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Localization of devices in a structure

Abstract

Disclosed are various embodiments for localizing smart devices in a structure. An image of a portion of at least one room of a structure may be rendered on a display of the mobile device. A point in the image may be determined where a nonlocalized device is depicted, the nonlocalized device being positioned in the at least one room of the structure. The nonlocalized device is localized in the at least one room of the structure based on a position and orientation of the mobile device relative to the at least one room of the structure and based on a location of the point in the image. Alternatively, a location of a nonlocalized device in the structure may be determined by using the location of a mobile device as proxy.

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Background/Summary

BACKGROUND
(1) Recent advances in networking infrastructure have resulted in the streaming of content over the world wide web using smart devices. In addition, the advent of smart devices in the home provides for greater convenience and control in the home. Such advancements have resulted in a proliferation of so called smart devices and other devices in commercial and residential structures.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, with emphasis instead being placed upon clearly illustrating the principles of the disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

(2) FIG. **1** is a drawing of a networked environment that includes a mobile device and smart devices in a structure according to various embodiments of the present disclosure.

(3) FIG. **2** is a depicts a structure floor plan that includes smart devices included in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

(4) FIG. **3** is a drawing depicting the determination of distances between a smart device of FIG. **2** and multiple points within a structure in order to localize such smart device according to various embodiments of the present disclosure.

(5) FIG. **4** is a drawing depicting the generation of a point cloud that represents rooms of the structure using the mobile device of FIG. **1** according to various embodiments of the present disclosure.

(6) FIG. **5** is a drawing depicting a tap to locate approach to localizing one of the smart devices of FIG. **1** according to various embodiments of the present disclosure.

(7) FIG. **6** is a drawing depicting a self-identification signaling approach to localizing one of the smart devices of FIG. **1** according to various embodiments of the present disclosure.

(8) FIG. **7** is a drawing depicting a location by proximity approach to localizing one of the smart devices of FIG. **1** according to various embodiments of the present disclosure.

(9) FIG. **8** is a drawing of a user interface generated on the mobile device of FIG. **1** according to various embodiments of the present disclosure.

(10) FIG. **9** is a drawing of another user interface generated on the mobile device of FIG. **1** according to various embodiments of the present disclosure.

(11) FIG. **10** is a flow chart depicting functionality for localization of smart devices in the structure of FIG. **1** according to various embodiments of the present disclosure.

(12) FIGS. **11**A, **11**B, and **11**C are flow charts depicting further functionality for localization of smart devices in the structure of FIG. **1** according to various embodiments of the present disclosure.

(13) FIG. **12** is a flow chart depicting functionality for proximity localization of smart devices in the structure of FIG. **1** according to various embodiments of the present disclosure.

(14) FIG. **13** is a flow chart depicting functionality to determine a direction of cameras associated with some smart devices in the structure of FIG. **1** according to various embodiments of the present disclosure.

(15) FIG. **14** is a schematic block diagram that provides one example illustration of a computing environment employed in the networked environment of FIG. **1** according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

(16) A given structure such as a home may have multiple different smart devices that automate various activities in the home. Such smart devices may comprise smart bulbs, smart speakers, digital media players, and other smart devices. Some of these smart devices may communicate with other ones of the smart devices to accomplish a task. For example, a user may ask a smart speaker that provides for a digital virtual assistant to change the channel played by a digital media player. However, when there are multiple digital media players in the home, the digital virtual assistant may not know which digital media player to which the request is directed and may change the channel on the wrong digital media player.

(17) According to various embodiments, different approaches are provided to localize smart devices in a structure such as a home or business using a mobile device such as a smart phone. To

localize smart devices that transmit radio frequency signals or audio, a distance between such smart devices and multiple points in the structure may be determined by way of measuring signal strengths or by sonic ranging using a mobile device whose position in the structure is known. These distances may be used to localize such smart devices by way of multilateration or other approaches. For smart devices for which such an approach is not possible, localization may be performed by tapping on a screen of a mobile device to indicate the position of such devices on the screen and using ray casting techniques to determine a location for such devices relative to a point cloud created for rooms of the structure. In addition, devices may be localized by placing the mobile device next to such smart devices and using the location of the mobile device as the location of such smart device.

(18) In the following discussion, a general description of the system and its components is provided, followed by a discussion of the operation of the same.

(19) With reference to FIG. **1**, shown is a networked environment **100** according to various embodiments. The networked environment **100** includes a computing environment **103** that is coupled to a network **106**.

(20) The computing environment **103** may comprise, for example, a server computer or any other system providing computing capability. Alternatively, the computing environment **103** may employ a plurality of computing devices that may be arranged, for example, in one or more server banks or computer banks or other arrangements. Such computing devices may be located in a single installation or may be distributed among many different geographical locations. For example, the computing environment **103** may include a plurality of computing devices that together may comprise a hosted computing resource, a grid computing resource and/or any other distributed computing arrangement. In some cases, the computing environment **103** may correspond to an elastic computing resource where the allotted capacity of processing, network, storage, or other computing-related resources may vary over time.

(21) The network **106** may comprise, for example, the Internet and other networks as can be appreciated.

(22) The network **106** is coupled to, and in data communication with, a local area network **109** that is associated with a structure **113**. The structure **113** includes one or more rooms. The local area network **109** may comprise, for example, wide area networks (WANs), local area networks (LANs), wired networks, wireless networks, cellular networks, or other suitable networks, etc., or any combination of two or more such networks. For example, such networks may comprise Ethernet networks, wireless fidelity (WIFI) networks, and other types of networks.

(23) Associated with the structure **113** are a plurality of smart devices **116**. The smart devices **116** may comprise, for example, smart speakers, virtual assistants, smart bulbs, smart switches, temperature sensors, thermostats, contact sensors, smart plugs, cameras, digital media players, and other devices. According to one embodiment, a location of many of the smart devices **116** within a room of the structure **113** may not be known by other systems. Also associated with the structure is a smart home hub **119** that communicates with respective ones of the smart devices **116**. In this respect, the smart home hub **119** may communicate with various ones of the smart devices **116** by way of one or more network protocols such as WIFI, Zigbee, Zwave, or other protocols. Also, the smart home hub **119** may be coupled to the local area network **109** by way of a hardwire connection such as an Ethernet connection or communication between the smart home hub **119** and the local area network **109** may comprise a wireless connection such as WIFI or other connection.

(24) Some of the smart devices **116** are capable of transmitting electromagnetic signals **126** such as Bluetooth Low Energy (BLE) signals, WIFI signals, or other wireless signals. In one embodiment, such signals **126** announce the presence of a respective device including information about the device, the transmission power, and other information.

(25) Also, smart devices **116** may comprise a smart speaker that is capable of transmitting audio that may be used for sonic ranging as will be described.

(26) A mobile device **123** may be located within the structure from time to time. According to one embodiment, the mobile device **123** comprises a smart phone that communicates, for example, by way of a cellular network or WIFI. The mobile device **123** may be in data communication with the computing environment **103** and the various smart devices **116** through the local area network **109**. Alternatively, the mobile device **123** may communicate with the devices on the local area network **109** through the network **106** where the network **106** includes a cellular network as can be appreciated.

(27) Various applications that may be executed on the mobile device **123** include, for example, a mobile localization application **129** and other applications. The mobile localization application **129** is executed to localize the smart devices **116** by identifying their positions within one or more rooms within the structure **113** as will be described.

(28) According to various embodiments, the computing environment **103** includes various applications and data. For example, the applications may comprise instances of a digital virtual assistant **133**, a localization application **136**, and other applications not described herein. Also, various data may be stored a data store that is accessible by the digital virtual assistant **133**, the localization application **136**, and other applications. Such data includes, for example, a structure floorplan **139** and smart device data **117** that includes data about each of the smart devices **116** that are associated with the structure **113** as will be described. The structure floorplan **139** comprises a floorplan of the structure **113** according to one embodiment.

(29) The digital virtual assistant **133** comprises a system that resides in the computing environment **103** and performs various tasks such as voice interaction, playing music, creating to-do lists, providing information such as weather, traffic, news, or other information. The digital virtual assistant **133** may also control various smart devices **116** that are in data communication with the local area network **109** and the network **106**. For example, the digital virtual assistant **133** may control lights, audio components, and other smart devices **116** associated with the structure. In one embodiment, the digital virtual assistant **133** employs natural language processing in order to receive commands from people and perform tasks accordingly.

(30) In order to exercise control over various smart devices **116**, one or more of the smart devices **116** associated with the structure **113** are surfaced to or otherwise made known to the digital virtual assistant **133** and are included in the smart device data **117**. To this end, the digital virtual assistant **133** may be in communication with the smart home hub **119** or with other smart devices **116** directly coupled to the local area network **109** in order to exercise control over such smart devices **116**. For example, one might ask the digital virtual assistant **133** to turn on the lights in a given room and the digital virtual assistant **133** would communicate with the smart home hub **119** or individual light bulbs coupled to the local area network **109** to turn on the respective lights associated with the specified room. To this end, at least some of the smart devices **116** may be "digital virtual assistant" capable providing an interface by which a user may interact with the digital virtual assistant **133**. In this respect, such devices may relay questions or commands to the digital virtual assistant **133** that is executed in the computing environment **103**. In response to such questions or commands, the digital virtual assistant **133** may implement tasks and take such action as is appropriate. For example, the digital virtual assistant **133** may send a command to a smart device **116** coupled to the local area network **109** or to the smart home hub **119** that directs certain action be taken with respect to certain smart devices **116** such as turning lights on or off, closing or opening blinds, enabling or disabling security systems, or other action.

(31) Referring next to FIG. **2**, shown is an example of a structure floorplan **139** of the structure **113** (FIG. **1**) with which a number of smart devices **116***a-c* are associated. As shown, a plurality of smart devices **116***a*, **116***b*, and **116***c* that are positioned at various locations throughout the structure floorplan **139**.

(32) The smart devices **116***a* are capable of transmitting electromagnetic signals or radio frequency signals such as WIFI signals, Bluetooth Low Energy (BLE) signals, Zigbee signals, or Zwave

signals to communicate with other devices. Such signals may be remeasured in terms of Milliwatts (mW), decibels in relation to milliwatts (dBm), or some other units of measurement. For example, a BLE signal is typically designed for low power consumption transmitting data in the 2.4 GHZ frequency band. In another example, WIFI signals are transmitted in bands located at 2.4 GHz, 5 GHz, and other frequency bands.

(33) The signals transmitted by smart devices **116a** embody and identifier which comprises data that uniquely identifies the transmitting smart device **116a** relative to all other smart devices **116** (FIG. **1**) associated with a given structure **113**. Also, such signal may include information indicating a signal strength transmitted by the smart device **116a**. It is understood that such signals will become weaker as they propagate due to geometrical spreading and attenuation in the transmission medium such as air. As such, it is possible to estimate how far away the **123** is from a given smart device **116a** based on the received signal strength at the mobile device **123** that is positioned a distance away from the smart device **116a**.

(34) The smart devices **116b** may comprise, for example, audio devices such as smart speakers and the like. An audio smart devices **116b** may provide for sonic ranging to determine the distance between a mobile device **123** and the smart device **116b** at a given moment. Specifically, in order to determine a distance from a smart device **116b** and the mobile device **123**, a sonic pulse can be generated by the smart device **116** at time T.sub.1 and the sonic pulse is detected by the mobile device **123** at time T.sub.2. Given that the speed of sound through air is known, the distance between the respective smart device **116b** and the mobile device **123** may be calculated by determining the time it took for the pulse to travel through the air from the smart device **116b** to the mobile device **123**. The position of the mobile device **123** when the distance is determined is stored in memory along with a value for the actual distance calculated. This may be repeated multiple times until there are three or more measurements of distance between the respective smart device **116b** and the corresponding positions of the mobile device **123** where the sonic pulse generated by the respective smart device **116b** was detected by the mobile device **123**.

(35) The smart device **116** may be instructed to transmit the sonic pulse at time T.sub.1 by the digital virtual assistant **133** (FIG. **1**) or some other application. Also, the digital virtual assistant **133** provides the mobile device **123** with time T.sub.1 when the sonic pulse was transmitted taking into account a data communication delay between the digital virtual assistant **133** and the mobile device **123** if such a delay is substantial enough for consideration.

(36) The smart devices **116c** are those that may not transmit radio frequency signals or audio signals. Alternatively, if the smart devices **116c** do transmit radio frequency signals, the device identifier or the transmission signal strength may not be embodied in the signals they broadcast which prevents automatic localization for such devices.

(37) An example of a pathway **153** is noted in the structure floorplan **139** that traces movement of a mobile device **123** (FIG. **1**) when scanning the rooms within the structure **113** using a sensor such as a light detection and ranging (LIDAR) sensor or other scanning technology included in the mobile device **123** to generate a point cloud of the rooms of the structure **113** as will be described.

(38) In one embodiment, various ones of the smart devices **116** may be nonlocalized in that the specific locations of such smart devices **116** within the one or more rooms of the structure **113** are not known to the digital virtual assistant **133** or other applications. That is to say, a location of a given smart device **116** within the structure **113** may not be included in the information about the given smart device **116** stored as part of the smart device data **117**. As such, the digital virtual assistant **133** would not know where nonlocalized smart devices **116** are positioned with respect to the structure **113**. Thus, a nonlocalized smart device **116** refers to smart devices **116**, for example, for which a position relative to and/or within the structure **113** is unknown to the digital virtual assistant **133** as the position is not included in the smart device data **117** (FIG. **1**).

(39) According to one embodiment, the mobile device **123** may be employed to localize the nonlocalized smart devices **116**. As contemplated herein, localizing a nonlocalized smart device

116 refers to identifying the location of such nonlocalized smart device **116** relative to and/or within the structure **113**.

(40) With respect to FIG. **3**, shown is one example of how a nonlocalized smart device **116***a* may be localized according to one embodiment. As the mobile device **123** moves around the rooms of the structure **113**, its location at any given instant is known based on the ARCore Geospatial API provide by Google, Inc. of Mountain View, California. Alternatively, the mobile device **123** may maintain its position within the structure **113** based on signals from beacons, signals from cell phone towers, Global Positioning System signals, or based on some other approach.

(41) As the mobile device **123** moves along the pathway **153**, measurements are taken of the signal strength of radio frequency signals transmitted by one or more smart devices **116***a*. As shown in FIG. **3**, the mobile device **123** acquires measurements of the signal strength of a signal transmitted by any given smart device **116***a* at three locations **156***a*, **156***b*, and **156***c*. Alternatively, measurements of the signal strength of the signal from each of the smart devices **116***a* may be taken at many more locations than the three depicted. Also, the mobile device **123** may obtain the identification of the smart device **116***a* and the transmitted signal strength from the signal itself. When the mobile device **123** is placed in a mode to acquire the measurements of the signal strengths of the respective smart devices **116***a* as the mobile device **123** moves around the rooms of the structure **113**, the signal strength measured and the location in the structure **113** where the signal strength was measured is stored in association with the respective smart device **116***a* known by virtue of the identifier received in the signal transmitted by the smart device **116***a*. Also, the transmitted signal strength is associated with the respective smart device **116***a* and is stored in association with the smart device **116***a*.

(42) In some cases, the identifier may be encrypted where the actual identifier is known to the digital virtual assistant **133** or other application. In such case, the mobile device **123** may communicate with the digital virtual assistant **133** to provide the encrypted identifier thereto, where the digital virtual assistant **133** or other application transmits the actual identifier to the mobile device **123** in response.

(43) The smart devices **116***a* may transmit signals in various modes. For example, the transmission of signals may be periodic, ad hoc, or on demand. In a periodic mode, the signals may be transmitted once every second or interval during a specified period of time during the day. Alternatively, in an ad hoc mode, when the mobile device **123** is scanning for smart devices **116***a*, the mobile device **123** may send a signal to the smart devices **116***a* to begin to send signals at a high rate such as, for example, 10 times per second or other rate. The smart devices **116***a* would proceed to send such signals at the predefined rate. When the mobile device **123** is done with scanning function, it sends a signal to the mobile devices **116***a* to stop transmitting signals, where the smart devices **116***a* may revert to a periodic mode or other mode of operation. In an on demand mode, the mobile device **123** transmits a signal to the smart device(s) **116***a* to transmit a signal on demand as needed. The smart device(s) **116***a* may then respond by transmitting their signal. The mobile device **123** may repeatedly request that smart devices **116***a* within range transmit their signals as a scan of the structure **113** is performed.

(44) Once the transmitted signal strength and the measured signal strength is known with respect to a given smart device **116***a*, an estimate of the distances D**1-3** between the respective locations **156***a-c* and the transmitting smart device **116***a* may be determined given that the signal strength of a radio frequency signal in air trails off predictably with distance due to geometrical spreading and attenuation in the transmission channel.

(45) Alternatively, assuming that the mobile device **123** passes near a smart device **116***b*, then estimates of the distances D**1-3** between respective locations **156***a-c* and the smart device **116***b* may be determined by way of sonic ranging as described above. In such case, the identity of the respective smart device **116***b* is known as the digital virtual assistant controls the smart device **116***b* to implement sonic ranging as described above.

(46) Once an estimate of the distances D**1-3** is known for a given smart device **116***a/b*, a location of such smart devices **116***a*/**116***b* can be determined. In one example, the location of the respective smart device **116***a* may be determined by way of multilateration as shown. Alternatively, the location of the respective smart devices **116***a*/**116***b* may be determined using other approaches such as by use of matrix factorization, factor graphs, and/or other approaches. In this respect, the smart devices **116***a* may be localized automatically without further input from the user once a scan of the rooms of the structure **113** is accomplished. That is to say, as the mobile device **123** is moved around the rooms of the structure **113**, the mobile device **123** acquires the identifiers, transmitted signal strengths, and locations where the signal strength of each signal from a given smart device **116***a* is measured. Such data is termed "smart device transmission data" herein. This data acquired for each smart device **116***a* may be used to automatically localize respective ones of the smart devices **116***a* without requiring further user action.

(47) In one embodiment, the smart device transmission data may be used to localize the respective smart device **116***a*. Such data may be transmitted from the mobile device **123** to the localization application **136** (FIG. **1**) in the environment **103** (FIG. **1**) and stored as part of the smart device data **117** (FIG. **1**). Ultimately, the localization application **136** may access such data to determine a location of the respective smart device **116***a*. Alternatively, the mobile localization application **129** (FIG. **1**) may perform this task locally on the mobile device **123**.

(48) For smart devices **116***c* that do not transmit signals, or do not communicate their identifiers or transmitted signal strengths, other approaches may be employed to localize such smart devices **116***c* as will be described.

(49) Referring next to FIG. **4**, shown is an example of a portion of a point cloud **163** that is generated by the mobile device **123**. The point cloud **163** comprises a gridwork or other arrangement of points that represent the structural boundaries **166** of the one or more rooms of the structure **113** (FIG. **2**). The point cloud **163** is generated from a scan using a sensor on the mobile device **123** such as a light detection and ranging (LIDAR) sensor or other type sensor. In particular, the scan is performed as the user follows a pathway **153** (FIG. **2**) within the structure **113**. In this respect, the sensor of the mobile device **123** is used to sense of the structural boundaries **166** as the mobile device **123** is moved around one or more rooms of the structure **113**. The resulting data representing the point cloud **163** is stored in the memory of the mobile device **123** and also is transmitted to and stored in memory associated with the computing environment **103** to be accessed by the localization application **136** to be used in localizing certain ones of the smart devices **116** (FIG. **1**) as will be described.

(50) With reference to FIG. **5**, shown is an example of a portion of a room within the structure **113** (FIG. **2**) that is also depicted on a display of the mobile device **123** according to one embodiment. As mentioned above, the mobile device **123** maintains its location within the various rooms of the structure **113** as a user moves around the structure **113** as described above. The movement of the mobile device **123** may occur when the point cloud **163** is being generated as mentioned above, or to obtain the smart device transmission data described above. In this respect, the user may place the mobile device **123** into a mode where smart devices **116***c* may be identified as will be described.

(51) From time to time, a nonlocalized smart device **116***c* may appear in the display **169** of the mobile device **123**. In one embodiment, the display **169** comprises a touch screen. As depicted in FIG. **5**, the smart device **116***c* may comprise a smart bulb or other lighting device. Assuming the nonlocalized smart device **116***c* is not capable of transmission of a radio frequency signal or an audio signal, or that the transmission signal strength is not provided by way of a signal transmitted by such smart device **116***c*, in order to localize the smart device **116***c*, a user may tap on the smart device **116***c* as rendered on the display **169** of the mobile device **123** to identify the smart device **116***c* for purposes of localization. The user may tap on the smart device **116***c* with their finger, knuckle, a stylus, or other item. A "tap" on the display **169** of the mobile device **123** refers to directing a finger, knuckle, stylus, or other item to collide with the display **169** of the mobile device

123 as can be appreciated.

(52) The mobile device **123** includes an inertial measurement unit (IMU) that includes, for example, a three dimensional accelerometer, a gyroscope, and a magnetometer. At any given time, the IMU generates values that indicate the orientation of the mobile device **123**. When a user taps on the display **169** of the mobile device **123**, several tap localization data items are stored in memory in the mobile device **123** that facilitate the localization of the respective smart device **116***a*. The tap localization data includes, for example, the orientation and location of the mobile device **123** when the display **169** is tapped. Also, a copy of the image depicted in the display **169** may be stored. In addition, a position of the tap on the display **169** is stored. Further, any magnification or zoom setting of the camera of the mobile device **123** that generates the image in the display **169** is also stored.

(53) The tap localization data may be transmitted to the localization application **136** (FIG. **1**) which localizes the respective smart device **116***c* by determining an approximate the location of the corresponding smart device **116***a*. Alternatively, the mobile localization application **129** (FIG. **1**) may perform this task locally on the mobile device **123**.

(54) Before either the localization application **136** or the mobile localization application **129** are able to localize a smart device **116***c* based on corresponding tap localization data, at least the portion of the point cloud **163** that coincides with the image that includes the smart device **116***c* to be localized needs to be generated. This is because in localizing a respective smart device **116***a*, a ray casting operation is performed by the localization application **136** or the mobile localization application **129**.

(55) A ray casting operation involves mathematically or algorithmically casting a "ray" from a location associated with the mobile device **123** (e.g. in a first coordinate system or point cloud) based on a known orientation of the mobile device (e.g. with respect to the first coordinate system or point cloud) to a position on the point cloud **163** that is ultimately taken as the approximate location of the respective smart device **116***a*. The location and orientation of the mobile device relative to a coordinate system or point cloud can be characterized as a pose of the mobile device relative to the coordinate system or point cloud.

(56) The ray casting operation is performed based on the tap localization data described above. If the point cloud **163** was not created, the ray casting operation could not be performed.

(57) In order to facilitate performing the ray casting operation, the area of contact of a tap on the display **169** may be reduced to a single pixel. That is to say, if the area of contact of a given tap comprises, for example, a portion of a fingerprint or other area of contact, an approximate center of the portion of the fingerprint on the display **169** may be identified to reduce the area of the tap to a single pixel. The location of this pixel on the display **169** or in the corresponding image may be used to perform the ray casting operation.

(58) Note that the actual position on the point cloud **163** identified for a respective smart device **116***c* may be an approximation of the actual position of the smart device **116***c*. For example, in one example, a smart device **116***c* may be positioned in front of a wall on a small table. A gap may exist between the smart device **116***c* and the wall. A ray casting operation would localize the smart device **116***c* to the wall itself given that the point cloud **163** ideally coincides with the wall. Assuming the position on the point cloud **163** that intersects with the mathematical ray generated in the ray casting operation is reasonably close to the actual smart device **116***c* positioned near the wall, then such inaccuracy may be tolerated given that it is perhaps more important to localize the smart device **116***c* as being positioned in a particular room of the structure **113**.

(59) Once a location is determined for the smart device **116***c*, the location coordinates are ultimately stored in a memory associated with the computing environment **103** as the smart device data **117** (FIG. **1**). In the event that the mobile localization application **129** is executed to determine the location of a given mobile device **123**, then the mobile localization application **129** would transmit the location coordinates to the computing environment **103** for storage as the smart device

data **117**.

(60) Referring next to FIG. **6**, shown is a further example of a portion of a room within the structure **113** (FIG. **2**) that is also depicted on a display of the mobile device **123** according to one embodiment. As mentioned above, the mobile device **123** maintains its location within the various rooms of the structure **113** as a user moves around the structure **113** as described above. The movement of the mobile device **123** may occur when the point cloud **163** is being generated, or to obtain the smart device data **117** described above. If the mobile device **123** is used to obtain the smart device data **117** without generating the point cloud **163**, the user may place the mobile device **123** into a mode where smart devices **116***c* may be identified as will be described.

(61) As shown in FIG. **6**, a portion of a room of the structure **113** is depicted, where the mobile device **123** generates an image of the same on the display **169**. A smart device **116***c* is positioned in the portion of the room depicted and also appears in the image rendered on the display **169**.

(62) According to one embodiment, the smart device **116***c* is capable of self-identification signaling. Self-identification signaling refers to an ability of a given smart device **116***c* to be controlled to impart a visual indication of its presence. For example, if a given smart device **116***c* comprises a smart bulb, it may be controlled to turn on and impart light of a specific color. If there are several such smart bulbs in the structure **113**, each such smart bulb may be controlled to generate light in a color that is unique with respect to all other smart bulbs. In this way, each such smart bulb can distinguish itself from all others in the structure **113** based on the color it displays.

(63) Alternatively, a self-identification signaling smart device **116***c* may be controlled to indicate a code that is different from other similar self-identification signaling smart devices **116***c*. For example, if such a smart device **116***c* is a smart bulb, then such device may be turned on and off according to a predefined sequence that is unique with respect to sequences of other such smart bulbs in the structure **113**. Stated another way, where the self-identification signaling smart device **116***c* is a light bulb, the self-identification signaling may comprise cycling the light bulb according to a first on-off signaling sequence that is unique with respect to one or more second on-off signaling sequences of one or more other light bulbs in the structure **113**. In another embodiment, the self-identification signaling further comprises illuminating the light bulb at a first level of brightness that is unique with respect to a second level of brightness of one or more other light bulbs in the structure **113**.

(64) Also, automated blinds might be moved in a unique way with respect to each other. Thus, in one embodiment self-identification signaling smart devices **116***c* may each self-identify by generating a unique visual appearance or coded operation that differs from the visual appearances or coded operation of all other such self-identification signaling smart devices **116***c*.

(65) In order to cause each of the self-identification signaling smart devices **116***c* to engage in self-identification signaling as described above, the mobile device **123** may be controlled to send a request to the digital virtual assistant **133** (FIG. **1**) to cause all of the self-identification signaling smart devices **116***c* to engage in self-identification signaling. Also, if localization of such smart devices **116***c* is to be performed by way of the mobile localization application **129** (FIG. **1**), the mobile device **123** may also request a list of the smart devices **116***c* that indicates their respective self-signaling behaviors so that the mobile localization application **129** can identify such mobile devices **116***c* once the list is received. Alternatively, the mobile localization application **129** may communicate directly with the mobile devices **123** or with the smart home hub **119** to cause such devices to engage in self-identification signaling.

(66) If the respective smart devices **116***c* are controlled to engage in self-identification signaling, the mobile device **123** may encounter one of such smart devices **116***c* as the mobile device **123** is moved around the rooms of the structure **113**. In one embodiment, the mobile localization application **129** detects a self-identification signaling on the part of a smart device **116***c* in the image depicted in the display **169**. If the self-identification signaling comprises illuminating a smart device **116***c* such as a smart bulb with a predefined color, such smart device **116***c* may be

detected by identifying the color in the image. Alternatively, where the self-identification signaling comprises causing a smart device **116***c* to display the self-identification signaling behavior such as cycling a smart bulb on and off according to a predefined timed sequence.

(67) Once detected, a position of the smart device **116***c* that displays the self-identification signaling within the image rendered by the display **169** may be determined from the self-identification signaling displayed. For example, where the smart device **116***c* is a smart bulb, a point that is the approximate center of the self-identification signaling smart device **116***c* may be identified. Specifically, first the area of pixels on the display **169** that render the self-identification signaling smart device **116***c* are identified and the approximate center of such area is calculated. In order to localize the self-identification signaling smart device **116***c*, certain self-identification signaling device data is stored in a memory. Such self-identification signaling device data may comprise, for example, the position and orientation of the mobile device **123**, a screen shot or image that depicts the self-identification signaling smart device **116***c*, the location of the self-identification signaling smart device **116***c* within the screen shot or display **169**, a description of the self-identification signaling detected, and potentially other data. Note that if the self-identification signaling comprises an on-off signaling sequence over time, the self-identification signaling device data may include an excerpt of video instead of a screen shot or image.

(68) This data may be used to localize the respective device. Such data may be transmitted from the mobile device **123** to the localization application **136** (FIG. **1**) in the environment **103** (FIG. **1**) and stored as part of the smart device data **117** (FIG. **1**). Ultimately, the localization application **136** may access such data to determine a location of the respective smart device **116***c*. Alternatively, the mobile localization application **129** (FIG. **1**) may perform this task locally on the mobile device **123**.

(69) Once the point that identifies the position of the self-identification signaling smart device **116***c* on the display **169** has been determined, then an approximate location of the respective smart device **116***c* may be identified using ray casting as was described above with respect to the discussion of FIG. **5**. Rather than surface a list of smart devices **116***c* so that a user may select the smart device **116***c* depicted in a screen shot or image, the self-identification signaling may be employed to identify a respective one of the smart devices **116***c* with which the location determined for such smart device **116***c* is associated.

(70) With reference to FIG. **7**, shown is an example of how a smart device **116***c* may be localized by way of proxy localization. As shown, a smart device **116***c* is placed on a surface such as a table or other surface. In one embodiment, the mobile device **123** is placed near the smart device **116***c*. The mobile device **123** may be placed in a mode that facilitates localization of smart devices **116** (FIG. **1**) by way of proxy localization. Alternatively, proxy localization may be performed at any time during the generation of the point cloud **163** (FIG. **4**) or while localizations Once this mode is implemented, a user may place the mobile device **123** adjacent to the smart device **116***c*. In one embodiment, the mobile device **123** is placed within a predefined distance from the smart device **116***c*, where the predefined distance may comprise 1 foot or other distance. In another embodiment, the user may place the mobile device **123** next to the smart device **116***c* such that the mobile device **123** touches the smart device **116***c*.

(71) In addition, if the smart device **116***c* is capable of transmitting a radio frequency signal, then the mobile device **123** may determine whether it is close enough to the smart device **116***c* for proxy localization by sensing the signal strength. In one embodiment, the mobile device **123** may signal when it is close enough to the smart device **116***c* for proxy localization by way of an indication on the display **169** (FIG. **6**), haptic feedback, or other signal.

(72) In one embodiment, when the mobile device **123** is determined to be stationary in a given position for a predefined period of time, then the position of the mobile device **123** may be taken as the location of the respective smart device **116***c*. The inertial measurement unit (IMU) may detect that the mobile device **123** is in a stationary position and the mobile localization application **129**

may determine whether the mobile device **123** has been stationary for the predefined period of time. Thereafter, a list of nonlocalized smart devices **116** may be presented on the display **169** so that a user may select the respective smart device **116***c* for which proxy localization has been performed. In this manner, the location of the mobile device **123** proximate to the respective smart device **116***c* may be associated with the respective smart device **116***c*. This information may be sent to the localization application **136** (FIG. **1**) so that it may be properly located in the structure floorplan **139** so that the digital virtual assistant **133** can know where the respective smart device **116***c* is located when performing tasks and the like for users in the structure **113**.

(73) With reference to FIG. **8**, shown is an example of a user interface **173** rendered on the display **169** of the mobile device **123** by the mobile localization application **129** (FIG. **1**) according to an embodiment of the present disclosure. The user interface **173** includes a device scan button **183**, a Locate Item by Proxy button **186**, an identify camera direction button **189**, and potentially other elements.

(74) When the device scan button **183** is manipulated, the mobile localization application **129** proceeds to generate the data that may be used to localize all smart devices **116** that can be localized without further user input including the smart devices **116***a* (FIG. **2**) and **116***b* (FIG. **2**), as well as self-identification signaling smart devices **116***c*. This is done while the user moves the mobile device **123** along the pathway **153** (FIG. **2**) around the rooms of the structure **113** (FIG. **2**).

(75) In addition, the mobile device **123** may also proceed to generate a point cloud **163** (FIG. **4**) while simultaneously generating data that is used to localize the smart devices **116**.

(76) While the mobile device **123** is moved around the pathway **153**, the mobile localization application **129** facilitates a user tapping on the display **169** to generate the tap localization data to localize one or more smart devices **116***c*. Also, the mobile localization application **129** generates the self-identification signaling device data when a self-identification signaling mobile device **116***c* is detected as described above.

(77) In one embodiment, the mobile localization application **129** facilitates the localization of as many smart devices **116** as possible without user input. As such, the list of possible devices that is presented to a user to select a particular smart device **116** when localizing devices by tapping or proxy is reduced to make it easier to find a particular smart device **116**.

(78) When the locate item by proxy button **186** is manipulated, the mobile localization application **129** proceeds to facilitate the localization of smart devices **116***c* by proxy. Also, when the identify camera direction button **189** is manipulated, the mobile localization application **129** facilitates determining where a camera associated with one of the smart devices **116** is directed as will be described.

(79) Referring next to FIG. **9**, shown is an example of another user interface **193** rendered on the display **169** of the mobile device **123** by the mobile localization application **129** (FIG. **1**) according to an embodiment of the present disclosure. The user interface **193** is rendered in order to input a selection of a smart device **116** (FIG. **1**) from among the one or more possible current nonlocalized smart devices **116** associated with the structure **113** (FIG. **1**). As shown, the user interface **193** includes a smart device list **196** that sets forth a number of possible smart devices **116** from which a user may select in order to identify a smart device **116** that is to be localized with respect to tap localization data or proxy data as will be described.

(80) Referring next to FIG. **10** shown is a flowchart that provides one example of the operation of at least a portion of the mobile localization application **129** according to various embodiments. It is understood that the flowchart of FIG. **10** provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the mobile localization application **129** as described herein. As an alternative, the flowchart of FIG. **10** may be viewed as depicting an example of elements of a method implemented in the mobile device **123** (FIG. **1**) according to one or more embodiments.

(81) The portion of the mobile localization application **129** depicted in FIG. **10** is executed when

the device scan button **183** (FIG. **8**) is manipulated in the user interface **173** (FIG. **8**) or based on some other trigger that initiates execution.

(82) Beginning with box **203**, the mobile localization application **129** begins the scan for smart devices **116** (FIG. **1**) within the rooms of the structure **113** (FIG. **1**) by obtaining a list of smart devices **116** (FIG. **1**) to be localized. This may be done, for example, by requesting the list of smart devices **116** from the digital virtual assistant **133** (FIG. **1**). In this respect, the digital virtual assistant **133** may interact with the devices on the local area network **109** (FIG. **1**) including the smart home hub **119** as can be appreciated.

(83) Next, in box **206** the mobile localization application **129** sends a request to the digital virtual assistant **133** to cause all self-identification smart devices **116***c* (FIG. **2**) to begin self-identification signaling so that they can be detected during a scan through the rooms of the structure **113**. The digital virtual assistant **133** provides a listing of the smart devices **116***c* that are self-identification signaling, where the list includes the type of signal that is displayed by each respective smart device **116***c*. Thereafter, in box **209** a scan of the rooms of the structure **113** is initiated in the case that a point cloud **163** is to be generated at the same time that smart devices **116** are to be localized. In this respect, an image of at least a portion of a room of the structure **113** is rendered on the display **169** of the mobile device **123**. In box **213**, the mobile localization application **129** begins to generate and store the smart device transmission data that is detected from smart devices **116***a* as a user moves the mobile device **123** along a pathway **153** through the rooms of the structure **113**. In addition, the point cloud **163** may be generated simultaneously if the point cloud **153** has not already been generated.

(84) In box **219** it is determined whether a self-identification signaling smart device **116***c* has been detected. In particular, such a smart device **116***c* may be detected based upon the specific behavior of the device as directed by the digital virtual assistant **133**. In this respect, the location in the image where a nonlocalized smart device **116***c* is depicted comprises a location of the self-identification signaling within the image. If a self-identification signaling smart device **116***c* is detected, then the mobile localization application **129** proceeds to box **223**. Otherwise, execution moves to box **226** as shown.

(85) In box **223**, the mobile localization application **129** identifies which smart device **116***c* is signaling. For example, if the smart device **116***c* comprises a smart bulb, then it may be illuminated with a predefined color or caused to repeat a predefined on-off sequence, where the color or the predefined on-off sequence for each such smart bulb is unique with respect to all other smart bulbs associated with the structure **113**. As mentioned above, the digital virtual assistant **133** provides a listing of the self-identification signaling smart devices **116***c* to the mobile localization application **129**, where the listing sets forth the specific signaling behavior of each respective self-identification signaling smart device **116***c*.

(86) Next, in box **229** the mobile localization application **129** stores the self-identification signaling device data that is acquired when the self-identification signaling smart device **116***c* is detected. The same data may be transmitted to the localization application **136** (FIG. **1**) when the localization application **136** is to determine the location of the respective smart device **116***c* therefrom. Thereafter, the mobile localization application **129** proceeds to box **226**.

(87) In box **226**, the mobile localization application **129** detects whether a tap or other contact on the image rendered on the display **169** has occurred indicating that a smart device **116***c* is depicted in the image generated on the display **169** (FIG. **5**). Such a tap on the display **169** of the mobile device **123** may be detected, for example, during the generation of the point cloud **163**, where the location in the image where a nonlocalized smart device **116***c* is depicted comprises a location of the tap relative to the image. Alternatively, the tap may on the display **169** of the mobile device **123** may occur at a time when the point cloud **163** is not being generated.

(88) Assuming that the user has tapped the display **169**, the mobile localization application **129** proceeds to box **233**. Otherwise, the mobile localization application **129** moves to box **236**.

(89) In box **233** the tap localization data is stored in memory to be localized. Such tap localization data may include, for example, the position and orientation of the mobile device **123** within the structure **113**, and the location of the tap on the display **169**. This may be done while, simultaneously, the portion of the point cloud **163** that coincided with the image depicted on the display **169** is being generated assuming that the point cloud **163** has not been generated separately. For example, the tap on the display **169** may comprise an area of several pixels that is impacted by the portion of one's finger that comes into contact with the display **169**. As such, the location of the tap on the display **169** may be calculated as an approximate center of such area.

(90) In the case that localization is performed by the localization application **136**, the tap localization data may be transmitted to the localization application **136**. Thereafter, in box **239** the user interface **193** (FIG. **9**) is generated on the display **169** that depicts the list of nonlocalized smart devices **116** associated with the structure **113**. Then in box **243** the mobile localization application **129** inputs a selection of a respective one of the smart devices **116**. The selected one of the smart devices **116** is associated with the instance of tap localization data generated by the tap on the display **169**. Thereafter, the mobile localization application **129** proceeds to box **236**. Note that the functionality of surfacing a list of nonlocalized smart devices **116** to input a selection as set forth in boxes **239** and **243** may be performed after as many of the smart devices **116***a/b* have been localized so as to reduce the number of smart devices **116** on the list to make selection of a respective smart device **116** easier.

(91) In box **236** the mobile localization application **129** determines whether the scan of the smart devices **116** in the various rooms of the structure **113** is complete. Note that this may be indicated by a user manipulation of a respective user interface element that ends the scanning of the structure **113**. If the scanning of the structure **113** to acquire data about the smart devices **116** is not complete in box **236**, then the mobile localization application **129** reverts back to box **213** to continue the process. Otherwise, the process ends as shown.

(92) Referring next to FIG. **11**A shown is a flowchart that provides one example of the operation of at least a portion of the localization application **136** according to various embodiments. It is understood that the flowchart of FIG. **11**A provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the localization application **136** as described herein. As an alternative, the flowchart of FIG. **11**A may be viewed as depicting an example of elements of a method implemented in the computing environment **103** (FIG. **1**) according to one or more embodiments.

(93) Although the functionality as depicted in the flowchart of FIG. **11**A is depicted as being implemented as part of the localization application **136** executed in the computing environment **103** (FIG. **1**), the same functionality can be implemented by the mobile localization application **129** (FIG. **1**) in the mobile device **123**.

(94) In box **253**, the localization application **136** accesses smart device transmission data for respective smart devices **116***a* (FIG. **2**). The smart device transmission data includes, for example, device identifiers, transmitted signal strengths, and locations where the signal strength of signals from corresponding smart devices **116***a* were measured.

(95) Alternatively, the localization application **136** may access sonic ranging data for audio capable smart devices **116***b* (FIG. **2**). In this respect, the distance between several positions of the mobile device **123** and the respective smart devices **116***b* may be accessed from memory.

(96) Next, in box **256** the location of the respective smart devices **116***a/b* are determined based on the distances using one of a plurality of approaches including, for example, nonlinear optimization approaches such as multilateration, factor graphs, or other approach. Alternatively, other approaches such as matrix factorization may be employed. Thereafter, in box **259**, the location of the respective smart devices **116***a/b* within the structure **113** (FIG. **1**) are stored in memory. In this respect, the location of the respective smart devices **116***a/b* may be plotted on the structure floorplan **139**. As such, the digital virtual assistant **133** (FIG. **1**) can be made aware of the relative

positioning of respective ones of the smart devices **116***a/b* within the rooms of a given structure **113** without user input beyond a scan of the rooms of the structure **113** (FIG. **1**). Thereafter, the process ends as shown.

(97) The localization application **136** allows the digital virtual assistant **133** to draw appropriate associations between respective pairs or groups of smart devices **116** to execute various commands made by users. For example, if a user asks a digital virtual assistant **133** through a specific smart device **116** to turn on certain media content on a digital media player, the digital virtual assistant **133** can consult the structure floorplan **139** to determine which digital media player is closest to the specific smart device **116** and cause the desired media content to be rendered by such digital media player.

(98) Referring next to FIG. **11**B shown is a flowchart that provides another example of the operation of at least a portion of the localization application **136** that determines a location of a smart device **116***c* (FIG. **2**) based on a tap on the display **169** (FIG. **5**) according to various embodiments. It is understood that the flowchart of FIG. **11**B provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the localization application **136** as described herein. As an alternative, the flowchart of FIG. **11**B may be viewed as depicting an example of elements of a method implemented in the computing environment **103** (FIG. **1**) or the mobile device **123** (FIG. **1**) according to various embodiments.

(99) Although the functionality as depicted in the flowchart of FIG. **11**B is depicted as being implemented as part of the localization application **136** executed in the computing environment **103** (FIG. **1**), the same functionality can be implemented by the mobile localization application **129** (FIG. **1**) in the mobile device **123**.

(100) Beginning with box **273**, the localization application **136** obtains the position and orientation of the mobile device **123** as well as the location of the tap on the display **169** by a user identifying where the respective smart device **116***c* is located on the display **169**. In addition, the localization application **136** obtains the identity of the respective smart device **116***c* that was selected by the user as described with respect to boxes **239** (FIG. **10**) and **243** (FIG. **10**) above.

(101) In box **276** the localization application **136** performs a ray casting operation to project the position of the tap on the image that includes the respective smart device **116***c* on the display **169** to a position on the point cloud **163**. The ray casting operation is performed based on the position of the tap on the image or the display **169**, the orientation of the mobile device **123**, and the corresponding one of the positions of the mobile device **123** within one or more rooms of the structure.

(102) In this respect, at least a portion of the point cloud **163** that coincides with the image on the display **169** that depicts the respective smart device **116***c* is created in order to perform the ray casting operation. In order to perform the ray casting operation, the point cloud **163** needs to be established at the point where the ray that is cast would intersect with the point cloud **163**. Otherwise, any ray that is cast could not intersect the point cloud **163** to localize a respective smart device **116***c*.

(103) In one embodiment, if the functionality set forth in FIG. **11**B is executed by the mobile localization application **129**, then the point cloud **163** may be generated simultaneously along with localization of the various smart devices **116** (FIG. **1**). In the event that a tap localization is to occur as implemented by the flowchart of FIG. **11**B, the point cloud **163** would need to be created at least with respect to the boundaries of the rooms of the structure **113** that appear in an image that depicts a respective smart device **116***c* for which a ray casting operation is to be performed to localize such smart device **116***c*.

(104) Thereafter, in box **279**, the location of the respective smart device **116***c* within the structure **113** (FIG. **1**) is stored in memory. In this respect, the location of the respective smart device **116***c* may be plotted on the structure floorplan **139**. As such, the digital virtual assistant **133** (FIG. **1**) can

be made aware of the relative positioning of respective ones of the smart devices **116** within the rooms of a given structure **113** without user input beyond a scan of the rooms of the structure **113** (FIG. **1**). After box **279**, the portion of the localization application **136** ends as shown.

(105) Referring next to FIG. **11**C shown is a flowchart that provides another example of the operation of a further portion of the localization application **136** that determines a location of a smart device **116***c* (FIG. **2**) based on self-identification signaling detected on the display **169** (FIG. **5**) according to various embodiments. It is understood that the flowchart of FIG. **11**C provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the localization application **136** as described herein. As an alternative, the flowchart of FIG. **11**C may be viewed as depicting an example of elements of a method implemented in the computing environment **103** (FIG. **1**) or the mobile device **123** (FIG. **1**) according to various embodiments.

(106) Although the functionality as depicted in the flowchart of FIG. **11**C is depicted as being implemented as part of the localization application **136** executed in the computing environment **103** (FIG. **1**), the same functionality can be implemented by the mobile localization application **129** (FIG. **1**) in the mobile device **123**.

(107) Beginning with box **303**, the localization application **136** identifies a center of the self-signaling smart device **116***c* in the image or clip of video that includes the self-signaling smart device **116***c*. For example, if the smart device **116***c* is a smart bulb that is self-identification signaling by being illuminated with a specific color, the approximate center of the illumination in a given image may be identified. Next, in box **305**, the localization application **136** obtains the location and orientation of the mobile device **123** when it generated the image or clip of video that includes the self-signaling smart device **116***c*. Such information may be obtained from the smart device data **117** (FIG. **1**) or from the memory in the mobile device **123**. Thereafter, in box **306** the localization application **136** performs a ray casting operation to project the position of the self-identification signaling in the image that includes the respective smart device **116***c* to a position on the point cloud **163**.

(108) This is done based on the position and orientation of the mobile device **123** when the self-identification signaling smart device **116***c* was detected. That is to say, the ray casting operation is performed based on the position where the self-identification signaling smart device **116***c* is depicted on the image or the display **169**, the orientation of the mobile device **123**, and the corresponding one of the positions of the mobile device **123** within one or more rooms of the structure.

(109) In this respect, at least a portion of the point cloud **163** that coincides with the image on the display **169** that depicts the respective smart device **116***c* would need to have been created in order to perform the ray casting operation. In order to perform the ray casting operation, the point cloud **163** needs to be established at the point where the ray that is cast would intersect with the point cloud **163**. Otherwise, any ray that is cast could not intersect the point cloud **163** to localize a respective smart device **116***c*.

(110) In box **309**, the position on the point cloud **163** identified by way of the ray casting operation is then stored in memory in association with the respective smart device **116***c*. Thereafter, this portion of the localization application **136** ends as shown.

(111) Referring next to FIG. **12** shown is a flowchart that provides another example of the operation of a further portion of the mobile localization application **129** that determines a location of a smart device **116***c* (FIG. **2**) based on proximity between the smart device **116***c* and the mobile device **123** according to various embodiments. It is understood that the flowchart of FIG. **12** provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the mobile localization application **129** as described herein. As an alternative, the flowchart of FIG. **12** may be viewed as depicting an example of elements of a method implemented in the mobile device **123** (FIG. **1**) according to

various embodiments.

(112) The portion of the mobile localization application **129** that provides for location of smart devices **116***c* by proximity may be executed when the Locate Item by Proxy button **186** is manipulated on the user interface **173** described above. Alternatively, the same may be executed at the time that a scan of the rooms of a structure **113** is performed to localize smart devices **116**. In one embodiment, such a scan for smart devices **116** may be performed while, simultaneously, the mobile device **123** is scanning the rooms of the structure **113** to generate the point cloud **163** as was described above. As such, a user would be able to localize most, if not all, smart devices **116** in a single scan of the rooms of the structure **113**.

(113) Upon execution, in box **323**, the mobile localization application **129** determines whether the mobile device **123** has been positioned at a proxy location relative to a given nonlocalized smart device **116***c* in the structure **113**. There are a few approaches that may be employed to make this determination.

(114) In the case that the smart device **116***c* transmits a radio frequency signal, the mobile device **123** may determine whether it is in close proximity to the respective smart device **116***c* depending on whether the signal strength is above a predefined threshold given the transmitted signal strength from the respective smart device **116***c*. Specifically, it is determined whether the mobile device **123** is positioned at the proxy location relative to the nonlocalized smart device **116***c* in the structure **113** by determining whether a received signal strength of a signal transmitted by the nonlocalized smart device **116***c* is of a magnitude indicating that the mobile device **123** is within a predefined distance from the nonlocalized smart device **116***c*.

(115) Alternatively, the mobile device **123** may present a user interface that includes a button or other element that may be manipulated by a user after the mobile device **123** has been positioned in proximity to a given smart device **116***c* to confirm that the mobile device **123** is so positioned.

(116) As an additional alternative, the mobile localization application **129** may determine whether the mobile device **123** has been placed by a given smart device **116** by consulting the inertial measurement unit (IMU) in the mobile device **123** as described above. The IMU can detect whether the mobile device **123** is still held by a user or has been placed on a surface based on the output of the IMU.

(117) Assuming that it is determined that the mobile device **123** has been placed in proximity to a respective smart device **116***c* that is to be localized by proxy, the mobile localization application **129** proceeds to box **326** in which the location of the mobile device **123** is acquired from respective subsystems in the mobile device **123**. Thereafter, in box **329** the smart device list **196** (FIG. **9**) that sets forth a list of nonlocalized smart devices **116** associated with the structure **113** is rendered in the user interface **193** (FIG. **9**) to obtain an indication from the user as to which nonlocalized smart device **116** is proximate to the mobile device **123**.

(118) In box **333**, the mobile localization application **129** waits to receive a selection of a respective one of the smart devices **116** in the smart device list **196**. Once a selection of a respective one of the smart devices **116** is received, execution proceeds to box **336** in which the coordinates indicating the location of the mobile device **123** are associated with the selected one of the smart devices **116** as stored in memory. In one embodiment, the respective smart device **116** may be included in a digital representation of one or more rooms of the structure **113**. Thereafter, in box **339**, a user interface may be generated on the display **169** of the mobile device **123** that indicates that a location of the respective mobile device **116***c* has been determined, thereby allowing the user to pick up the mobile device **123** to localize other smart devices **116** and/or generate the point cloud **163**.

(119) Next, in box **343**, the mobile localization application **129** determines if execution is done or if execution should revert back to box **323** to detect that the mobile device **123** has been placed proximate to another smart device **116***c*. If the execution is done, then this portion of the mobile localization application **129** ends as shown. Otherwise, execution reverts back to box **323** as

shown.

(120) Referring next to FIG. **13** shown is a flowchart that provides another example of the operation of a further portion of the mobile localization application **129** that determines an orientation of a camera associated with a respective one of the smart devices **116** (FIG. **1**) based on a position of the mobile device **123** relative to a position of the respective one of the smart devices **116** according to various embodiments. It is understood that the flowchart of FIG. **13** provides merely an example of the many different types of functional arrangements that may be employed to implement the operation of the portion of the mobile localization application **129** as described herein. As an alternative, the flowchart of FIG. **13** may be viewed as depicting an example of elements of a method implemented in the mobile device **123** (FIG. **1**) according to various embodiments.

(121) In one embodiment, this portion of the mobile localization application **129** is executed when a user manipulates the Locate Item by Proxy button **186** (FIG. **8**) in the user interface **173** (FIG. **8**) as described above. Alternatively, this portion of the mobile localization application **129** may be executed upon an occurrence of some other trigger.

(122) Beginning with box **353**, the mobile localization application **129** determines whether the mobile device **123** is positioned relative to a given smart device **116** that includes a camera in order to determine an orientation of the camera. The positioning of the mobile device **123** in this manner may comprise placing the mobile device **123** directly in front of the camera of the respective smart device **116**. To this end, the mobile device **123** may generate a user interface that provides instructions to the user with respect to placing the mobile device **123** relative to the camera of the respective smart device **116**.

(123) In box **356**, the orientation of the camera of the respective smart device **116** is determined based upon the relative positions of the respective smart device **116** and the mobile device **123**. In particular, an imaginary line may be drawn from the camera to the mobile device **123** where the direction of such line facing toward the mobile device **123** indicates the direction of the camera.

(124) Next, in box **359**, the orientation of the camera is stored in memory in association with the respective smart device **116**. Also, the orientation of the camera of the respective smart device **116** may be communicated to the localization application **136** executed in the computing environment **103** so that such orientation may be depicted in the structure floorplan **139**.

(125) Thereafter, this portion of the mobile localization application **129** ends as shown.

(126) With reference to FIG. **14**, shown is a schematic block diagram of the computing environment **103** according to an embodiment of the present disclosure. The computing environment **103** includes one or more computing devices **369**. Each computing device **369** includes at least one processor circuit, for example, having a processor **373** and a memory **376**, both of which are coupled to a local interface **379**. To this end, each computing device **369** may comprise, for example, at least one server computer or like device. The local interface **379** may comprise, for example, a data bus with an accompanying address/control bus or other bus structure as can be appreciated.

(127) The memory **376** is defined herein as including both volatile and nonvolatile memory and data storage components. Volatile components are those that do not retain data values upon loss of power. Nonvolatile components are those that retain data upon a loss of power. Thus, the memory **376** may comprise, for example, random access memory (RAM), read-only memory (ROM), hard disk drives, solid-state drives, and/or other memory components.

(128) Although flowcharts depicted herein may show a specific order of execution, it is understood that the order of execution may differ from that which is depicted.

(129) Also, any logic or application described herein that comprises software or code can be embodied in any non-transitory computer-readable medium for use by or in connection with an instruction execution system such as, for example, a processor **373** in a computer system or other system. In this sense, the logic may comprise, for example, statements including instructions and

declarations that can be fetched from the computer-readable medium and executed by the instruction execution system. In the context of the present disclosure, a "computer-readable medium" can be any medium that can contain, store, or maintain the logic or application described herein for use by or in connection with the instruction execution system such as read only memory (ROM), random access memory (RAM), disk drives, solid state memory, and other types of memory.

(130) Disjunctive language such as the phrase "at least one of X, Y, or Z," unless specifically stated otherwise, is otherwise understood with the context as used in general to present that an item, term, etc., may be either X, Y, or Z, or any combination thereof (e.g., X, Y, and/or Z). Thus, such disjunctive language is not generally intended to, and should not, imply that certain embodiments require at least one of X, at least one of Y, or at least one of Z to each be present.

(131) It should be emphasized that the above-described embodiments of the present disclosure are merely possible examples of implementations set forth for a clear understanding of the principles of the disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

Claims

1. A non-transitory, computer-readable medium comprising machine-readable instructions that, when executed by a processor of a mobile device, cause the mobile device to: generate a point cloud representing structural boundaries of at least one room of a structure from a sensor of the mobile device; render an image of a portion of the at least one room of the structure on a display of the mobile device simultaneously during the generation of the point cloud; store, in a memory, the image and a position and orientation of the mobile device relative to the at least one room of the structure where the image was rendered; store, in the memory, a location in the image where a nonlocalized device is depicted, the nonlocalized device being positioned in the at least one room of the structure; after at least a portion of the point cloud that coincides with the image is completed, calculate a position on the at least the portion of the point cloud based on the position and orientation of the mobile device, and based on the location in the image where the nonlocalized device is depicted; identify the nonlocalized device from among a plurality of possible nonlocalized devices associated with the structure; and associate the position with the identified nonlocalized device, thereby localizing the nonlocalized device.

2. The non-transitory, computer-readable medium of claim 1, further comprising machine-readable instructions that, when executed by the processor of the mobile device, further cause the mobile device to detect a tap on the display of the mobile device during the generation of the point cloud, where the location in the image where a nonlocalized device is depicted comprises a location of the tap relative to the image.

3. The non-transitory, computer-readable medium of claim 1, further comprising machine-readable instructions that, when executed by the processor of the mobile device, further cause the mobile device to detect a self-identification signaling by the nonlocalized device in the image, where the location in the image where a nonlocalized device is depicted comprises a location of the self-identification signaling within the image.

4. The non-transitory, computer-readable medium of claim 1, wherein the calculating of the position on the at least the portion of the point cloud based on the position and orientation of the mobile device, and based on the location in the image where the nonlocalized device is depicted further comprises performing a ray casting operation.

5. A system, comprising: a mobile device; and at least one processor circuit in the mobile device, the at least one processor circuit having a memory comprising instructions that, when executed by

the processor circuit, cause the at least one processor circuit to at least: render an image of a portion of at least one room of a structure on a display of the mobile device; determine a point in the image where a nonlocalized device is depicted, the nonlocalized device being positioned in the at least one room of the structure; and localize the nonlocalized device in the at least one room of the structure based on a position and orientation of the mobile device relative to the at least one room of the structure and based on a location of the point in the image.

6. The system of claim 5, wherein the determining of the point in the image where a nonlocalized device is depicted further comprises identifying a position of a contact on the display depicting the image.

7. The system of claim 5, wherein the nonlocalized device further comprises a self-identifying device configured to perform self-identification signaling, and the determining of the point in the image where the nonlocalized device is depicted further comprises identifying an area in the image that depicts the self-identification signaling.

8. The system of claim 7, wherein the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises illuminating the light bulb using a first color that is unique with respect to at least one second color of at least one second light bulb in the structure.

9. The system of claim 7, wherein the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises cycling the light bulb according to a first on-off signaling sequence that is unique with respect to at least one second on-off signaling sequence of at least one other light bulb in the structure.

10. The system of claim 7, wherein the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises illuminating the light bulb at a first level of brightness that is unique with respect to a second level of brightness of at least one other light bulb in the structure.

11. The system of claim 5, wherein the localizing the nonlocalized device in the at least one room of the structure further comprises: performing a ray casting operation based on the position and orientation of the mobile device relative to the at least one room of the structure and based on the location of an area in the image to identify a position on a point cloud representing a plurality of structural boundaries of the at least one room of the structure; and associating the position on the point cloud with the nonlocalized device.

12. The system of claim 11, wherein the associating of the position on the point cloud with the nonlocalized device further comprises: rendering a list of possible nonlocalized devices on the display of the mobile device; and inputting in the mobile device a selection of one of the possible nonlocalized devices as the nonlocalized device with which the position on the point cloud is associated.

13. The system of claim 12, wherein the display of the mobile device further comprises a touch screen.

14. The system of claim 7, wherein the rendering of the image and the determining of the point in the image are performed simultaneously with a generation of a point cloud in the mobile device, the point cloud representing a plurality of structural boundaries of the at least one room of the structure from a sensor of the mobile device.

15. A method comprising: displaying, on a display of a user device, a first image generated using a camera of the user device, and one or more interface elements prompting a user to touch a position on the display corresponding to an electronic device to be localized; receiving, at the user device, touchscreen input indicating a touch on a portion of the first image; based on the touchscreen input, determining first location data indicating a first location of the user device relative to a first coordinate system associated with first point cloud data; determining first orientation data indicating an orientation of the user device relative to the first coordinate system associated with the first point cloud data; determining, based on first field of view data corresponding to a field of view of the camera and touch data indicating one or more pixels of the first image corresponding to

the touch, first direction data indicating a first direction of a location corresponding to a touched pixel relative to the user device; determining, based on the first direction data and the first orientation data, second direction data indicating a second direction of a location corresponding to the touched pixel relative to the first coordinate system; performing, based on the second direction data and the first location data, a ray casting operation to determine one or more points of a point cloud intersected by a line projected from the first location in the second direction; determining, based on the determining of the one or more points of the point cloud, second location data; storing the second location data in association with an identifier of a first electronic device; and displaying, on the display of the user device, one or more interface elements indicating that the first electronic device has been localized.

16. The method of claim 15, wherein the method further comprises: displaying, on the display of the user device, a list of electronic devices; and receiving, at the user device, second touchscreen input representing selection of the first electronic device from the list of electronic devices.

17. The method of claim 15, wherein the first electronic device comprises an indoor camera, television, or personal assistant device.

18. A non-transitory, computer-readable medium comprising machine-readable instructions that, when executed by a processor of a mobile device, cause the mobile device to: render an image of a portion of at least one room of a structure on a display of the mobile device; determine a point in the image where a nonlocalized device is depicted, the nonlocalized device being positioned in the at least one room of the structure; and localize the nonlocalized device in the at least one room of the structure based on a position and orientation of the mobile device relative to the at least one room of the structure and based on a location of the point in the image.

19. The non-transitory, computer-readable medium of claim 18, wherein the determining of the point in the image where a nonlocalized device is depicted further comprises identifying a position of a contact on the display depicting the image.

20. The non-transitory, computer-readable medium of claim 18, wherein the nonlocalized device further comprises a self-identifying device configured to perform self-identification signaling, and the determining of the point in the image where the nonlocalized device is depicted further comprises identifying an area in the image that depicts the self-identification signaling.

21. The non-transitory, computer-readable medium of claim 20, wherein the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises illuminating the light bulb using a first color that is unique with respect to at least one second color of at least one second light bulb in the structure.

22. The non-transitory, computer-readable medium of claim 20, the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises cycling the light bulb according to a first on-off signaling sequence that is unique with respect to at least one second on-off signaling sequence of at least one other light bulb in the structure.

23. The non-transitory, computer-readable medium of claim 20, wherein the self-identifying device further comprises a light bulb, and the self-identification signaling further comprises illuminating the light bulb at a first level of brightness that is unique with respect to a second level of brightness of at least one other light bulb in the structure.