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(54) **SYSTEMS AND METHODS FOR ENRICHING A VIRTUAL REALITY TOUR**

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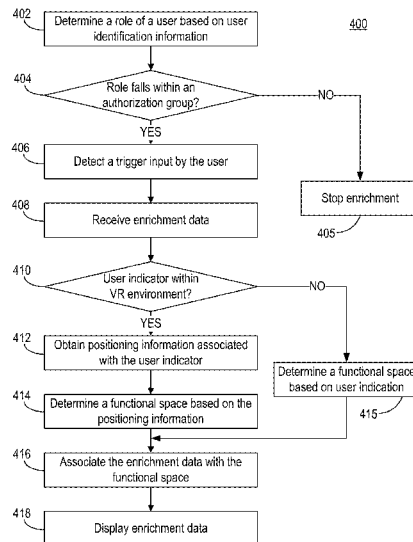
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(57) **ABSTRACT**

Systems and methods are provided for enriching an in-door virtual reality (VR) tour. An exemplary system may include a communication interface configured to receive input from a user, a memory storing computer-readable instructions, and at least one processor coupled to the communication interface and the memory. The computer-readable instructions, when executed by the at least one processor, may cause the at least one processor to perform operations. The operations may include detecting, through the communication interface, a trigger input by the user. In response to the detection of the trigger, the operations may include receiving, through the communication interface, enrichment data input by the user. The operations may also include determining a functional space based on a user indicator representing the user in the in-door VR tour. The operations may further include associating the enrichment data with the functional space.

**15 Claims, 6 Drawing Sheets**



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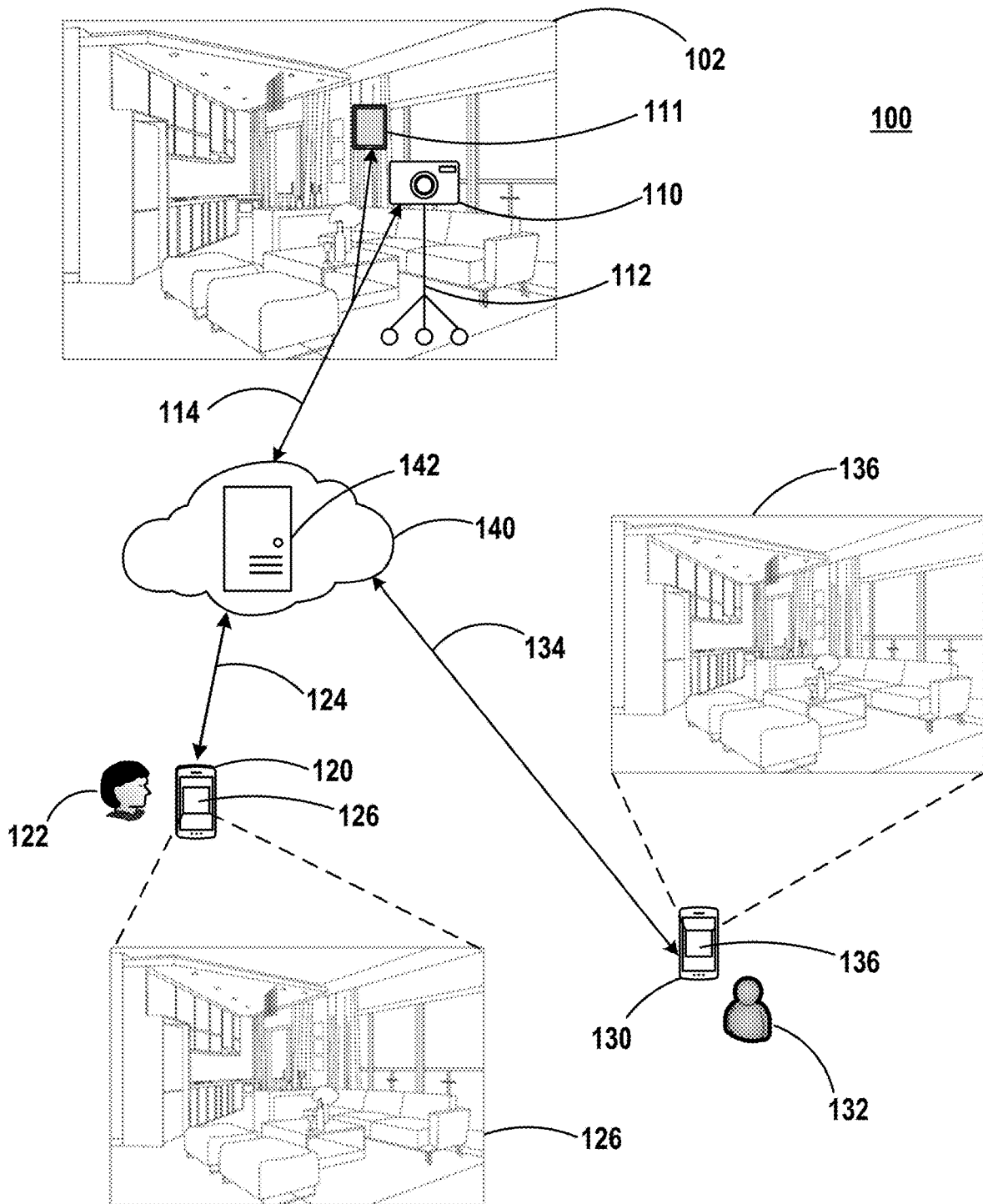


FIG. 1

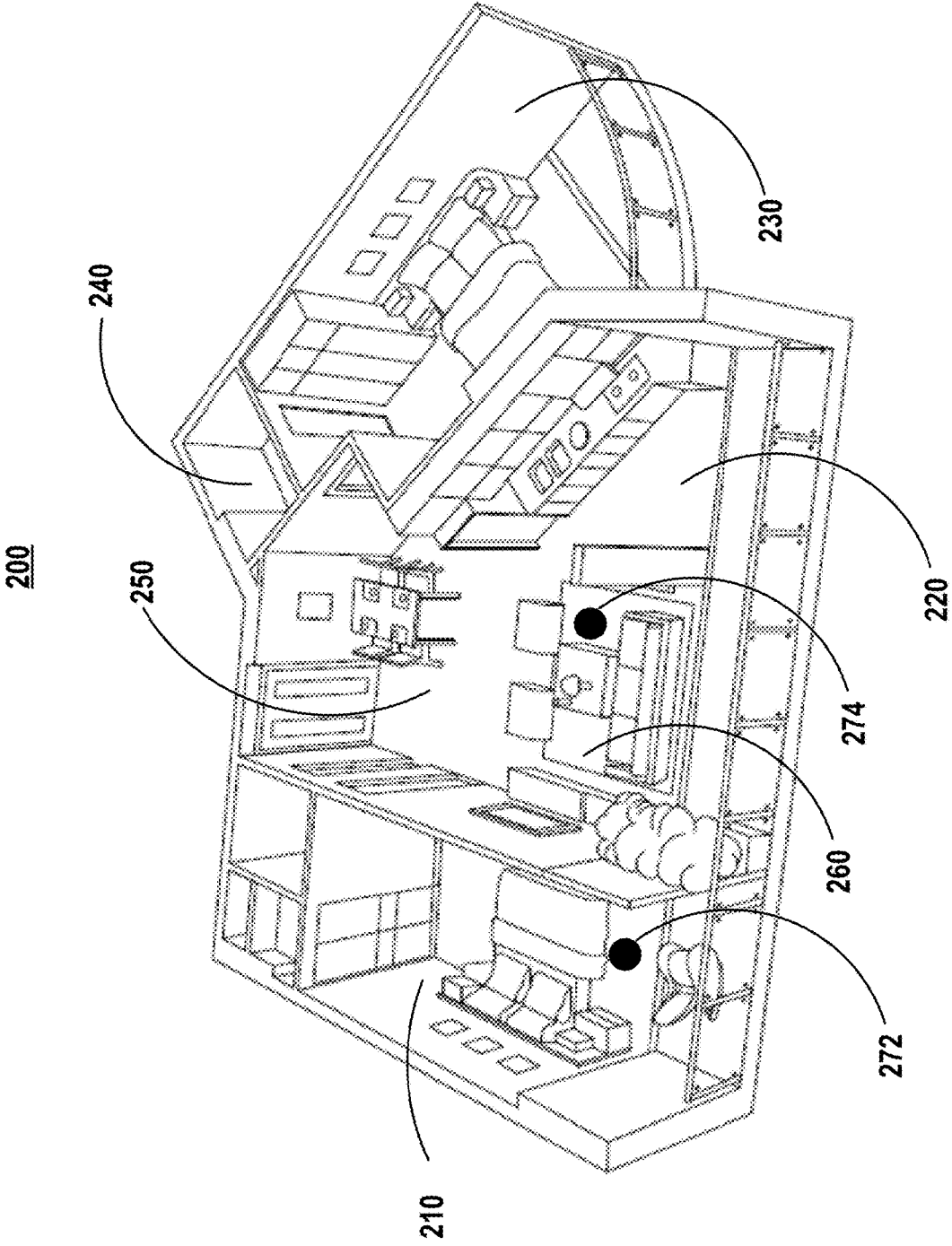


FIG. 2

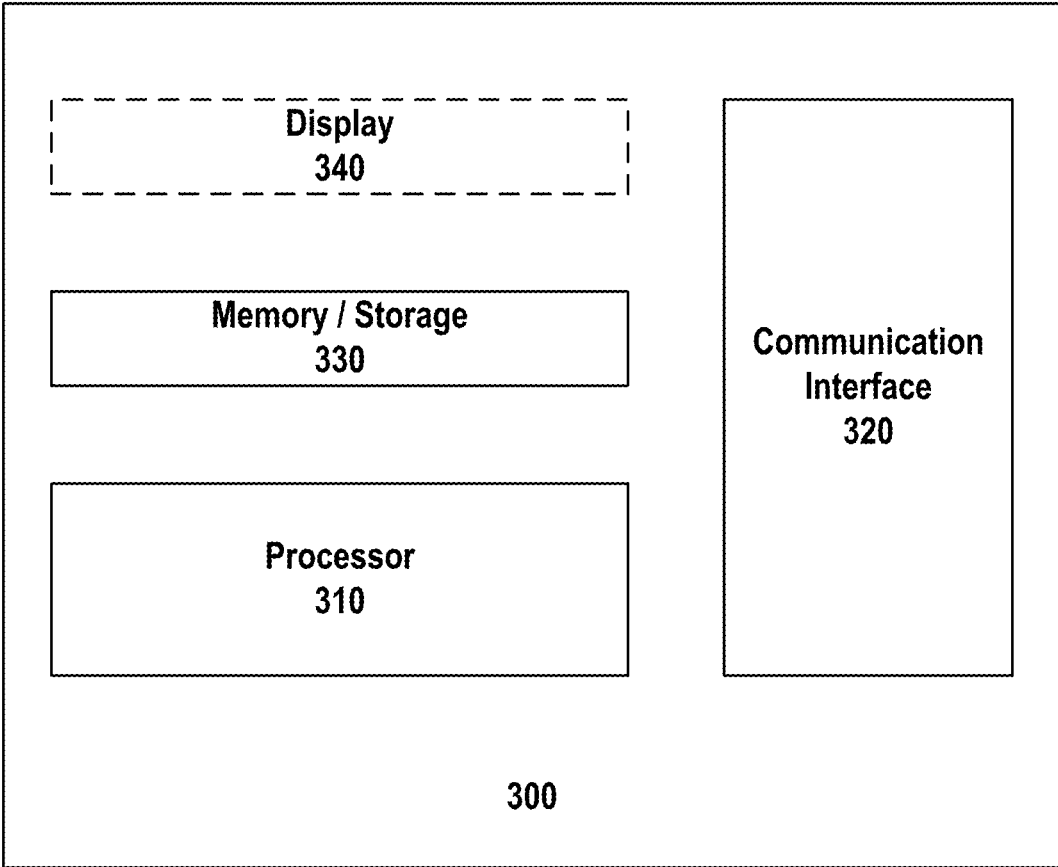


FIG. 3

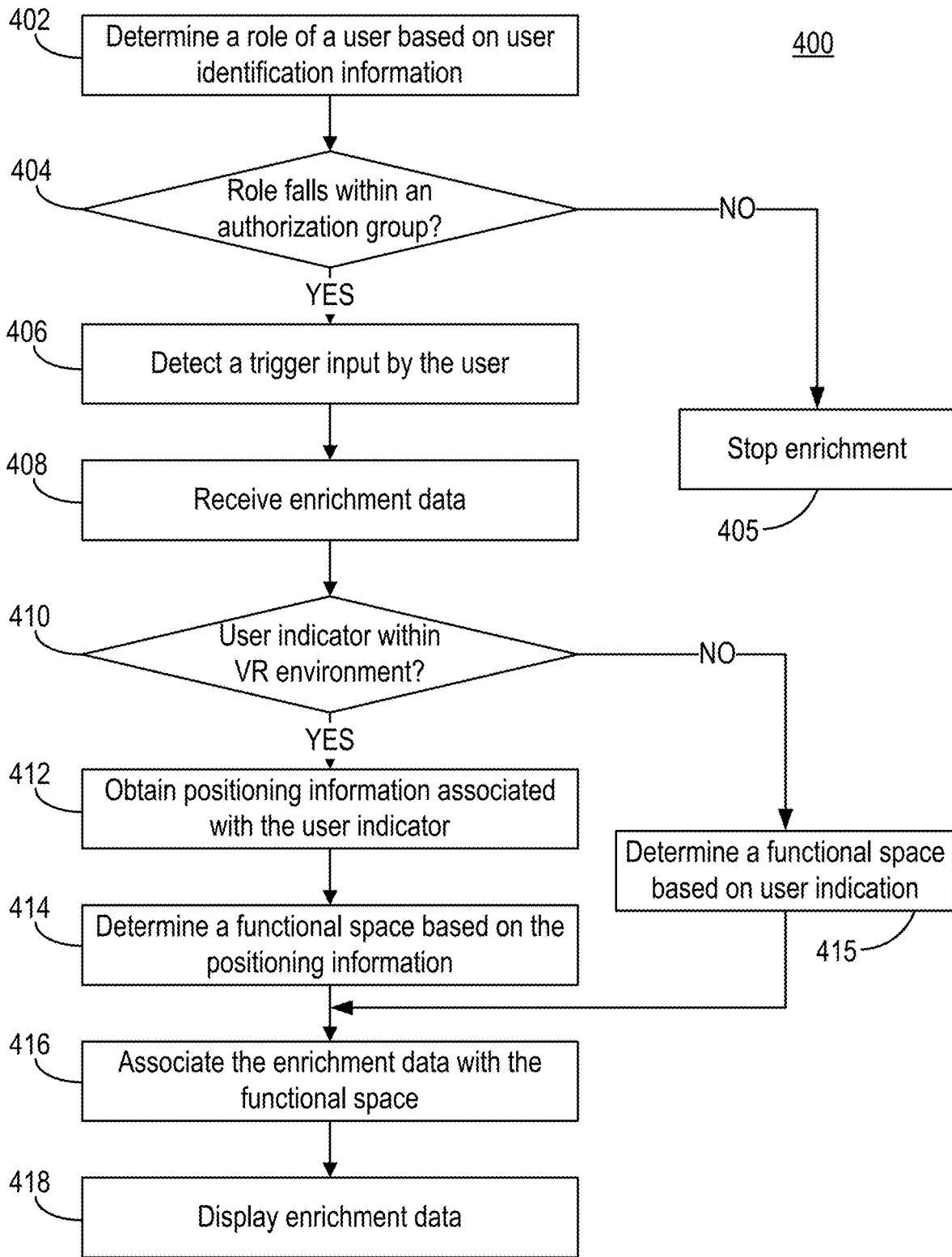


FIG. 4

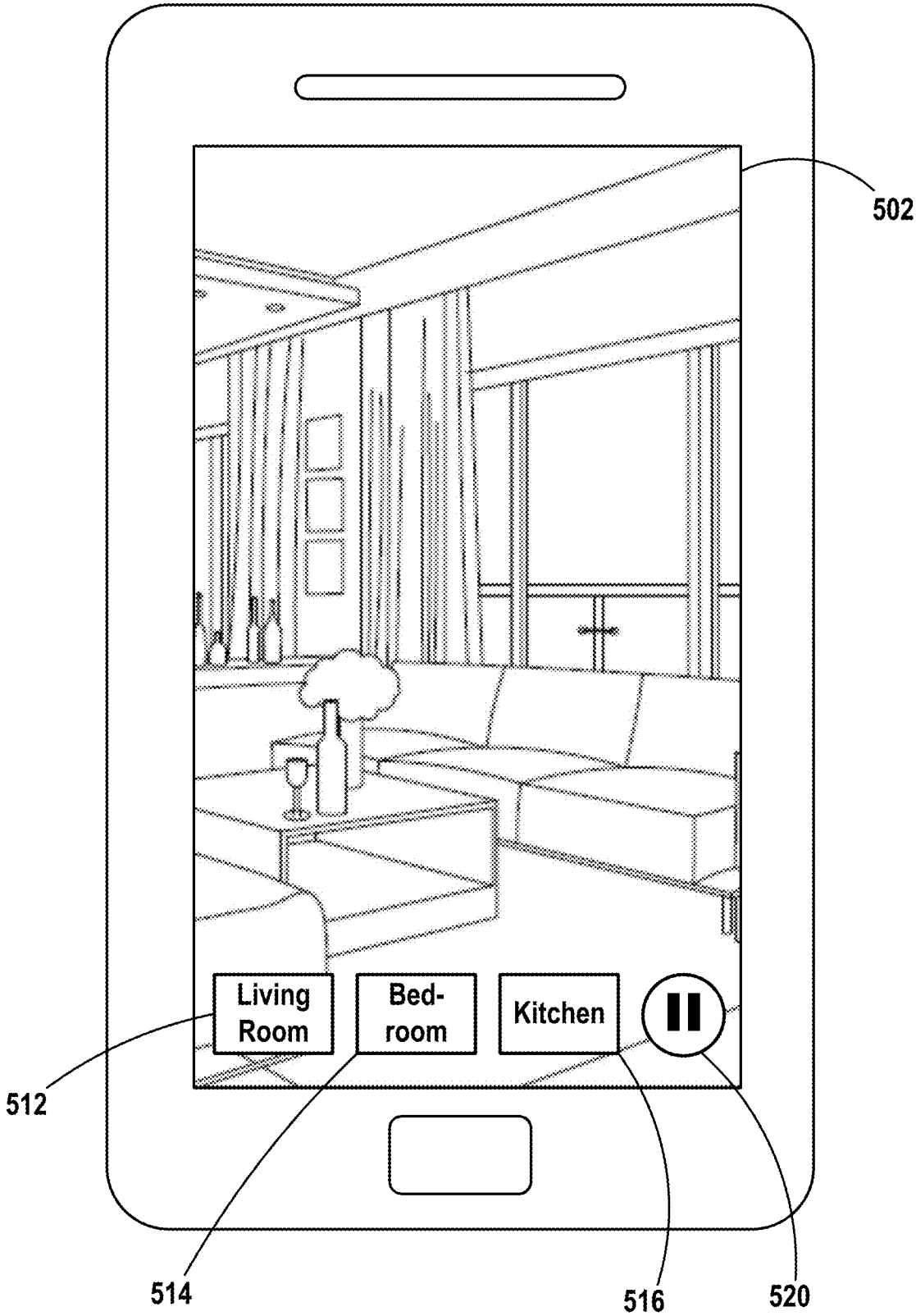


FIG. 5

600

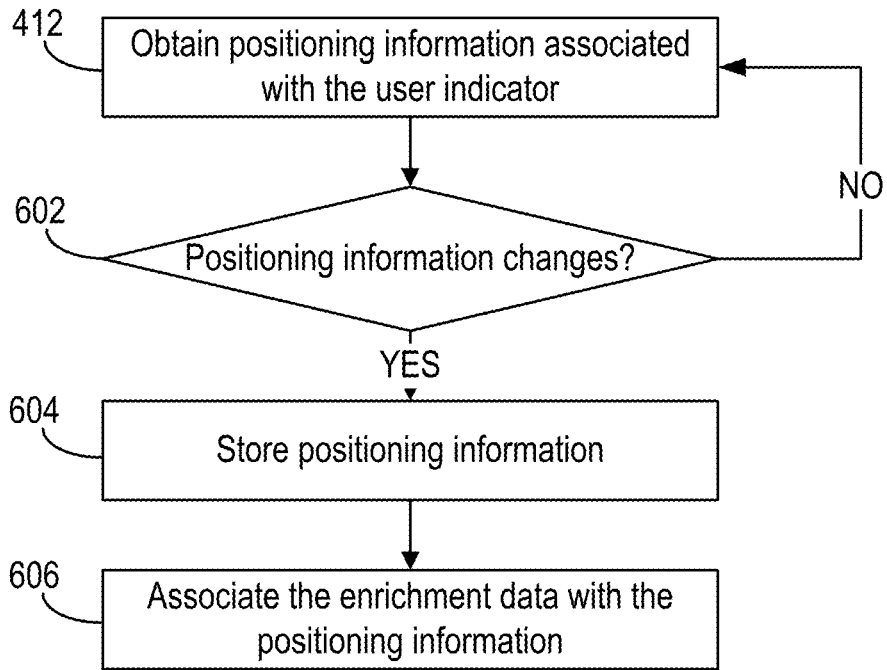


FIG. 6



## SYSTEMS AND METHODS FOR ENRICHING A VIRTUAL REALITY TOUR

### RELATED APPELLATIONS

This application claims the benefits of priority to Chinese Application Nos. CN 201810538113.5, filed May 30, 2018 and CN 201810540328.0, filed May 30, 2018. The entire contents of the above-identified applications are expressly incorporated herein by reference.

### TECHNICAL FIELD

The present application relates to virtual reality (VR) technologies. More specifically, the present application relates to systems and methods for enriching a VR tour in an in-door environment.

### BACKGROUND

Conventional real estate sales rely on distribution of paper pamphlets and advertisement through newspaper and other paper-based media channels. These off-line advertising methods suffer from low efficiency and limited customer base. Promoting real estate sales on-line has become popular thanks to the proliferation of Internet and network-connected mobile devices. Real estate information augmentation services may collect for-sale information and distribute such information to subscribers through mailing list or publish the information on websites or mobile app portals. While the on-line approach improves the timeliness and reaches a larger audience, the contents delivered on-line remain largely the same as their off-line counterparts. For example, a typical on-line real estate advertisement includes a set of photos of the subject property and some textual descriptions. In order to gain more detailed knowledge about the property, such as specific parts not covered or insufficiently depicted by the photos, a visit to the property would normally be required. In addition, the textual descriptions are often provided in the form of a laundry list, lacking context to specific features of the underlying real estate property.

Embodiments of the present disclosure improve the user experience in exploring and virtually touring real estate properties by providing VR tours enriched by multimedia contents to provide contextual information.

### SUMMARY

In one aspect, a system is provided for providing an in-door VR tour. The system may include a communication interface configured to receive input from a user, a memory storing computer-readable instructions, and at least one processor coupled to the communication interface and the memory. The computer-readable instructions, when executed by the at least one processor, may cause the at least one processor to perform operations. The operations may include detecting, through the communication interface, a trigger input by the user. In response to the detection of the trigger, the operations may include receiving, through the communication interface, enrichment data input by the user. The operations may also include determining a functional space based on a user indicator representing the user in the in-door VR tour. The operations may further include associating the enrichment data with the functional space.

In another aspect, a method is provided for enriching an in-door VR tour. The method may include detecting, through

a communication interface, a trigger input by a user. In response to the detection of the trigger, the method may include receiving, through the communication interface, enrichment data input by the user. The method may also include determining, by at least one processor, a functional space based on a user indicator representing the user in the in-door VR tour. The method may further include associating, by the at least one processor, the enrichment data with the functional space.

In a further aspect, a non-transitory computer-readable medium is provided. The non-transitory computer-readable medium may store instructions that, when executed by at least one processor, cause the at least one processor to perform a method for enriching an in-door VR tour. The method may include detecting, through a communication interface, a trigger input by a user. In response to the detection of the trigger, the method may include receiving, through the communication interface, enrichment data input by the user. The method may also include determining a functional space based on a user indicator representing the user in the in-door VR tour. The method may further include associating the enrichment data with the functional space.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an exemplary system for providing an in-door VR tour, according to embodiments of the disclosure.

FIG. 2 illustrates an exemplary three-dimensional (3D) VR environment, according to embodiments of the disclosure.

FIG. 3 illustrates a block diagram of an exemplary computer system configured to provide, display, or enrich an in-door VR tour, according to embodiments of the disclosure.

FIG. 4 is a flow chart of an exemplary method for enriching an in-door VR tour, according to embodiments of the disclosure.

FIG. 5 illustrates an exemplary user interface for displaying or enriching an in-door VR tour, according to embodiments of the disclosure.

FIG. 6 is a flow chart of another exemplary method for enriching an in-door VR tour, according to embodiments of the disclosure.

### DETAILED DESCRIPTION

Reference will now be made in detail to the exemplary embodiments, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. 1 illustrates an exemplary system **100** for providing an in-door VR tour, according to embodiments of the disclosure. System **100** may include a data capturing portion, a data processing portion, and a VR displaying portion. The data capturing portion may include a camera device **110** configured to capture images of an in-door environment **102**, which may include enclosed or partially-enclosed space, such as one or more rooms of a residential or commercial real estate property, passenger or cargo space of a vessel (e.g., car, truck, recreational vehicle, trailer, train, ship, plane, etc.), a hall/suite/room of a cultural, political, indus-

trial, or business establishment, etc. In-door environment **102** may include fixtures (e.g., lights, fans, cabinets, closets, etc.), structures (furniture, decorations, etc.), or other features. In some embodiments, in-door environment **102** may include part of a real estate property that may be for sale or rent. For example, the example shown in FIG. **1** depicts a living room of an apartment, house, or office building. Embodiments of the disclosure may create a 3D model of in-door environment **102** to facilitate the provision of a VR tour of the in-door environment. For example, multiple images of in-door environment **102** may be captured, aligned, and combined to recreate or reconstruct a 3D representation of the in-door environment **102**. In some embodiments, range, depth, or distance information may also be acquired to aid in creating the 3D model.

In some embodiments, camera device **110** may be configured to capture images of in-door environment **102**. The image data captured by camera device **110** may include static images or photos, motion images or videos, 3D images including range, depth, or distance information, or any combination thereof. For example, camera device **110** may include a specially designed VR camera or 3D camera configured to capture 3D images having range/depth/distance information. In this case, camera device **110** may include multiple lenses. One or more of the lenses may be configured to capture the color or intensity information, while one or more other lenses may be configured to capture the range/depth/distance information. The color/intensity information and range/depth/distance information may be stored locally in a memory of camera device **110**, transmitted to an accompanying mobile device (**111**) located in the proximity to the camera device, and/or streamed to a remote server, such as server **142** located in a cloud computing service **140**, which will be discussed in greater detail below. For example, when mobile device **111** is used, image data captured by camera device **110** may be transmitted to mobile device **111**, where the image data may be preprocessed, including, for example, aligning and/or combining point cloud data captured at different shooting angles or positions, adding one or more feature points such as those on windows or mirrors, and conditioning the image data for transmission, such as streaming, dividing into packets, and/or compressing the image data.

In some embodiments, camera device **110** may include a camera not specifically designed to acquire 3D model data, such as a general-purpose digital camera, a camera equipped on a mobile device (e.g., a smart phone camera, a tablet camera, a laptop camera, etc.), a webcam, an action/sports camera, a panorama or 360-degree camera, or the like. In this case, images captured by camera device **110** may be aligned and combined based on feature recognition, image registration, machine learning, or other suitable techniques to convert multiple patches of 2D images into a 3D model.

In some embodiments, camera device **110** may include, separate from the image capturing device, a range device such as a light-based sensor (e.g., infra-red, laser, etc.) to acquire range/depth/distance information, which may be associated with 2D images captured by camera device **110** to create a 3D model.

As shown in the example of FIG. **1**, camera device **110** may be installed on a stand **112**. In some embodiments, stand **112** may include a tripod or similar supporting structures. Camera device **110** may be coupled to stand **112** through mounting, screwing, magnetically attaching, or any suitable mechanism to physically associate with stand **112**.

In some embodiments, camera device **110** may be rigidly associated with stand **112**. For example, the connection

between camera device **110** and stand **112** may not allow significant movement of camera device **110** relative to stand **112**. In some embodiments, camera device **110** may be flexibly associated with stand **112**. For example, camera device **110** may be connected to stand **112** via a ball head, pan head, gimbal, CV-joint, track, slider, etc., to allow movement (e.g., tilt, pan, linear motion, or the like) of camera device **110** relative to stand **112**. In some embodiments, motion of camera device **110** may be manually or remotely controlled by an operator. In some embodiments, motion of camera device **110** may be automatically controlled by a motorized mechanism and may be based on a predetermined routine or feedback from the captured information.

In some embodiment, stand **112** may be equipped with a motion mechanism to move around. For example, stand **112** may include wheels or similar structures to allow movement within in-door environment **102**. Stand **112** may be motorized to propel itself. For example, stand **112** may be mounted on or integrated with a motorized base, cart, or robotic platform. In some embodiments, the motion of stand **112** may be controlled by an operator. In some embodiments, the motion of stand **112** may be automatically controlled based on a predetermined routine or feedback from the captured information.

In some embodiments, stand **112** may be omitted. For example, camera device **110** may be placed directly on any suitable surface or held by a user during an image capturing process.

The captured image data of in-door environment **102** may be processed by the data processing portion of system **100**. In some embodiments, the data processing portion may include a cloud computing service (also referred to as cloud service or simply cloud) **140** comprising one or more servers **142** (hereinafter collectively referred to as server **142**). Image data captured by camera device **110** may be transmitted to cloud **140** via a communication channel **114**. In some embodiments, communication channel **114** may include a wired or physical connection, such as a data cable or card reader. In some embodiments, communication channel **114** may include a wireless connection, such as a wireless local area network (WLAN) connection, Bluetooth connection, telecommunication link (e.g., 3G, 4G, 5G, etc.), or the like. In some embodiments, when mobile device **111** is used to process the image data captured by camera device **110**, mobile device **111** may be part of the data processing portion. In this case, communication channel **114** may be between mobile device **111** and cloud **140** in addition to or instead of between camera device **110** and cloud **140**.

Server **142** may include data processing devices to process the image data received from camera device **110** and/or mobile device **111**. For example, the image data may include multiple images of in-door environment **102** captured at multiple locations and/or multiple shooting angles. The multiple images may include high-definition color photos, sometimes with multiple exposure levels, of features in the in-door environment **102**. The multiple images may also include or be associated with 3D range data (e.g., 3D point cloud data) and/or geographical information (e.g., GPS information) of in-door environment **102**. Based on the image data, server **142** may map the features contained in the images as well as image textures and details to a 3D model representing the in-door environment **102** using techniques such as automatic model creation, intelligent hole filling, automatic data extraction, and high-dynamic range (HDR) optimization. In this way, in-door environment **102** can be reconstructed in virtual reality to allow users to

explore, examine, and experience the features of in-door environment **102** in high fidelity without being physically present therein. In some embodiments, part or all of the data processing may be performed by mobile device **111**. For example, mobile device **111** and server **142** may work in tandem to process the image data captured by camera device **110**.

Viewing or touring the reconstructed in-door environment **102** can be accomplished through various ways, such as using a terminal device. For example, as shown in FIG. 1, a user **122** may use a terminal device **120** to view or virtually tour the VR version of the in-door environment (referred to as VR environment **126**) displayed on terminal device **120**. In some embodiments, terminal device **120** may communicate with cloud **140** to exchange information about displaying VR environment **126**. For example, data related to the VR environment **126**, such as the 3D model of in-door environment **102**, color information, texture information, spatial relationship among various features/objects, and one or more default view points, view angles, and/or field of views may be transmitted from cloud **140** to terminal device **120** via a communication channel **124**. User **122** may manipulate the view point, view angle, and field of view in the VR environment **126** to explore various features, for example to virtually “move” along a route to change the view point, pan/tilt to change the view angle, and zoom in/out to change the field of view. These manipulations may be fed back to cloud **140** via communication channel **124** to update the content of the VR environment **126** displayed on terminal device **120**. Communication channel **124** may include any suitable wired or wireless connections between cloud **140** and terminal device **124**, such as a broadband connection (e.g., via WLAN, LAN, and/or short-range communication links such as Bluetooth), a telecommunication link (e.g., 3G, 4G, 5G, etc.), or the like.

VR environment **126** displayed on terminal device **120** may be enriched with various enrichment data. For example, audio description or guidance may be added to VR environment **126** to enrich the user experience. The audio description or guidance may include a recorded voice guidance to introduce features of in-door environment **102**, background information, or other information to assist user **122** in understanding the features or characteristics of in-door environment **102**. In another example, video demonstration may be provided to showcase certain features displayed in VR environment **126**. In yet another example, one or more spatial operations altering the view of the VR environment **126** may be added to direct the user’s attention to specific aspects of VR environment **126**. Exemplary spatial operations may include panning, tilting, zooming, sliding or moving in any suitable manner, etc. These multimedia contents enrich the VR environment **126** by engaging user **122** with additional layers of interactions, thereby improving the user experience.

Enrichment data such as audio description, video demonstration, and spatial operations altering the view of the VR environment **126** may be added by a user **132**. In some embodiments, user **132** may have a role falling within a predetermined authorization group, such as a realtor, an owner or manager of a real estate property, or the like. User **132** may operate a terminal device **130** to create enrichment data or upload pre-created enrichment data to cloud **140**. For example, terminal device **130** may display a 3D VR environment **136** (also referred to as VR environment **136** or environment **136** for simplicity) that may be similar to VR environment **126** but may include additional interface elements configured for creating or adding enrichment data.

When user **132** is navigating through VR environment **136**, a user indicator, which may or may not be visible in VR environment **136**, may be used to determine the field of view depicted on terminal device **130**. For example, the user indicator may be represented by a view point within VR environment **136** simulating the position where user **132** is virtually located within VR environment **136** and the direction toward which user **132** faces. In some embodiments, whether the user indicator is within VR environment **136** or not may indicate whether user **132** engages or experiences VR environment **136**.

Terminal device **130** may communicate with cloud **140** via communication channel **134**, which may be similar to communication channel **124**. Enrichment data created or uploaded by user **132** may be transmitted to cloud **140** via communication channel **134**. After receiving the enrichment data, cloud **140**, through server **142**, may update the 3D model of in-door environment **102** stored thereon by adding the enrichment data, and provide the updated VR environment **126** to user **122**.

FIG. 2 illustrates an exemplary 3D VR environment **200**, according to embodiments of the disclosure. As shown in FIG. 2, 3D VR environment **200** may simulate or represent a residential unit, such as an apartment or house floor. It is noted that 3D VR environment **200** is not limited to the example shown in FIG. 2. Rather, 3D VR environment **200** may include a VR representation of any in-door space or environment. Referring to FIG. 2, 3D VR environment **200** may include one or more functional spaces, such as **210**, **220**, **230**, **240**, **250**, and **260**. As used herein, a functional space refers to an enclosed or partially enclosed space that is associated with a particular function. In some cases, a functional space may correspond to a room. For example, functional space **210** may correspond to a first bedroom, and functional space **230** may correspond to a second bedroom. In some cases, a functional space may correspond to an enclosed or partially enclosed space within or adjacent to a room. For example, functional space **240** may correspond to a closet. In some cases, a function space may correspond to an area that is generally used for a specific purpose. For example, functional space **220** may correspond to a kitchen area, functional space **250** may correspond to a dining area, and functional space **260** may correspond to a living room. Although functional spaces **220**, **250**, and **260** may share the same room (e.g., an enclosed area), they may be considered as different functional spaces due to their different functions.

FIG. 3 illustrates a block diagram of an exemplary computer system **300** configured to implement various functions disclosed herein. For example, computer system **300** may be configured as server **142** to create or reconstruct VR environment **126**. In another example, computer system **300** may be configured as terminal device **120** or **130** to display or enrich VR environment **126/136**. As shown in FIG. 3, computer system **300** may include a processor **310**, a communication interface **320**, a memory/storage **330**, and a display **340**. Memory/storage **330** may be configured to store computer-readable instructions that, when executed by processor **310**, can cause processor **310** to perform various operations disclosed herein. Memory **330** may be any non-transitory type of mass storage, such as volatile or non-volatile, magnetic, semiconductor-based, tape-based, optical, removable, non-removable, or other type of storage device or tangible computer-readable medium including, but not limited to, a ROM, a flash memory, a dynamic RAM, and a static RAM.

Processor **310** may be configured to perform the operations in accordance with the instructions stored in memory

**330.** Processor **310** may include any appropriate type of general-purpose or special-purpose microprocessor, digital signal processor, microcontroller, or the like. Processor **310** may be configured as a separate processor module dedicated to performing one or more specific operations disclosed herein. Alternatively, processor **310** may be configured as a shared processor module capable of performing other operations unrelated to the one or more specific operations disclosed herein.

Communication interface **320** may be configured to communicate information between computer system **300** and other devices or systems. For example, communication interface **320** may include an integrated services digital network (ISDN) card, a cable modem, a satellite modem, or a modem to provide a data communication connection. As another example, communication interface **320** may include a local area network (LAN) card to provide a data communication connection to a compatible LAN. As a further example, communication interface **320** may include a high-speed network adapter such as a fiber optic network adaptor, 10G Ethernet adaptor, or the like. Wireless links can also be implemented by communication interface **320**. In such an implementation, communication interface **320** can send and receive electrical, electromagnetic or optical signals that carry digital data streams representing various types of information via a network. The network can typically include a cellular communication network, a Wireless Local Area Network (WLAN), a Wide Area Network (WAN), or the like.

Communication interface **320** may also include various I/O devices such as a keyboard, a mouse, a touchpad, a touch screen, a microphone, a camera, a biosensor, etc. User **122/132** may input data to terminal device **120/130** through communication interface **320**.

Display **340** may be integrated as part of computer system **300** or may be provided as a separate device communicatively coupled to computer system **300**. Display **340** may include a display device such as a Liquid Crystal Display (LCD), a Light Emitting Diode Display (LED), a plasma display, or any other type of display, and provide a Graphical User Interface (GUI) presented on the display for user input and data depiction. In some embodiments, display device **340** may include a VR goggle, a pair of VR glasses, or other similar devices that provide immersive VR experience. For example, VR environment **126/136** may be displayed on display **340**. In some embodiments, display **340** may be integrated as part of communication interface **320**.

FIG. 4 illustrates a flowchart of an exemplary method **400** for enriching a VR tour of an in-door environment (e.g., in-door environment **102**), according to embodiments of the disclosure. In some embodiments, method **400** may be implemented by server **142**. However, method **400** is not limited to that exemplary embodiment and may be implemented by terminal device **120/130** or jointly by server **142** and terminal device **120/130**. As discussed above, server **142** and/or terminal device **120/130** may be implemented by computer system **300**. Method **400** may include steps **402-418** as described below. It is to be appreciated that some of the steps may be optional to perform the disclosure provided herein. Further, some of the steps may be performed simultaneously, or in a different order than shown in FIG. 5 illustrates an exemplary user interface for displaying or enriching an in-door VR tour. Method **400** will be described together with FIGS. 3 and 5.

In step **402**, processor **310** may determine a role of a user based on user identification information. For example, processor **310** may obtain user identification information based

on, for example, log on information such as user name or ID, a user profile, and biological information such as fingerprint, voice, and iris information. Based on the user identification information, processor **310** may determine the role of the user. The role may include, for example, a property viewer, a potential buyer/renter, a realtor, a property owner, a property manager, etc. For example, user **122** (shown in FIG. 1) may be a property viewer or potential buyer/renter, while user **132** may be a realtor, a property owner, or a property manager. Different roles may be provided with different features. For example, the feature of enriching a VR tour may be provided to the realtor, owner, and/or manager of a property, but may not be provided to general viewers.

In step **404**, processor **310** may determine whether the role determined in step **402** falls within a predetermined authorization group. For example, for a given property, the authorization group may include the realtor, owner, and/or manager of the property. In another example, the authorization group may include those users who have been authorized to provided enrichment data. If processor **310** determines that the role does not fall within the predetermined authorization group (the NO branch following step **404**), then method **400** proceeds to step **405**, in which the enrichment process may be stopped.

If processor **310** determines that the role falls within the predetermined authorization group (the YES branch following step **404**), then method **400** proceeds to step **406**, in which processor **310** may detect a trigger input by the user. In some embodiments, the trigger may include a pressing of holding of a predetermined button or key displayed to the user. For example, referring to FIG. 5, processor **310** may detect the trigger when a user (e.g., user **132**) presses or holds a record button **520**. In another example, processor **310** may detect the trigger when a user (e.g., user **132**) presses or holds one of the functional space buttons **512**, **514**, and **516**. It is noted that the buttons shown in FIG. 5 are exemplary only. Other forms of triggering mechanisms can also be used to initiate the enrichment data input process.

In response to the detection of the trigger, method **400** proceeds to step **408**, in which processor **310** may receive enrichment data input by the user through communication interface **320**. The enrichment data may take various forms. For example, the enrichment data may include an audio stream containing audio description of in-door environment **102**. In another example, the enrichment data may include a video stream containing video demonstration of in-door environment **102**. In yet another example, the enrichment data may include one or more spatial operations altering a view associated with the in-door VR tour, such as panning, tilting, zooming, sliding or moving in any suitable manner, etc. The enrichment data may be input through a microphone, a camera, operations on a touch screen, or any suitable manner provided by communication interface **320**.

In step **410**, processor **310** may determine whether a user indicator is within a 3D VR environment associated with the in-door VR tour. As discussed above, the user indicator may represent the user in the in-door VR tour and can be used to determine the field of view depicted on terminal device **130** when user **132** is navigating through VR environment **136**. The user indicator may or may not be visible in VR environment **136**. For example, the user indicator may be represented by a view point within VR environment **136** simulating the position where user **132** is virtually located within VR environment **136** and the direction toward which user **132** faces. In some embodiments, whether the user

indicator is within VR environment 136 or not may indicate whether user 132 engages or experiences VR environment 136.

If processor 310 determines that the user indicator is within VR environment 136 (the YES branch following step 410), method 400 proceeds to step 412, in which processor 310 may obtain positioning information associated with the user indicator. In some embodiments, the positioning information may include a spatial location of the user indicator within a VR environment (e.g., VR environment 136) associated with the in-door VR tour. For example, processor 310 may obtain the spatial location of the user indicator based on the position of the user indicator relative to other structures in the 3D model of the in-door environment. In some embodiments, the positioning information may include a field of view of the user indicator within the VR environment. For example, processor 310 may determine the position of the user indicator based on the current field of view experienced by the user indicator (e.g., displayed on terminal device 130).

In step 414, processor 310 may determine a functional space based on the positioning information. For example, based on the current location of the user indicator, processor 310 may determine in which functional space the user indicator is currently present. In another example, processor 310 may determine the functional space the user (e.g., user 132) is currently viewing (e.g., experiencing the VR tour) on terminal device 130. Referring to FIG. 2, when the positioning information indicates that the user indicator is located in position 272, processor 310 may determine that user indicator is in functional space 210 (e.g., bedroom). In another example, when the positioning information indicates that the user indicator is located in position 274, processor 310 may determine that user indicator is in functional space 260 (e.g., living room).

If, in step 410, processor 310 determines that the user indicator is not within VR environment 136 (the NO branch following step 410), method 400 proceeds to step 415, in which processor 310 may determine the functional space based on user indication. For example, user 132 may indicate which functional space is selected for adding enrichment data. Take the exemplary interface shown in FIG. 5 for example, user 132 may click one of the buttons 512, 514, or 516 to indicate which one of these functional spaces is to be associated with enrichment data.

In step 416, processor 310 may associate the enrichment data with the functional space determined in step 414 or 415. In the case of making association based on the result of step 414, processor 310 may associate the enrichment data created by user 132 while viewing or experiencing a functional space with that functional space. In this way, the added enrichment data may be automatically associated with the corresponding functional space. For example, when user 132 is “walking through” (e.g., in VR sense) a bedroom during a VR tour, the user, who may be a realtor, may introduce to the potential buyers features of the bedroom by making a voice recording (e.g., in the form of an audio stream). Processor 310 may determine that user 132 is positioned in the bedroom while making the voice recording based on the positioning information of the user indicator, and automatically associate the voice recording with the bedroom. In another example, user 132 may create a video demo of how to operate an appliance in the kitchen during a VR tour. Processor 310 may determine that the functional space corresponding to the creation of the video demo is the kitchen and automatically associate the video demo with the kitchen. In a further example, user 132 may change the field

of view to focus on a ceiling light during a VR tour of the living room. Processor 310 may identify living room as the proper functional space relevant to the spatial operation of changing the field of view, and automatically associate the changing of the field of view with the living room.

In the case of making association based on the result of step 415, user 132 may upload one or more enrichment data sets, each may be identified by a reference number (e.g., number 1 to 5). Based on user indication or a preset rule, processor 310 may establish mapping relationship between the uploaded enrichment data set and corresponding functional space. For example, enrichment data set 1 may be mapped to functional space 210 (shown in FIG. 2), enrichment data set 2 may be mapped to functional space 220, etc.

In step 418, processor 310 may display the enrichment data to users who wish to take a VR tour. For example, processor 310 may order multiple enrichment data sets according to their associated functional spaces and display a list of options on the user interface of a terminal device (e.g., terminal device 120). For example, buttons 512-516 shown in FIG. 5 are examples of enrichment data displayed on a terminal device. In some embodiments, user 122 may select a button to play the enrichment data, knowing that the enrichment data to be played are associated with a particular functional space. In some embodiments, a button corresponding to a functional space may appear when user 122 is within (in VR sense) that functional space. In the way, enrichment data can be classified and organized according to their relevant functional space, improving the user experience during a VR tour.

FIG. 6 is a flow chart of an exemplary method 600 for associating enrichment data with positioning information, according to embodiments of the disclosure. Method 600 may start from step 412 of method 400. Steps prior to step 412 of method 400 may or may not be present in method 600. Referring to FIG. 6, following step 412, processor 310 may detecting whether the positioning information changes in step 602. For example, processor 310 may repeatedly determine the positioning information and compare whether a change occurs. In another example, processor 310 may detect a difference between consecutive positioning information. When the difference exceeds a threshold, then processor 310 may determine that a change of the positioning information occurs. If no change is detected (the NO branch following step 602), then method 600 loops back to step 412 to repeatedly determine the positioning information. If, on the other hand, a changes is detected (the YES branch following step 602), then method 600 proceeds to step 604, in which processor 310 may store the positioning information in memory/storage 330. In step 606, processor 606 may associate the enrichment data with the stored positioning information. In this way, the enrichment data can be more precisely associated with the positioning information. For example, a first voice description describing the sofa can be associated with the position of the sofa, while a second voice description describing the coffee table can be associated with the position of the coffee table, even though the sofa and coffee table may both in the same functional space (e.g., living room).

Another aspect of the disclosure is directed to a non-transitory computer-readable medium storing instructions which, when executed, cause one or more processors to perform the methods, as discussed above. The computer-readable medium may include volatile or non-volatile, magnetic, semiconductor, tape, optical, removable, non-removable, or other types of computer-readable medium or computer-readable storage devices. For example, the com-

puter-readable medium may be the storage device or the memory module having the computer instructions stored thereon, as disclosed. In some embodiments, the computer-readable medium may be a disc or a flash drive having the computer instructions stored thereon.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed system and related methods. Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the disclosed system and related methods.

It is intended that the specification and examples be considered as exemplary only, with a true scope being indicated by the following claims and their equivalents.

The invention claimed is:

**1.** A system for providing an in-door virtual reality (VR) tour, comprising:

a communication interface configured to receive input from a user;

a memory storing computer-readable instructions; and  
at least one processor coupled to the communication interface and the memory, wherein the computer-readable instructions, when executed by the at least one processor, cause the at least one processor to perform operations comprising:

detecting, through the communication interface, a trigger input by the user;

obtaining user identification information;

determining a role of the user based on the user identification information;

determining whether the role of the user falls within a predetermined authorization group comprising at least one of a realtor, a property owner, or a property manager;

in response to the detection of the trigger and a determination that the role of the user falls within the predetermined authorization group, receiving, through the communication interface, enrichment data input by the user, wherein the enrichment data comprise a video stream containing a video demonstration of an in-door environment;

determining a functional space based on a user indicator representing the user in the in-door VR tour; associating the enrichment data with the functional space;

determining positioning information associated with the user indicator;

associating the enrichment data with the positioning information; and

controlling a display to display the enrichment data.

**2.** The system of claim 1, wherein the operations comprise:

determining whether the user indicator is within a three-dimensional (3D) VR environment associated with the in-door VR tour;

in response to a determination that the user indicator is within the 3D VR environment, obtaining positioning information associated with the user indicator; and determining the functional space based on the positioning information.

**3.** The system of claim 2, wherein the operations comprise:

in response to a determination that the user indicator is not within the 3D VR environment, determining the functional space based on an indication provided by the user.

**4.** The system of claim 2, wherein the trigger comprises a pressing or holding of a predetermined button displayed to the user.

**5.** The system of claim 1, wherein the operations comprise:

repeatedly determining the positioning information; detecting whether the positioning information changes; and

storing the positioning information in the memory in response to a detection of a change in the position information.

**6.** The system of claim 1, wherein the positioning information comprises at least one of:

a spatial location of the user indicator within a three-dimensional (3D) VR environment associated with the in-door VR tour; or

a field of view of the user indicator within the 3D VR environment.

**7.** The system of claim 1, wherein the enrichment data comprise an audio stream or at least one spatial operation altering a view associated with the in-door VR tour.

**8.** A method for enriching an in-door virtual reality (VR) tour, comprising:

detecting, through a communication interface, a trigger input by a user;

obtaining user identification information;

determining a role of the user based on the user identification information;

determining whether the role of the user falls within a predetermined authorization group comprising at least one of a realtor, a property owner, or a property manager;

in response to the detection of the trigger and a determination that the role of the user falls within the predetermined authorization group, receiving, through the communication interface, enrichment data input by the user, wherein the enrichment data comprise a video stream containing a video demonstration of an in-door environment;

determining, by at least one processor, a functional space based on a user indicator representing the user in the in-door VR tour;

associating, by the at least one processor, the enrichment data with the functional space;

determining positioning information associated with the user indicator;

associating the enrichment data with the positioning information; and

displaying the enrichment data.

**9.** The method of claim 8, comprising:

determining whether the user indicator is within a three-dimensional (3D) VR environment associated with the in-door VR tour;

in response to a determination that the user indicator is within the 3D VR environment, obtaining positioning information associated with the user indicator; and determining the functional space based on the positioning information.

**10.** The method of claim 9, comprising:

in response to a determination that the user indicator is not within the 3D VR environment, determining the functional space based on an indication provided by the user.

**11.** The method of claim 9, wherein the trigger comprises a pressing or holding of a predetermined button displayed to the user.

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12. The method of claim 8, comprising:  
 repeatedly determining the positioning information;  
 detecting whether the positioning information changes;  
 and  
 storing the positioning information in response to a detec- 5  
 tion of a change in the position information.

13. The method of claim 8, wherein the positioning  
 information comprises at least one of:  
 a spatial location of the user indicator within a three- 10  
 dimensional (3D) VR environment associated with the  
 in-door VR tour; or  
 a field of view of the user indicator within the 3D VR  
 environment.

14. The method of claim 8, wherein the enrichment data 15  
 comprise an audio stream or at least one spatial operation  
 alerting a view associated with the in-door VR tour.

15. A non-transitory computer-readable medium storing  
 instructions that, when executed by at least one processor,  
 cause the at least one processor to perform a method for  
 enriching an in-door virtual reality (VR) tour, the method 20  
 comprising:

detecting, through a communication interface, a trigger  
 input by a user;

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obtaining user identification information;  
 determining a role of the user based on the user identifi-  
 cation information;  
 determining whether the role of the user falls within a  
 predetermined authorization group comprising at least  
 one of a realtor, a property owner, or a property  
 manager;  
 in response to the detection of the trigger and a determi-  
 nation that the role of the user falls within the prede-  
 termined authorization group, receiving, through the  
 communication interface, enrichment data input by the  
 user, wherein the enrichment data comprise a video  
 stream containing a video demonstration of an in-door  
 environment;  
 determining a functional space based on a user indicator 15  
 representing the user in the in-door VR tour;  
 associating the enrichment data with the functional space;  
 determining positioning information associated with the  
 user indicator;  
 associating the enrichment data with the positioning infor-  
 mation; and  
 controlling a display to display the enrichment data.

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