, wherein the site is a tunnel or a building.

18. The augmented reality safety inspection system of claim 15, wherein the augmented reality safety inspection system further comprises:

a mobile command center communicatively coupled with the user through the AR device worn thereby.

19. The augmented reality safety inspection system of claim 15, wherein the user is a first responder responding to a real-time emergency at the site.

20. An augmented reality safety inspection system comprising:

a plurality of proximity data loaders, each proximity data loader of the plurality of proximity data loaders installed at and associated with a particular section within a site and storing a three-dimensional (3D) point cloud data set specific to the particular section associated therewith, wherein the 3D point cloud data set is created from a scan of the site by a terrestrial scanner;

a plurality of 3D image capture devices, each 3D image capture device installed at a different location within the site for capturing real-time 3D images of the site, wherein at least one of the 3D image capture devices is a 3D holographic projection camera and at least another one of the 3D image capture devices is configured with a 3D motion detector and video recorder;

an augmented reality (AR) device configured for receiving the 3D point cloud data set specific to the particular section from the proximity data loader associated therewith as a user traverses the site while wearing the augmented reality device and displaying a real-time time (AR) view of the site;

wherein the real-time AR view comprises a combination of at least one 3D image generated using the 3D point cloud data set received and at least one real-time 3D image of the site captured by at least one of the 3D image capture devices, wherein the real-time AR view shows a plurality of levels of the site and the user may suppress one or more levels of the plurality of levels from being displayed; and

wherein the user remotely activates one or more safety systems within the site using the real-time time (AR) view of the site displayed as the user traverses the site.

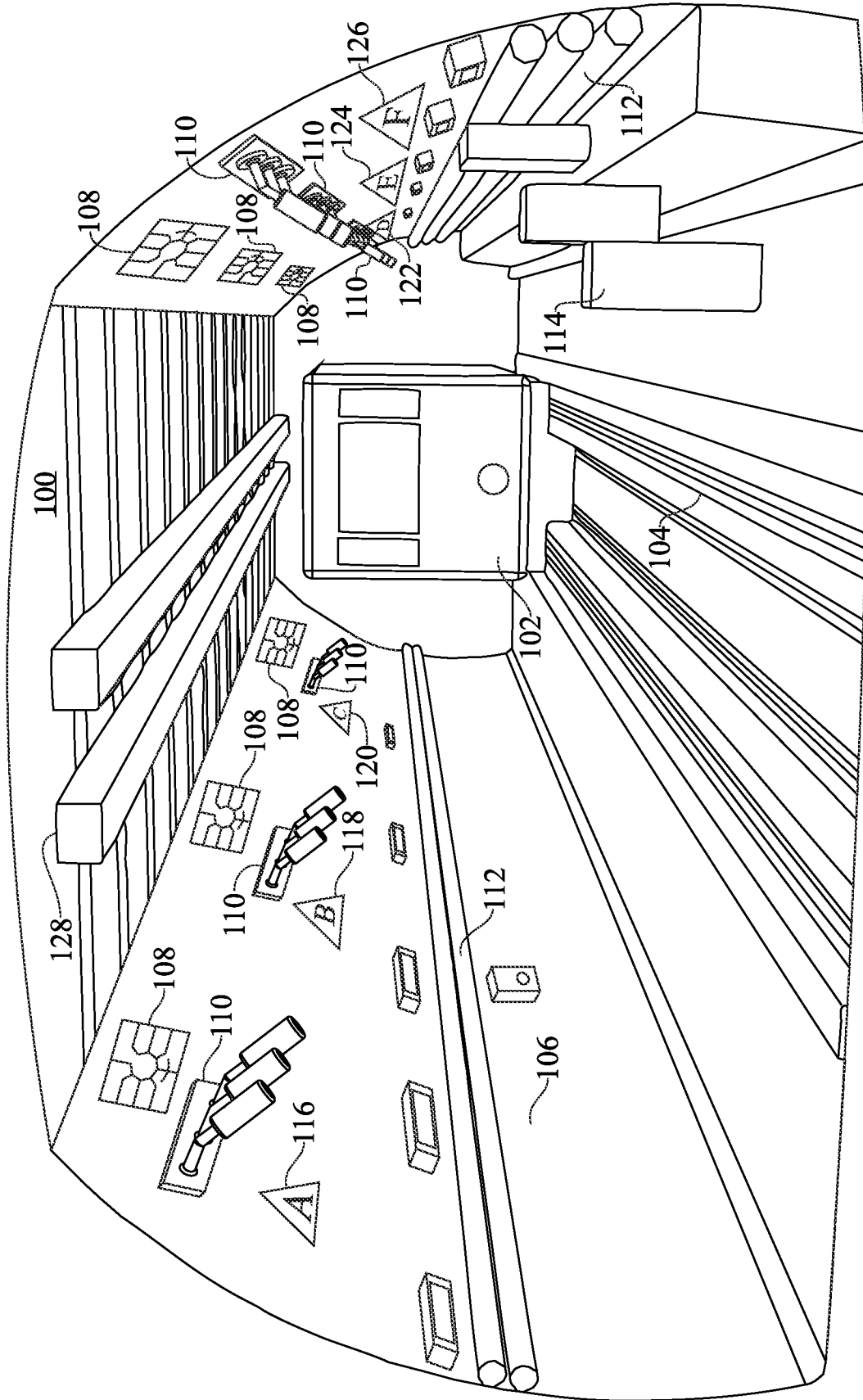


FIG. 1

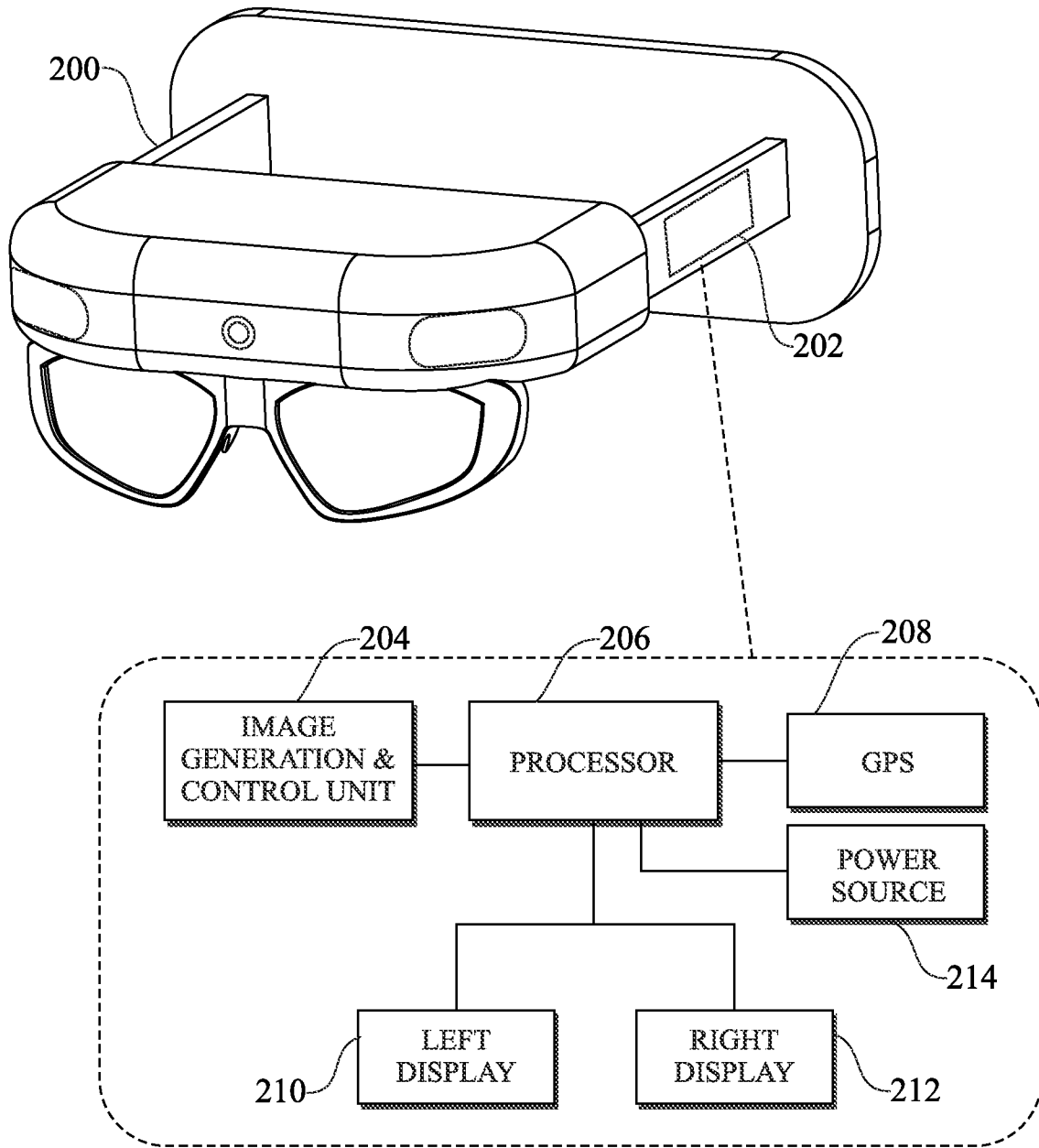


FIG. 2

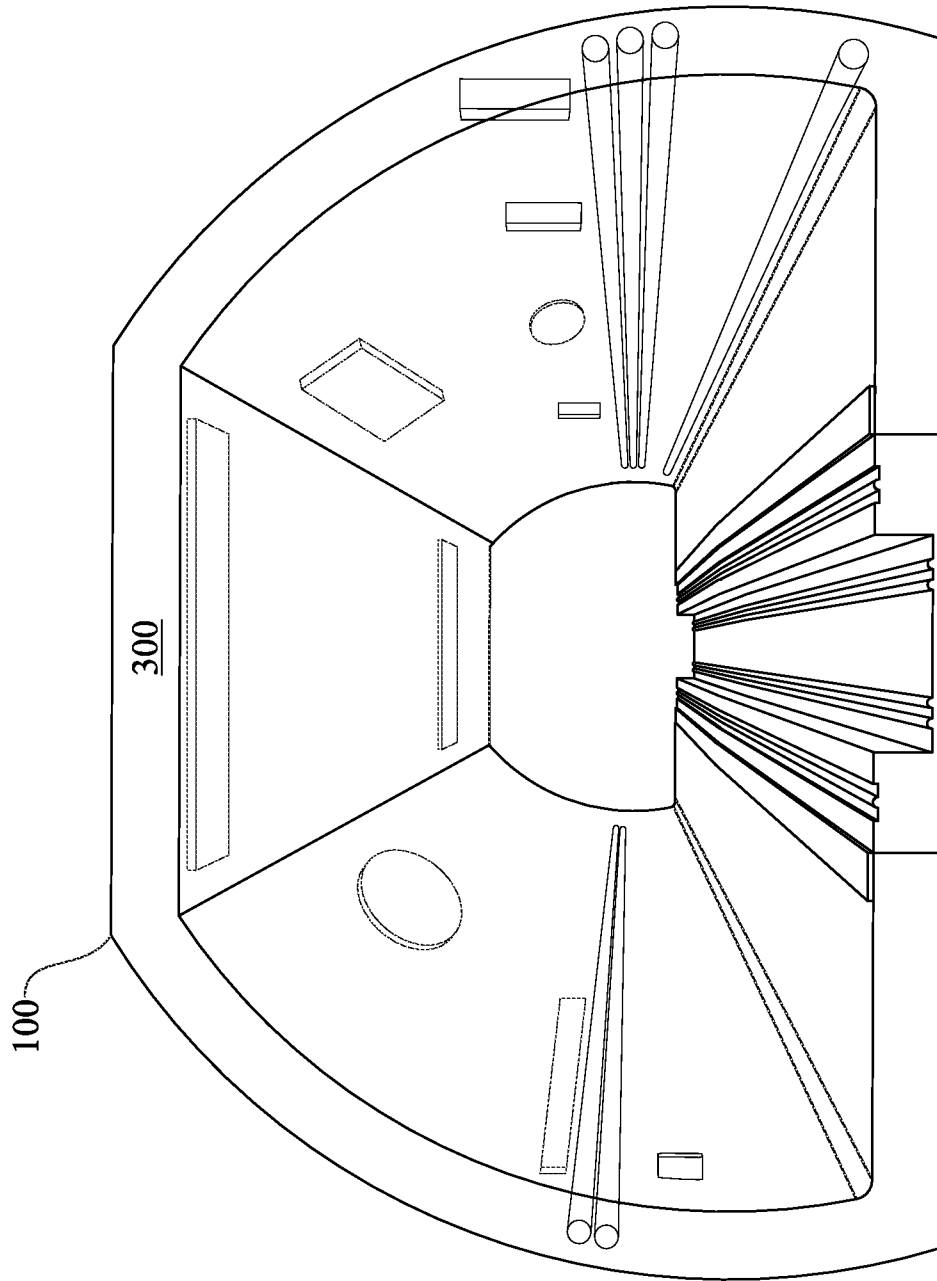


FIG. 3

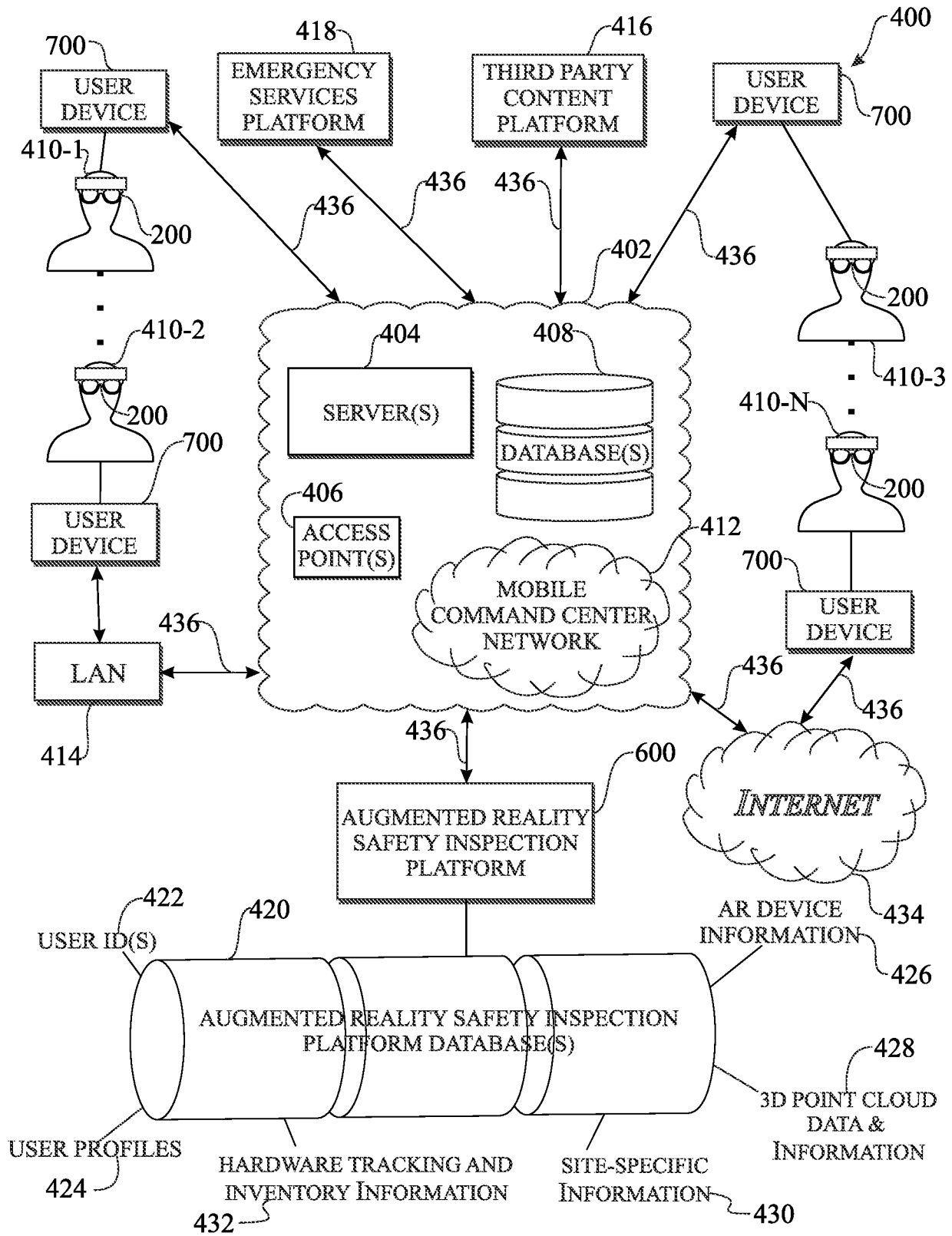


FIG. 4

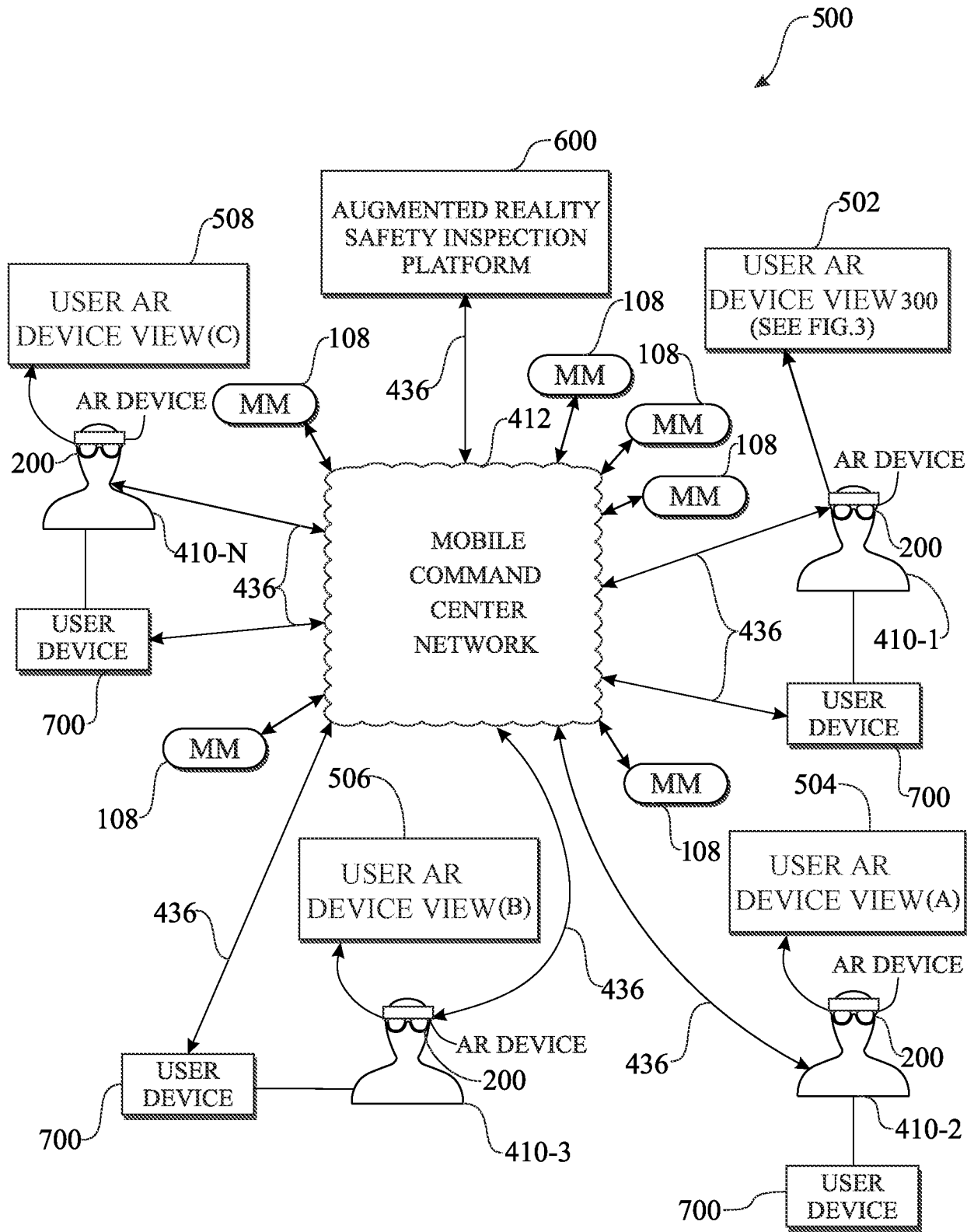


FIG. 5

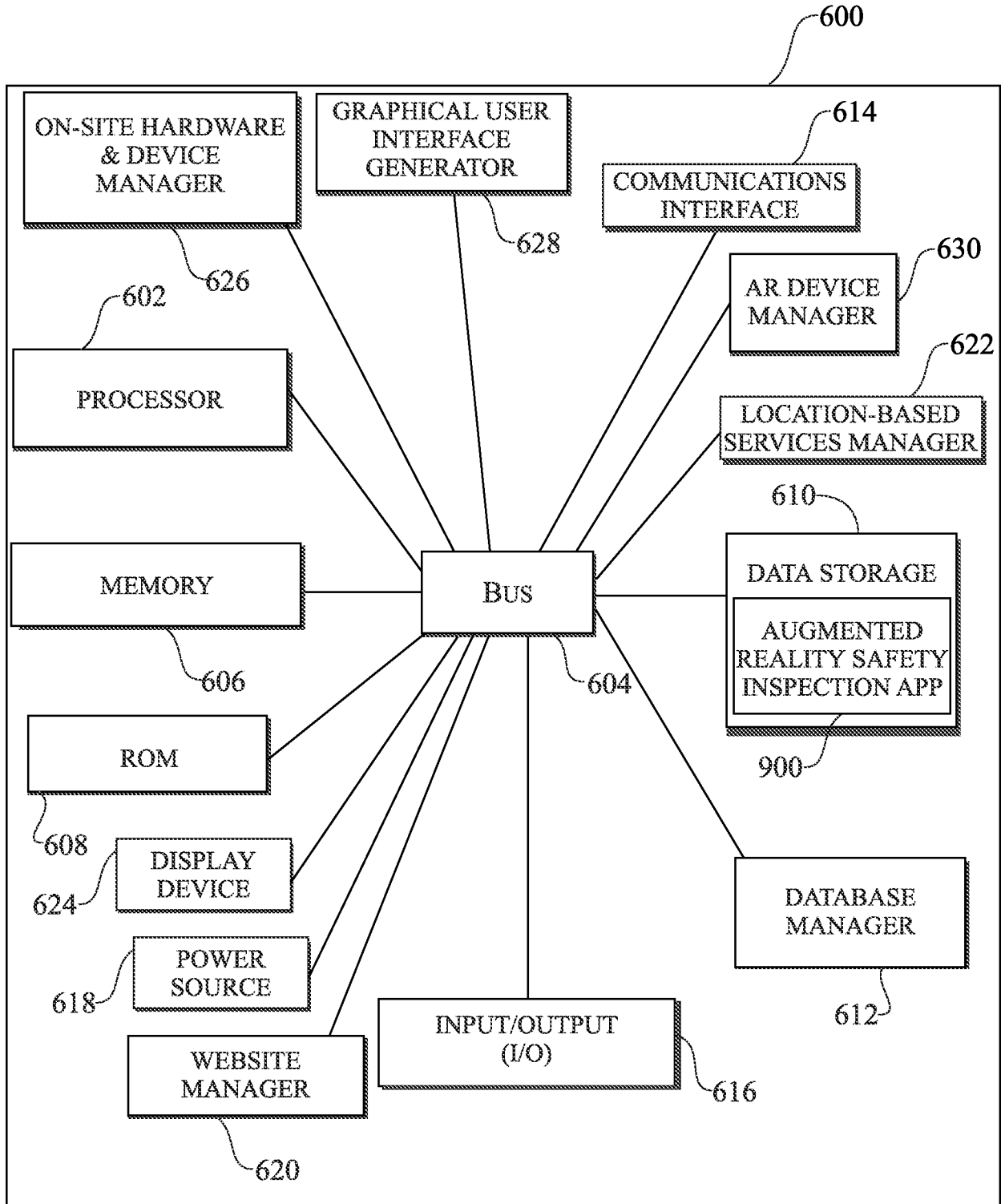


FIG. 6

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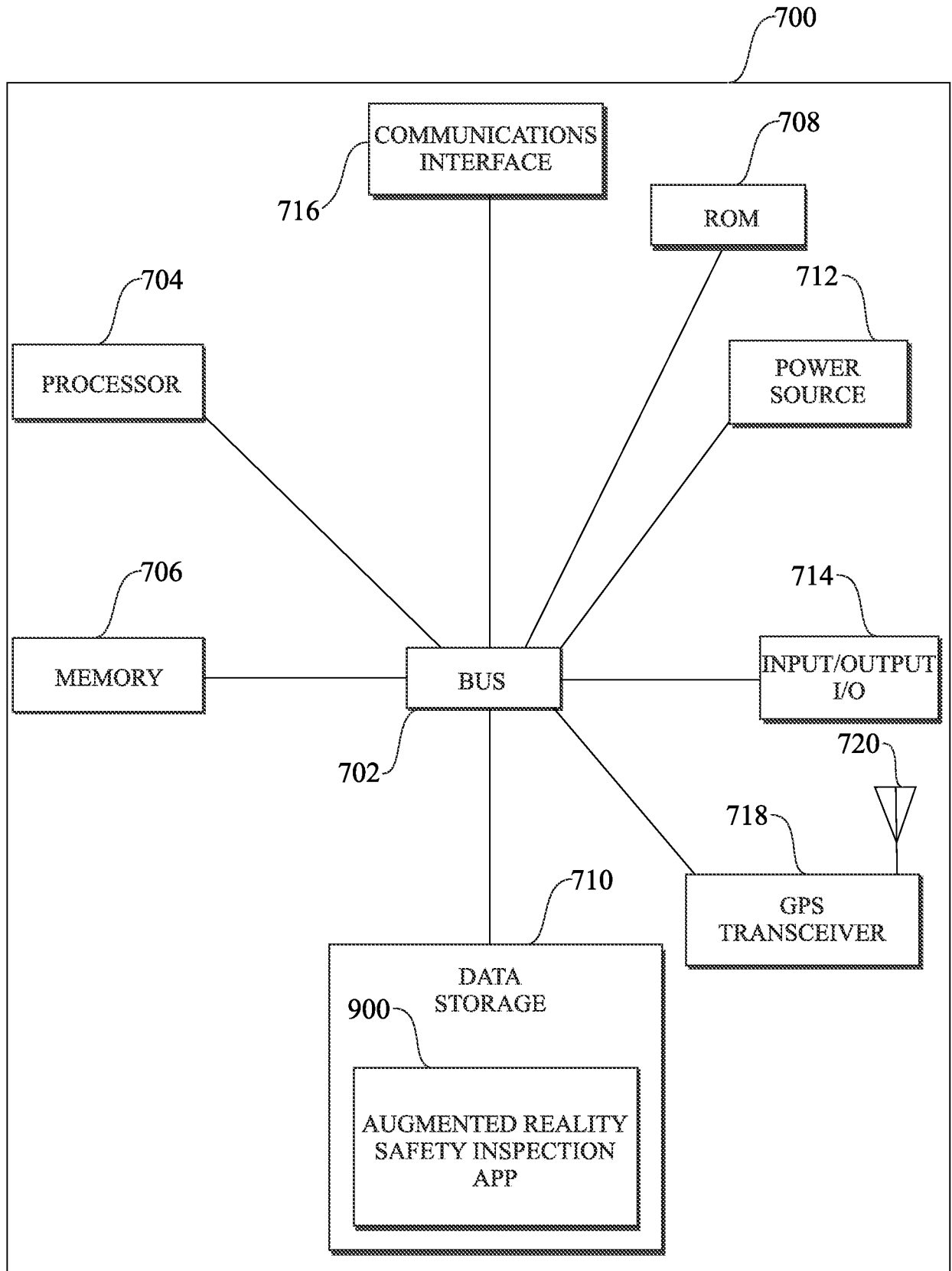


FIG. 7

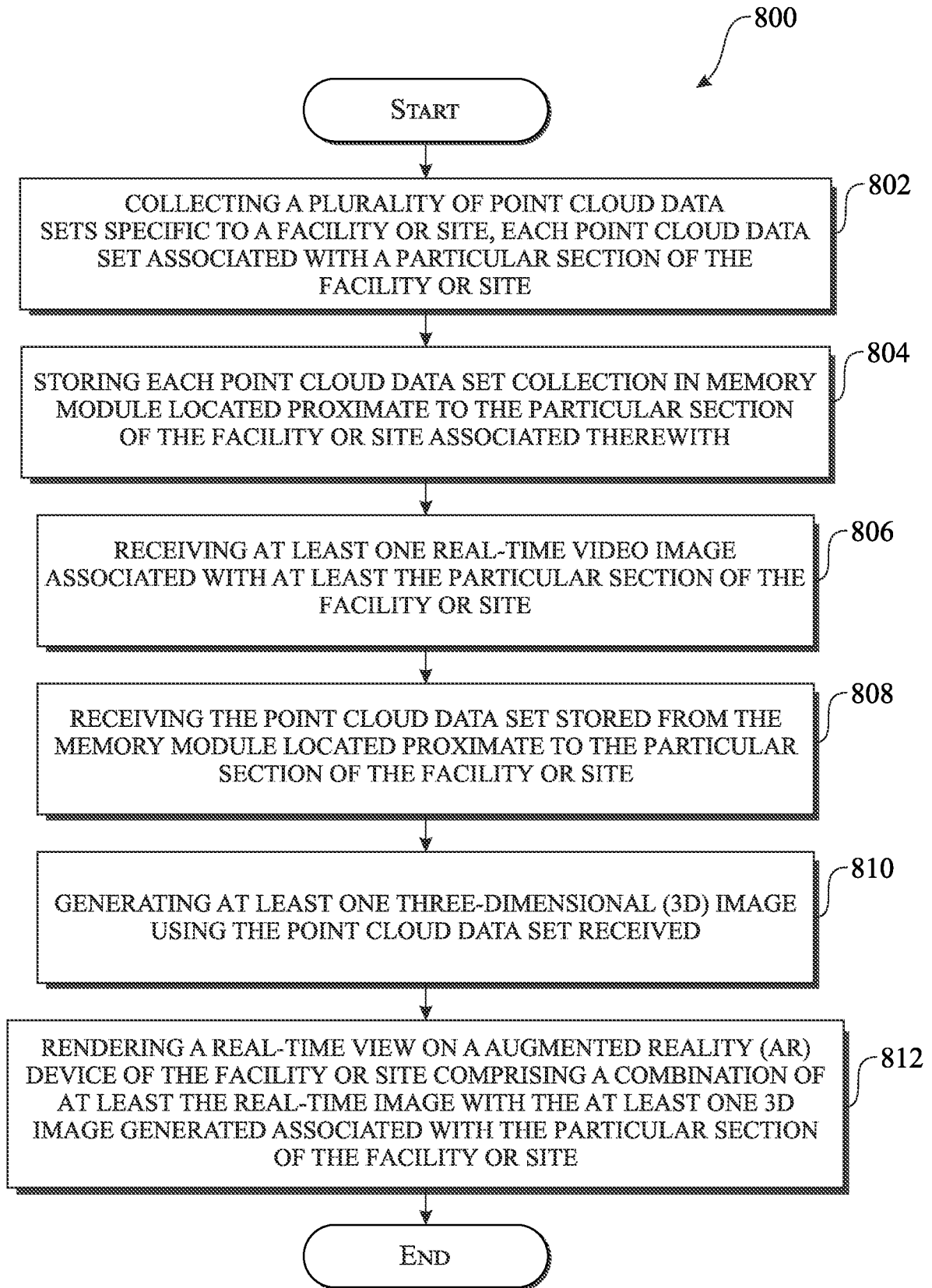


FIG. 8

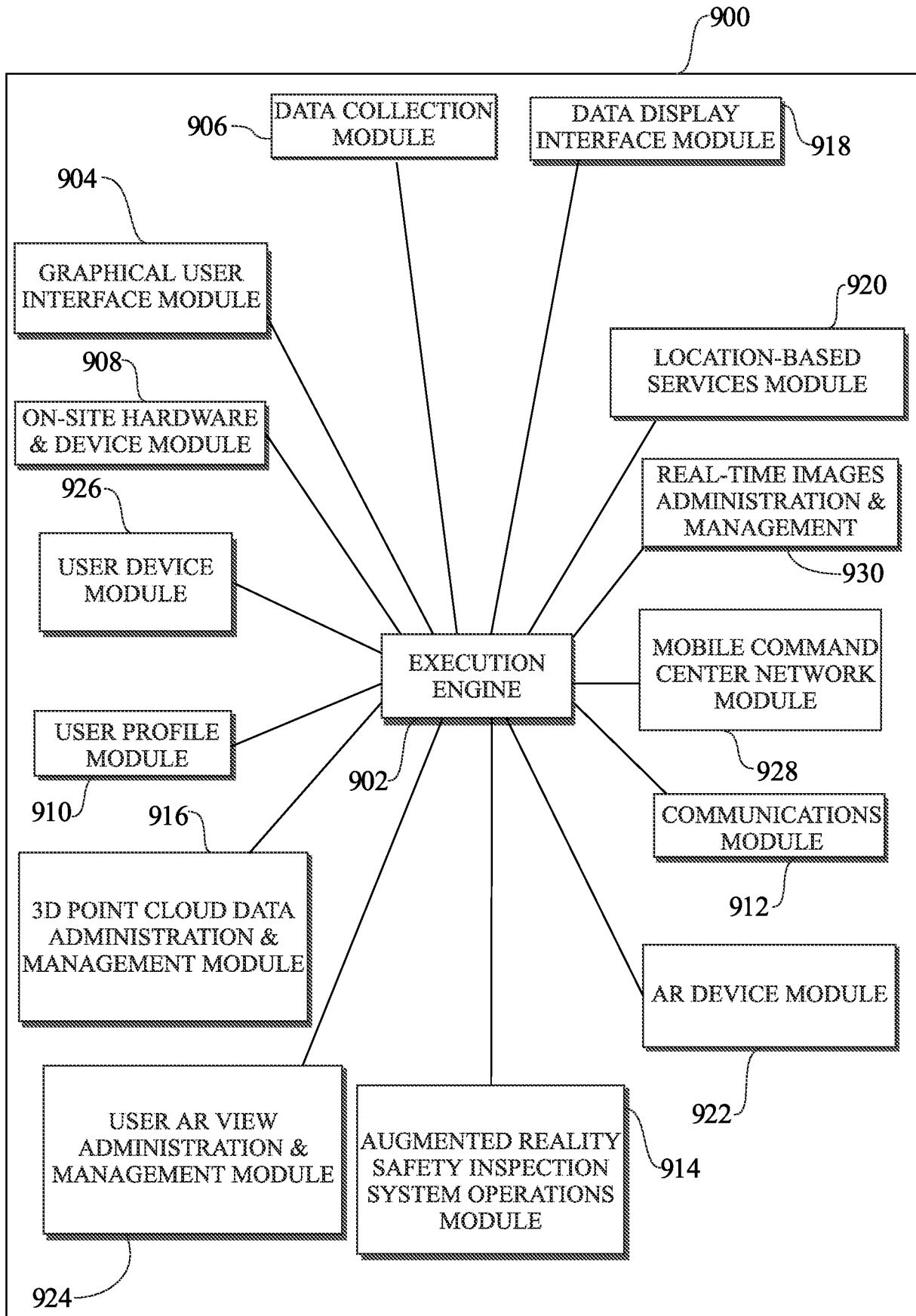


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/36577

A. CLASSIFICATION OF SUBJECT MATTER
 IPC - INV. G06T 19/00, G06V 10/74, G06V 20/20 (2023.01)
 ADD. G06V 20/00 (2023.01)

CPC - INV. G06T 19/006, G06V 10/74, G06V 20/20

ADD. G06V 20/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2019/0147655 A1 (Rockwell Automation Technologies, Inc.) 16 May 2019 (16.05.2019), entire document, especially [0042],[0053],[0056],[0059]-[0060],[0062],[0070],[0079],[0081],[0130],[0142],[0147],[0174],[0193],[0202],[0219],[0224],[0226]	1-4, 8-18, 20 ----- 5-7, 19
Y	US 2022/0163959 A1 (Strong Force IOT Portfolio 2016, LLC) 26 May 2022 (26.05.2022), entire document, especially [0012],[1538],[2205]	5-7, 19

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
 29 December 2023 (29.12.2023)

Date of mailing of the international search report

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