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(54) **DETECTING THE PRESENCE OF A VIRTUAL MEETING PARTICIPANT**

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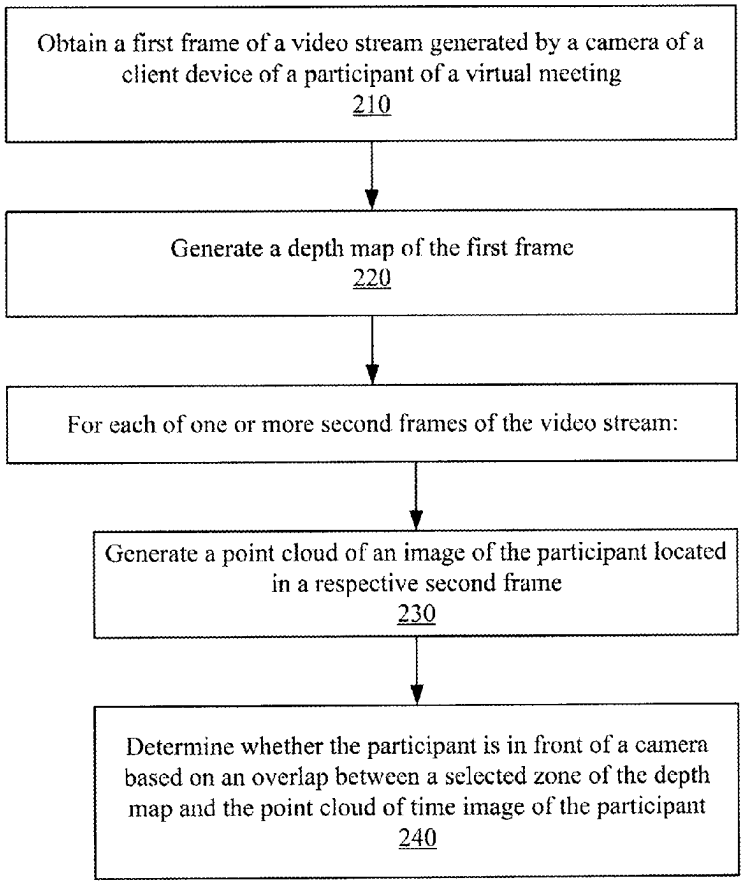
(57) **ABSTRACT**

A method for detecting the presence of a virtual meeting participant includes obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting. The method includes generating a depth map of the first frame. The method includes, for each of one or more second frames of the video stream, generating a point cloud of an image of the participant located in a respective second frame, and determining whether the participant is in front of the camera based on an overlap between a selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame. Responsive to the determining the participant is not in front of the camera, the method includes muting the participant's audio and deactivating the participant's video stream.



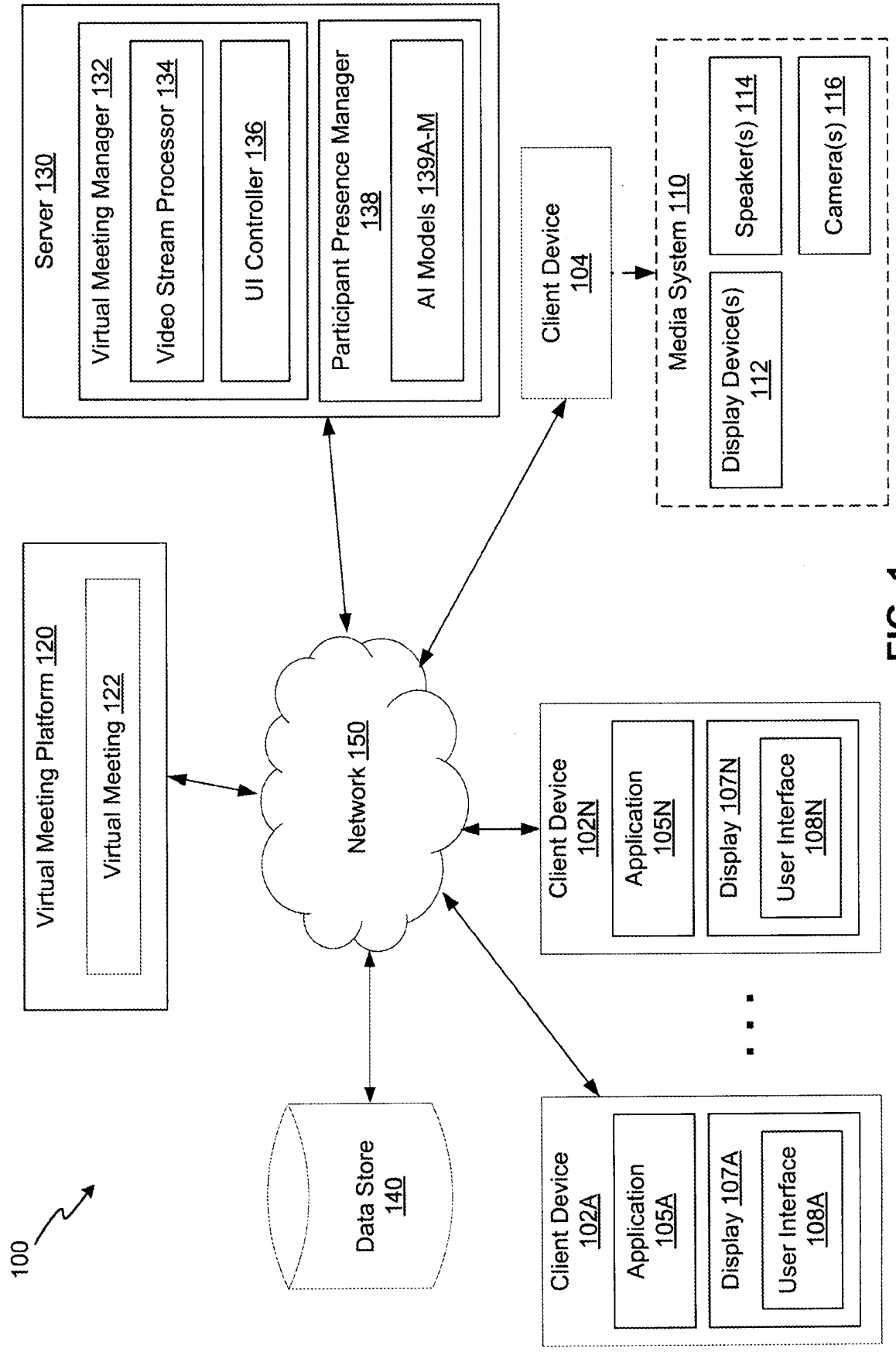

100
Server 130
Virtual Meeting Manager 132
Video Stream Processor 134
UI Controller 136
Participant Presence Manager 138
AI Models 139A-M
Client Device 104
Media System 110
Display Device(s) 112
Speaker(s) 114
Camera(s) 116
Virtual Meeting Platform 120
Virtual Meeting 122
Network 150
Client Device 102N
Application 105N
Display 107N
User Interface 108N
Data Store 140
Client Device 102A
Application 105A
Display 107A
User Interface 108A

FIG. 1

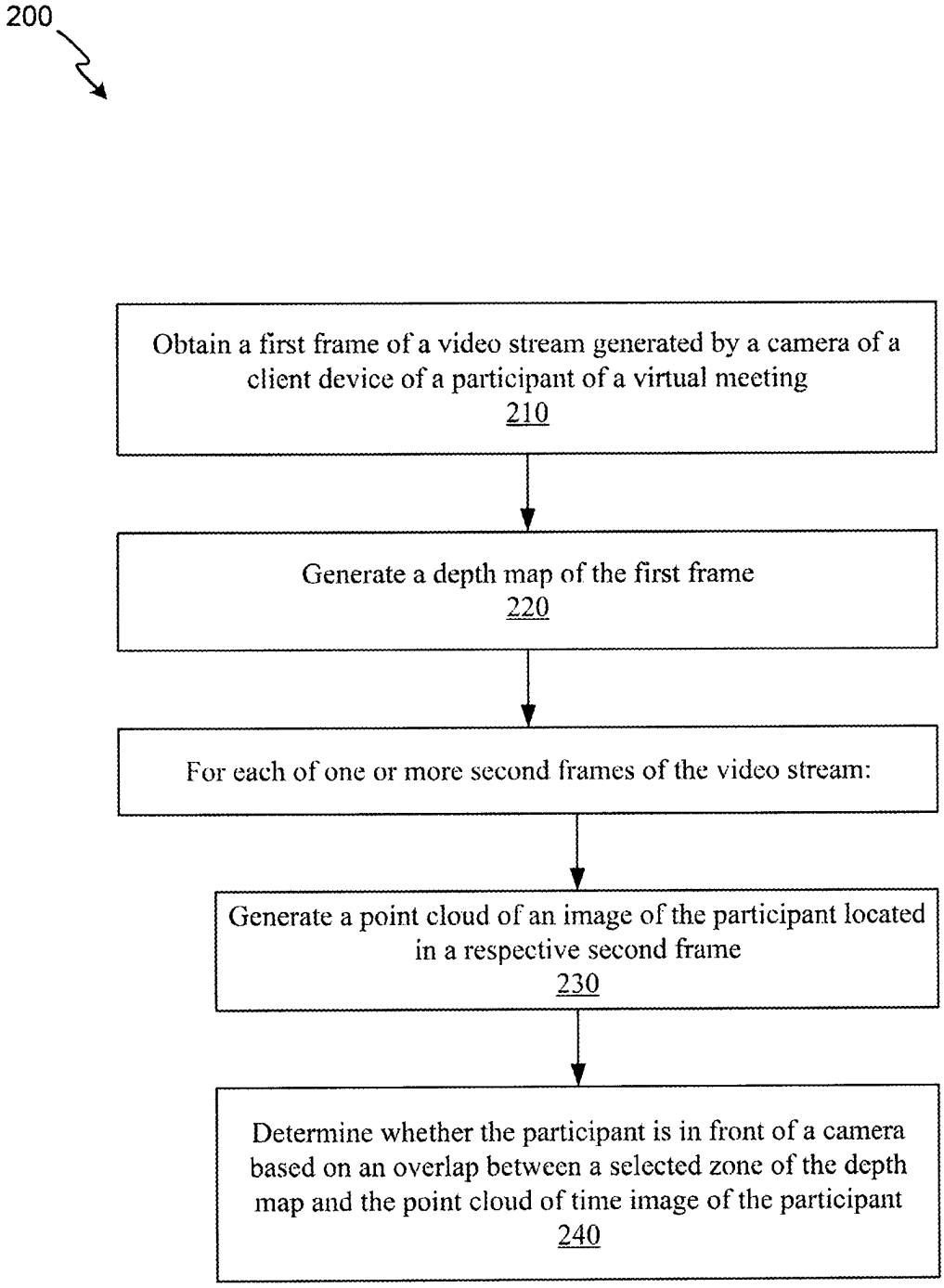

200
Obtain a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting
210
Generate a depth map of the first frame
220
For each of one or more second frames of the video stream:
Generate a point cloud of an image of the participant located in a respective second frame
230
Determine whether the participant is in front of a camera based on an overlap between a selected zone of the depth map and the point cloud of time image of the participant
240

FIG. 2

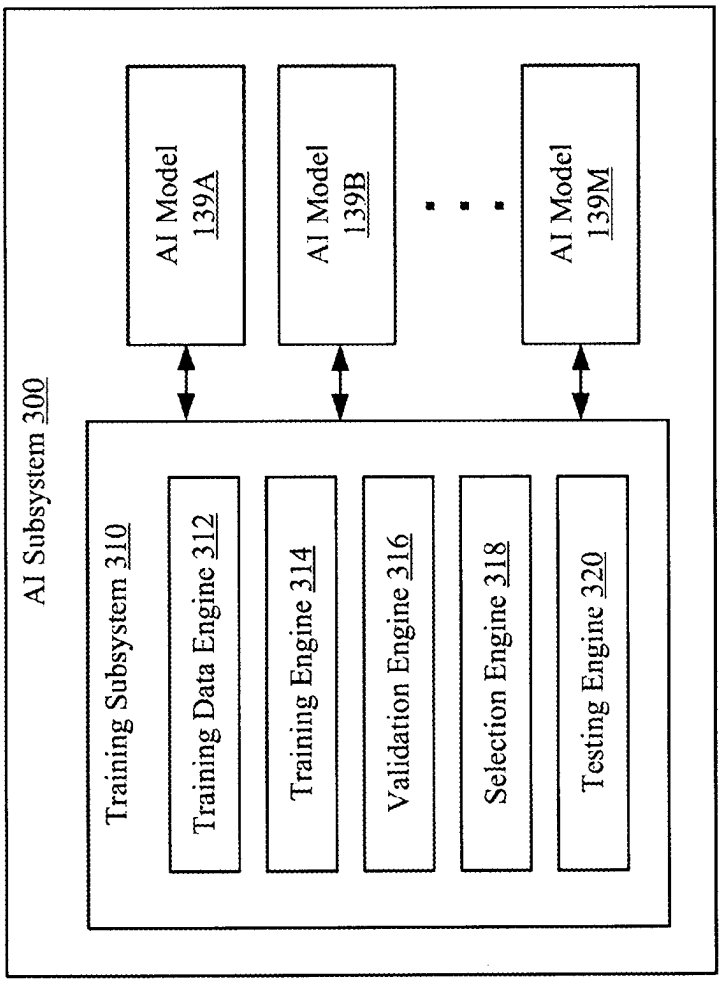

AI Subsystem 300
Training Subsystem 310
Training Data Engine 312
Training Engine 314
Validation Engine 316
Selection Engine 318
Testing Engine 320
AI Model 139A
AI Model 139B
AI Model 139M

FIG. 3

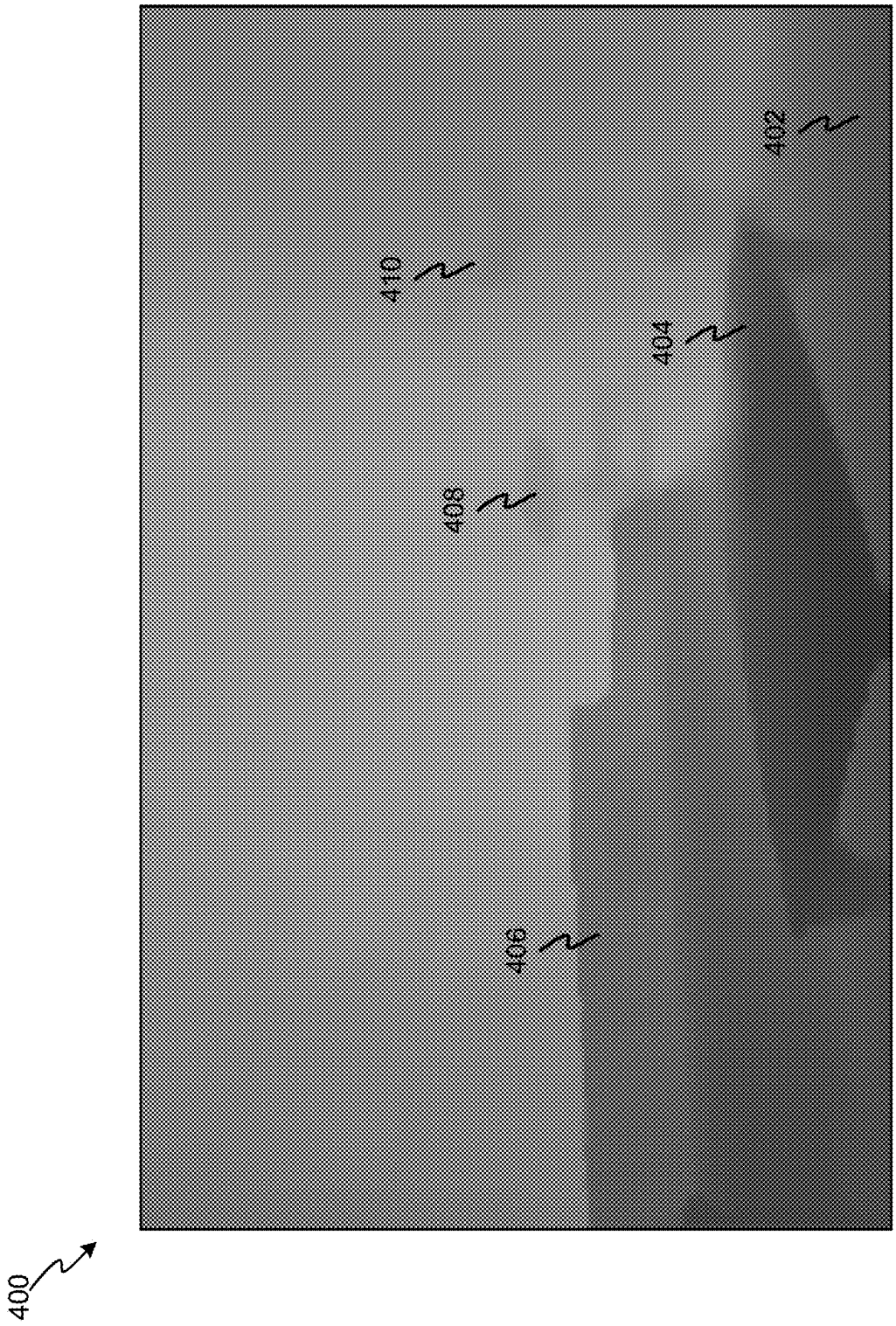


FIG. 4

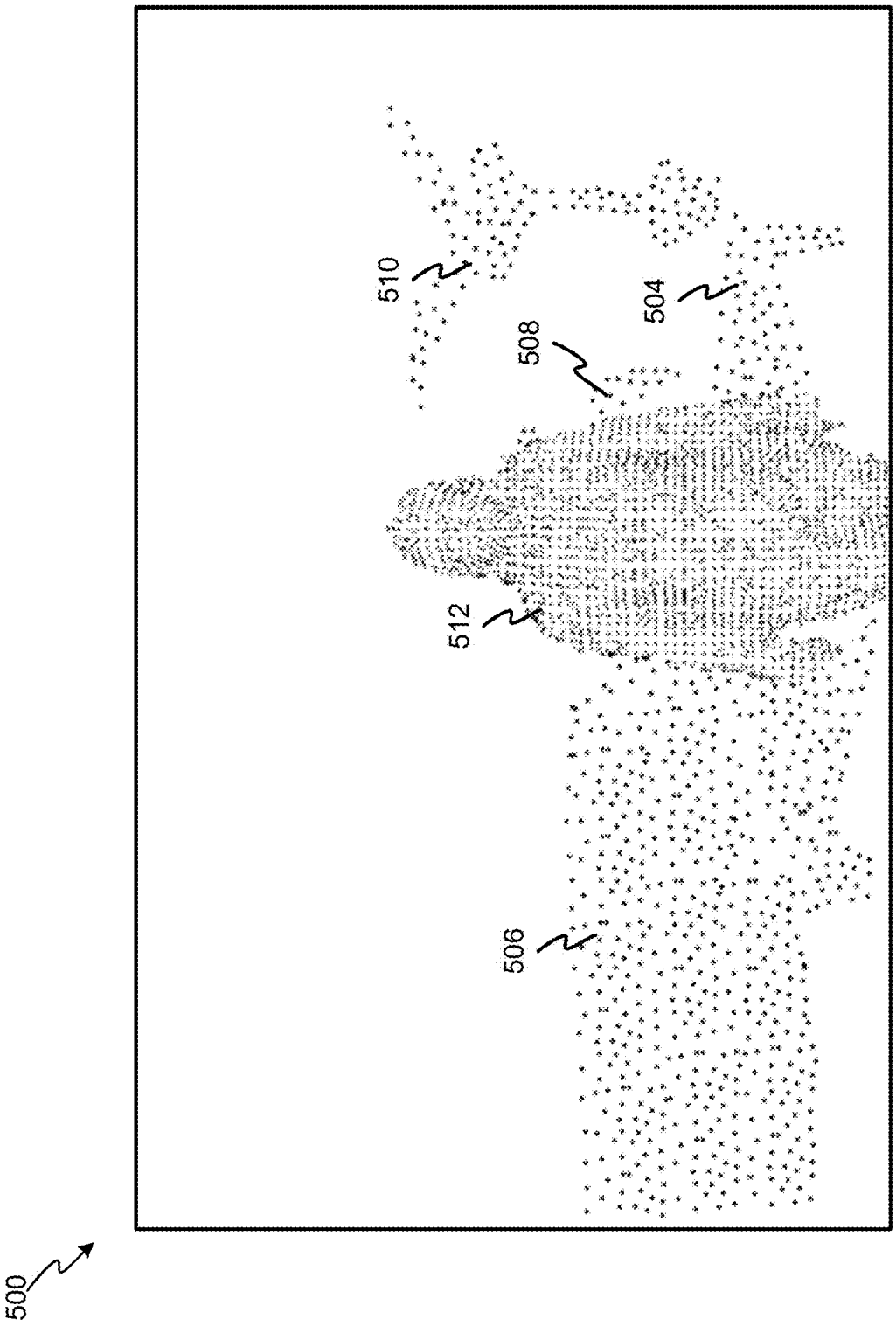


FIG. 5

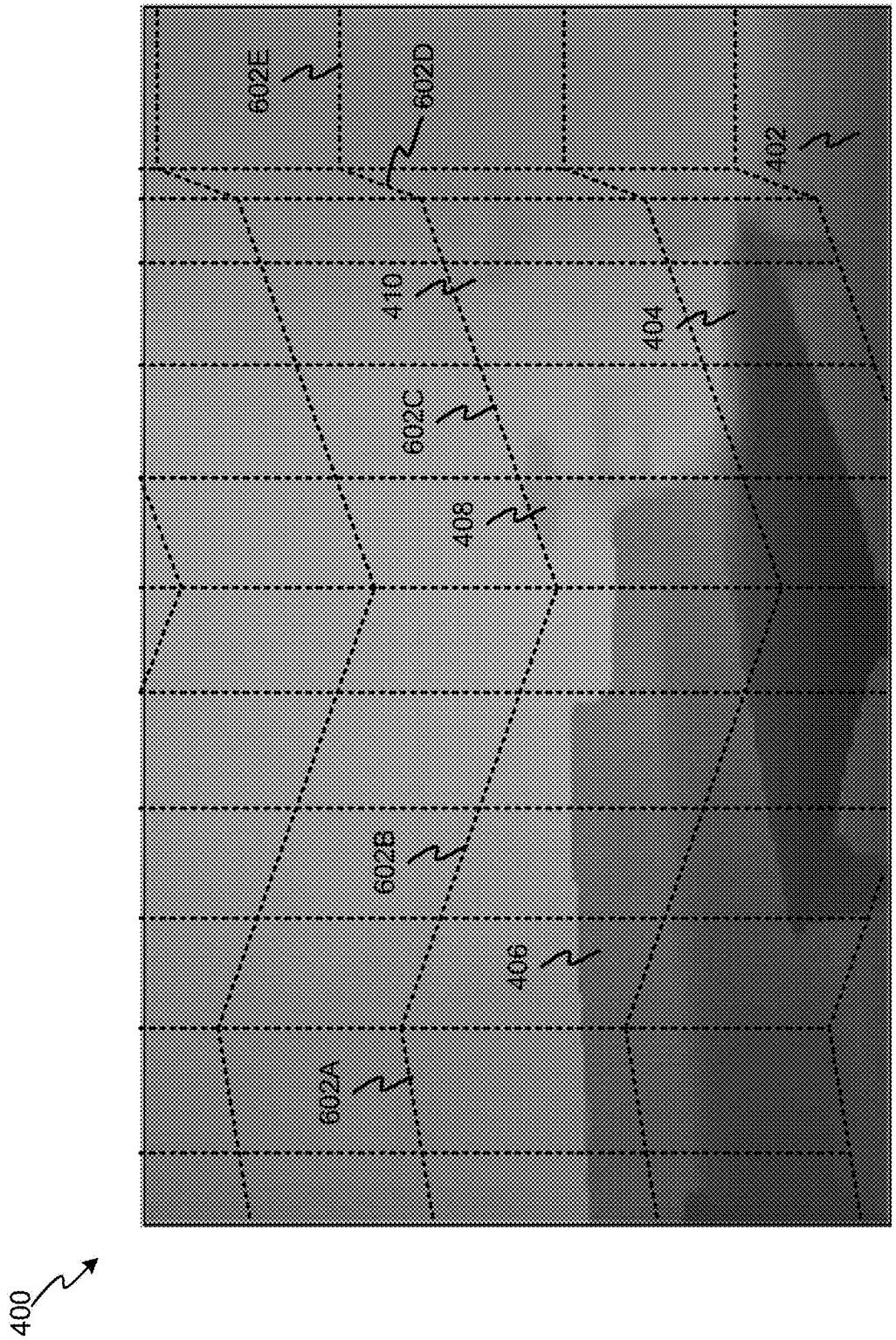


FIG. 6

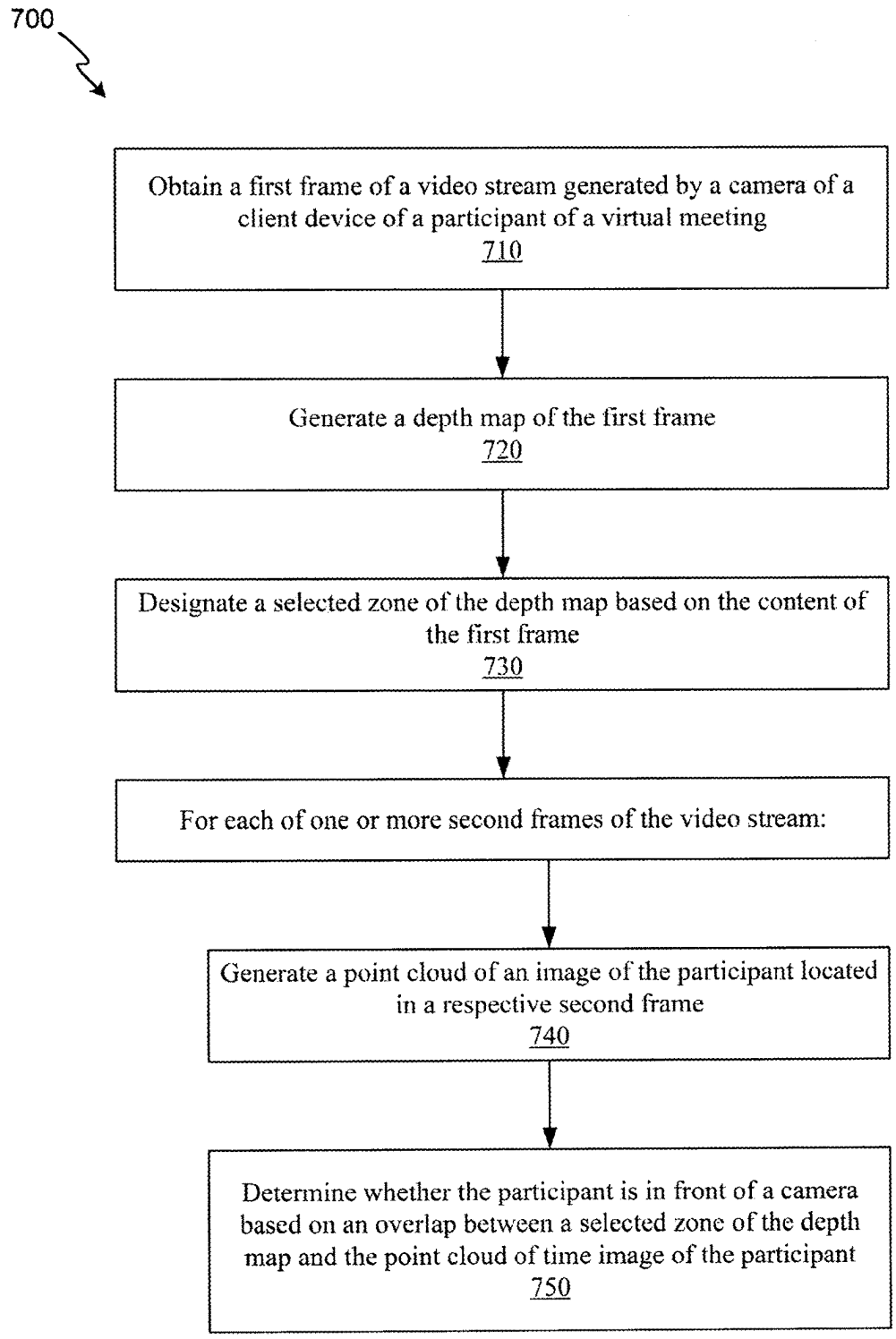

700
Obtain a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting
710
Generate a depth map of the first frame
720
Designate a selected zone of the depth map based on the content of the first frame
730
For each of one or more second frames of the video stream:
Generate a point cloud of an image of the participant located in a respective second frame
740
Determine whether the participant is in front of a camera based on an overlap between a selected zone of the depth map and the point cloud of time image of the participant
750

FIG. 7

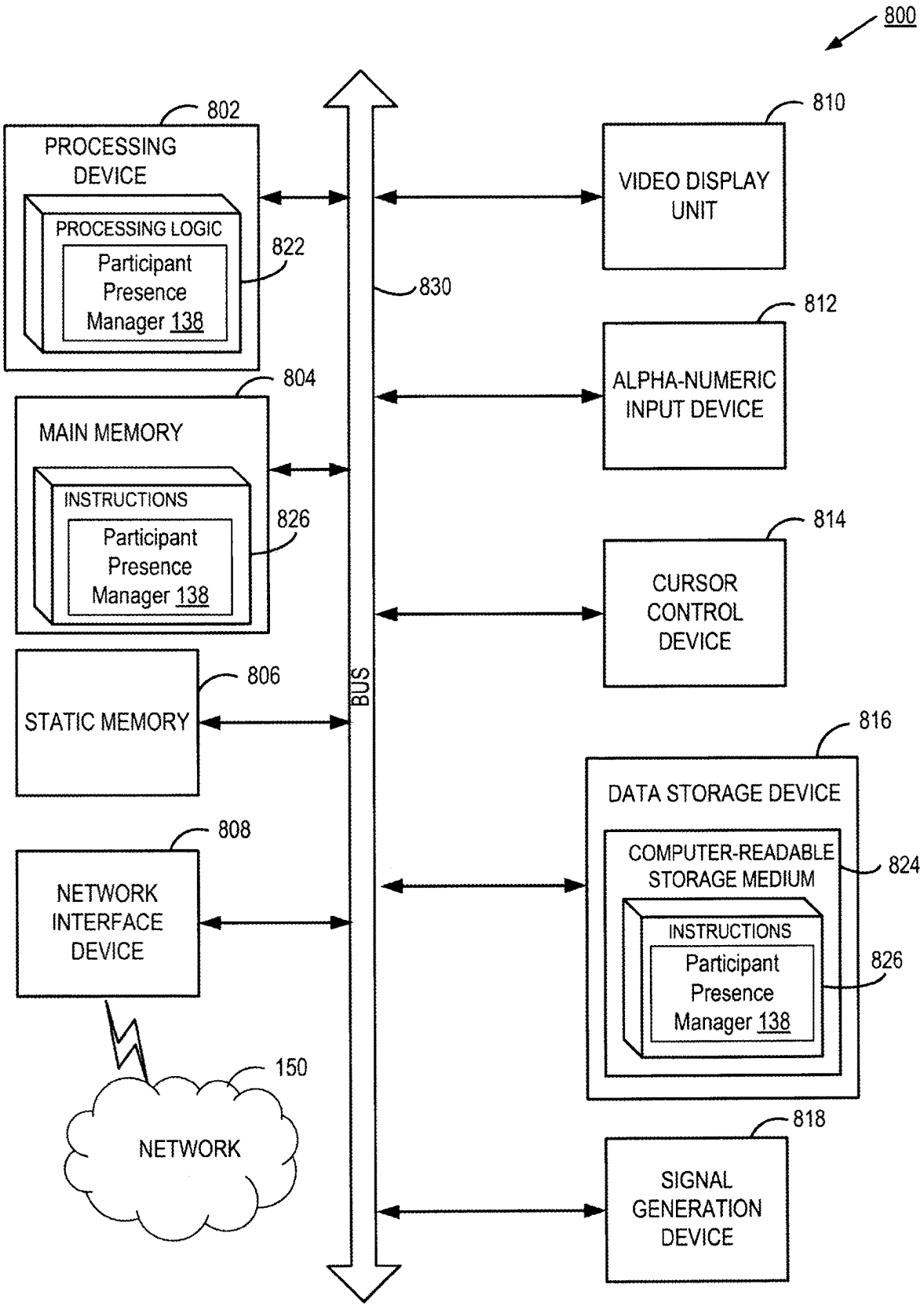

800
802
PROCESSING DEVICE
PROCESSING LOGIC
Participant Presence Manager 138
822
804
MAIN MEMORY
INSTRUCTIONS
Participant Presence Manager 138
826
806
STATIC MEMORY
808
NETWORK INTERFACE DEVICE
150
NETWORK
BUS
830
810
VIDEO DISPLAY UNIT
812
ALPHA-NUMERIC INPUT DEVICE
814
CURSOR CONTROL DEVICE
816
DATA STORAGE DEVICE
COMPUTER-READABLE STORAGE MEDIUM
824
INSTRUCTIONS
Participant Presence Manager 138
826
818
SIGNAL GENERATION DEVICE

FIG. 8

DETECTING THE PRESENCE OF A VIRTUAL MEETING PARTICIPANT

TECHNICAL FIELD

[0001] Aspects and implementations of the present disclosure relate to virtual meetings and more specifically to detecting the presence of a virtual meeting participant.

BACKGROUND

[0002] Virtual meetings can take place between multiple participants via a virtual meeting platform. A virtual meeting platform can include tools that allow multiple client devices to be connected over a network and share each other's audio (e.g., voice of a user recorded via a microphone of a client device) and/or video stream (e.g., a video captured by a camera of a client device, or video captured from a screen image of the client device) for efficient communication. To this end, the virtual meeting platform can provide a user interface that includes multiple regions to present the video stream of each participating client device.

SUMMARY

[0003] The below summary is a simplified summary of the disclosure in order to provide a basic understanding of some aspects of the disclosure. This summary is not an extensive overview of the disclosure. It is intended neither to identify key or critical elements of the disclosure, nor delineate any scope of the particular implementations of the disclosure or any scope of the claims. Its sole purpose is to present some concepts of the disclosure in a simplified form as a prelude to the more detailed description that is presented later.

[0004] An aspect of the disclosure provides a method for detecting the presence of a virtual meeting participant. The method may include obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting. The method may include generating a depth map of the first frame. For each of one or more second frames of the video stream, the method may include generating a point cloud of an image of the participant located in a respective second frame, and determining whether the participant is in front of the camera based on an overlap between a selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

[0005] Another aspect of the disclosure provides a system for detecting the presence of a virtual meeting participant. The system includes a memory and one or more processing devices, coupled to the memory, configured to perform one or more operations. The operations may include obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting, The operations may include generating a depth map of the first frame. For each of one or more second frames of the video stream, the operations may include generating a point cloud of an image of the participant located in a respective second frame, and determining whether the participant is in front of the camera based on an overlap between a selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

[0006] Another aspect of the disclosure provides another method for detecting the presence of a virtual meeting participant. The method may include obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting. The method may include generating a depth map of the first frame. The method may include designating a selected zone of the depth map based on content of the depth map. For each of one or more second frames of the video stream, the method may include generating a point cloud of an image of the participant located in a respective second frame, and determining whether the participant is in front of the camera based on an overlap between the selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Aspects and implementations of the present disclosure will be understood more fully from the detailed description given below and from the accompanying drawings of various aspects and implementations of the disclosure, which, however, should not be taken to limit the disclosure to the specific aspects or implementations, but are for explanation and understanding only.

[0008] FIG. **1** illustrates an example system architecture for detecting the presence of a virtual meeting participant, in accordance with some implementations of the present disclosure.

[0009] FIG. **2** depicts a flow diagram of a method for detecting the presence of a virtual meeting participant, in accordance with some implementations of the present disclosure.

[0010] FIG. **3** illustrates a schematic block diagram for an artificial intelligence (AI) subsystem of a virtual meeting platform, in accordance with some implementations of the present disclosure.

[0011] FIG. **4** illustrates an example depth map for use in detecting the presence of a virtual meeting participant, in accordance with some implementations of the present disclosure.

[0012] FIG. **5** depicts an example point cloud for use in detecting the presence of a virtual meeting participant, in accordance with some implementations of the present disclosure.

[0013] FIG. **6** depicts an example depth map with boundaries of a selected zone, in accordance with some implementations of the present disclosure.

[0014] FIG. **7** depicts a flow diagram of a method for detecting the presence of a virtual meeting participant, in accordance with some implementations of the present disclosure.

[0015] FIG. **8** is a block diagram illustrating an exemplary computer system, in accordance with some implementations of the present disclosure.

DETAILED DESCRIPTION

[0016] Aspects of the present disclosure relate to detecting the presence of a virtual meeting participant during a virtual meeting. A virtual meeting platform can enable video-based conferences between multiple participants via respective client devices that are connected over a network and share each other's audio (e.g., voice of a user recorded via a microphone of a client device) and/or video streams (e.g., a video captured by a camera of a client device) during a virtual meeting. In some instances, a virtual meeting platform can enable a significant number of client devices (e.g., up to one hundred or more client devices) to be connected

via the virtual meeting. A participant of a virtual meeting can speak to the other participants of the virtual meeting. Some existing virtual meeting platforms can provide a user interface (UI) to each client device connected to the virtual meeting, where the UI displays visual items corresponding to the video streams shared over the network in a set of regions in the UI.

[0017] In a typical virtual meeting, a participant mutes a microphone or a camera of the participant's client device by interacting with a UI of the virtual meeting (e.g., by using a "mute" button or a "video off" button) when the participant no longer wishes to be heard or seen by other participants. The participant may mute the microphone or the camera, e.g., to answer the door, answer the phone, or perform other tasks while participating in the virtual meeting. However, the participant may forget to mute the microphone or the camera, which may result in the participant unintentionally broadcasting video or audio to the virtual meeting. This can be distracting for other virtual meeting participants.

[0018] Implementations of the present disclosure address the above and other deficiencies by detecting whether a virtual meeting participant is not present in front of the participant's camera (or some other location) and automatically muting the microphone or the camera of the participant's client device during a virtual meeting. In particular, a participant presence manager of a virtual meeting platform can obtain a first frame from a video stream generated by the camera of the client device of the participant. The participant presence manager can generate a depth map of the first frame. The participant presence manager can use a generative diffusion artificial intelligence (AI) model to generate the depth map. The participant presence manager can, for each of one or more second frames, generate a point cloud of an image of the participant located within the respective second frame. The participant presence manager can use a second generative diffusion AI model to generate the point cloud. The participant presence manager can then determine whether the participant is in front of the client device's camera based on an overlap between (1) a selected zone of the depth map, and (2) the point cloud of the image of the participant. If the participant is not sufficiently in front of the camera, the participant presence manager can cause a virtual meeting application of the client device to mute the device's microphone and/or the camera.

[0019] Aspects of the present disclosure provide technical advantages over previous solutions. Aspects of the present disclosure can provide additional functionality to a virtual meeting platform by automatically detecting the presence of a virtual meeting participant in order to determine whether to mute a microphone or a camera of the participant's client device. This automated detection functionality, in some implementations, may use generative AI to assist in the detection of the presence of the participant. This may allow the virtual meeting platform to detect the presence of the participant without using specialty equipment, such as depth cameras, which may allow the functionality to be provided on a wider variety of client devices. Furthermore, aspects of the present disclosure can provide an improved user experience during virtual meetings by automatically muting a microphone or a camera of a participant's client device, which results in less distractions and disruptions for other virtual meeting participants.

[0020] FIG. **1** illustrates an example system architecture **100**, in accordance with implementations of the present disclosure. The system architecture **100** includes one or more client devices **102**A-**102**N or **104**, a virtual meeting platform **120**, a server **130**, and a data store **140**, each connected to a network **150**.

[0021] In some implementations, the virtual meeting platform **120** enables users of one or more of the client devices **102**A-**102**N, **104** to connect with each other in a virtual meeting (e.g., a virtual meeting **122**). A virtual meeting **122** refers to a real-time communication session such as a video-based call or video chat, in which participants can connect with multiple additional participants in real-time and be provided with audio and video capabilities. A virtual meeting **122** may include an audio-based call or chat, in which participants connect with multiple additional participants in real-time and are provided with audio capabilities. Real-time communication refers to the ability for users to communicate (e.g., exchange information) instantly without transmission delays and/or with negligible (e.g., milliseconds or microseconds) latency. The virtual meeting platform **120** can allow a user of the virtual meeting platform **120** to join and participate in a virtual meeting **122** with other users of the virtual meeting platform **120** (such users sometimes being referred to, herein, as "virtual meeting participants" or, simply, "participants"). Implementations of the present disclosure can be implemented with any number of participants connecting via the virtual meeting **122** (e.g., up to one hundred or more).

[0022] In implementations of the disclosure, a "user" or "participant" can be represented as a single individual. However, other implementations of the disclosure encompass a "user" being an entity controlled by a set of users or an organization and/or an automated source such as a system or a platform. In situations in which the systems discussed here collect personal information about users, or can make use of personal information, the users can be provided with an opportunity to control whether the virtual meeting platform **120** or the virtual meeting manager **132** collects user information (e.g., information about a user's social network, social actions or activities, profession, a user's preferences, or a user's current location), or to control whether or how to receive content from the virtual meeting platform **120** or the virtual meeting manager **132** that can be more relevant to the user. In addition, certain data can be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity can be treated so that no personally identifiable information can be determined for the user, or a user's geographic location can be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user can have control over how information is collected about the user and used by the virtual meeting platform **120** or the virtual meeting manager **132**.

[0023] In some implementations, the server **130** includes a virtual meeting manager **132**. The virtual meeting manager **132**, in one or more implementations, is configured to manage a virtual meeting **122** between multiple users of the virtual meeting platform **120**. The virtual meeting manager **132** can provide the UIs **108**A-**108**N to each client device **102**A-N, **104** to enable users to watch and listen to each other during a virtual meeting **122**. The virtual meeting manager **132** can also collect and provide data associated with the virtual meeting **122** to each participant of the virtual meeting **122**. In some implementations, the virtual meeting

manager **132** provides the UIs **108**A-**108**N for presentation by client applications **105**A-N. For example, the respective UIs **108**A-**108**N can be displayed on the display devices **107**A-**107**N by the client applications **105**A-N executing on the operating systems of the client devices **102**A-**102**N, **104**. In some implementations, the virtual meeting manager **132** determines visual items for presentation in the UIs **108**A-**108**N during a virtual meeting. A visual item can refer to a UI element that occupies a particular region in the UI and is dedicated to presenting a video stream from a respective client device. Such a video stream can depict, for example, a user of the respective client device **102**A-N, **104** while the user is participating in the virtual meeting **122** (e.g., speaking, presenting, listening to other participants, watching other participants, etc., at particular moments during the virtual meeting **122**), a physical conference or meeting room (e.g., with one or more participants present), a document or media content (e.g., video content, one or more images, etc.) being presented during the virtual meeting **122**, etc.

[0024] In some implementations, the virtual meeting manager **132** includes a video stream processor **134** and a UI controller **136**. Each of the video stream processor **134** or the UI controller **136** may include a software application (or a subset thereof) that performs certain virtual meeting functionality for the virtual meeting manager **132**. The video stream processor **134** may be configured to receive video streams from one or more of the client devices **102**A-**102**N, **104**. The video stream processor **134** may be configured to determine visual items for presentation in the UI of such client devices **102**A-N, **104** (e.g., the UIs **108**-**108**N, discussed below) during the virtual meeting **122**. Each visual item can correspond to a video stream from a client device **102**A-N, **104** (e.g., the video stream pertaining to one or more participants of the virtual meeting **122**). In some implementations, the video stream processor **134** receives audio streams associated with the video streams from the client devices (e.g., from an audiovisual component of the client devices **102**A-**102**N, **104**). Once the video stream processor **134** has determined visual items for presentation in the UI, the video stream processor **134** can notify the UI controller **136** of the determined visual items. The visual items for presentation can be determined based on current speaker, current presenter, order of the participants joining the virtual meeting **122**, list of participants (e.g., alphabetical), etc.

[0025] In some implementations, the UI controller **136** provides the UI for the virtual meeting **122**. The UI can include multiple regions. Each region can display a video stream pertaining to one or more participants of the virtual meeting **122**. The UI controller **136** can control which video stream is to be displayed by providing a command to one or more client devices **102**A-**102**N, **104** that indicates which video stream is to be displayed in which region of the UI (along with the received video and audio streams being provided to the client devices **102**A-**102**N, **104**). For example, in response to being notified of the determined visual items for presentation in the UI **108**A-**108**N, the UI controller **136** can transmit a command causing each determined visual item to be displayed in a region of the UI and/or rearranged in the UI.

[0026] In one or more implementations, the virtual meeting manager **132** includes a participant presence manager **138**. The participant presence manager **138** may include a software application (or a subset thereof) that performs certain virtual meeting functionality for a virtual meeting manager **132**. The participant presence manager **138** may be configured to detect whether a virtual meeting participant is present in front of the camera of the participant's client device **102**A-N, **104**, and if the participant is not present, the participant presence manager **138** can cause the application **105**A-N of the participant's client device **102**A-N, **104** to mute the microphone and/or camera of the client device **102**A-N, **104**. The participant presence manager **138** may include one or more generative AI models **139**A-M that the participant presence manager **138** can use to detect the presence of the participant. Functionality of the participant presence manager **138** is discussed further below in relation to FIGS. **2** and **7**.

[0027] In some implementations, each of the virtual meeting platform **120** or the server **130** include one or more computing devices (such as a rackmount server, a router computer, a server computer, a personal computer, a mainframe computer, a laptop computer, a tablet computer, a desktop computer, etc.), data stores (e.g., hard disks, memories, databases), networks, software components, and/or hardware components that can be used to enable a user to connect with other users via a virtual meeting **122**. The virtual meeting platform **120** can also include a website (e.g., one or more webpages) or application back-end software that can be used to enable a user to connect with other users by way of the virtual meeting **122**.

[0028] In some implementations, the one or more client devices **102**A-**102**N each include one or more computing devices such as personal computers (PCs), laptops, mobile phones, smart phones, tablet computers, netbook computers, network-connected televisions, etc. The one or more client devices **102**A-**102**N can also be referred to as "user devices." Each client device **102**A-**102**N can include an audiovisual component that can generate audio and video data to be streamed to the virtual meeting manager **132**. The audiovisual component can include a device (e.g., a microphone) to capture an audio signal representing speech of a user and generate audio data (e.g., an audio file or audio stream) based on the captured audio signal. The audiovisual component can include another device (e.g., a speaker) to output audio data to a user associated with a particular client device **102**A-**102**N. In some implementations, the audiovisual component includes an image capture device (e.g., a camera) to capture images and generate video data (e.g., a video stream) of the captured data of the captured images.

[0029] In some implementations, the system architecture **100** includes a client device **104**. The client device **104** can differ from a client device of the one or more client devices **102**A-N because the client device **104** may be associated with a physical conference or meeting room. Such client device **104** can include or be coupled to a media system **110** that can include one or more display devices **112**, one or more speakers **114** and one or more cameras **116**. Display device **112** can be, for example, a smart display or a non-smart display (e.g., a display that is not itself configured to connect to the network **150**). Users that are physically present in the room can use the media system **110** rather than their own devices (e.g., one or more of the client devices **102**A-**102**N) to participate in the virtual meeting **122**, which can include other remote users. For example, the users in the room that participate in the virtual meeting **122** can control the display device **112** to show a slide presentation or watch slide presentations of other participants. Sound and/or cam-

era control can similarly be performed. Similar to client devices **102**A-**102**N, the one or more client devices **104** can generate audio and video data to be streamed to the virtual meeting manager **132** (e.g., using one or more microphones, speakers **114** and cameras **116**).

[0030] As described previously, an audiovisual component of each client device **102**A-N, **104** can capture images and generate video data (e.g., a video stream) of the captured data of the captured images. In some implementations, the client devices **102**A-**102**N, **104** transmit the generated video stream to virtual meeting manager **132**. The audiovisual component of each client device **102**A-N, **104** can also capture an audio signal representing speech of a user and generate audio data (e.g., an audio file or audio stream) based on the captured audio signal. In some implementations, the client devices **102**A-**102**N, **104** transmit the generated audio data to the virtual meeting manager **132**.

[0031] In some implementations, each client device **102**A-**102**N or **104** includes a respective client application **105**A-N, which can be a mobile application, a desktop application, a web browser, etc. The client application **105**A-N can present, on a display device **107**-**107**N of a client device **102**A-**102**N or a UI (e.g., a UI of the UIs **108**A-**108**N), one or more features of the application **105**A-N for users to access the virtual meeting platform **120**. For example, a user of client device **102**A can join and participate in the virtual meeting **122** via a UI **108**A presented on the display device **107**A by the application **105**A. The user can present a document to participants of the virtual meeting **122** using the UI **108**A. Each of the UIs **108**A-**108**N can include multiple regions to present visual items corresponding to video streams of the client devices **102**A-**102**N provided to the server **130** for the virtual meeting **122**.

[0032] In one or more implementations, the participant presence manager **138** is part of a client device **102**A-**102**N, **104**. For example, the application **105**A-N can include the participant presence manager **138**, which can detect whether a virtual meeting participant is present in front of the camera of the participant's client device **102**A-N, **104**, and if the participant is not present, the application **105**A-N can mute the microphone of the client device **102**A-N, **104** and/or the camera of the client device **102**A-N, **104**. If the participant presence manager **138** detects that the participant is present in front of the camera of the participant's client device **102**A-N, **104**, the application **105**A-N can send the video stream to the virtual meeting manager **132**, which can use the UI controller **136** to generate the virtual meeting UIs and provide the UIs to the client devices **102**A-**102**N, **104**. In some implementations, the application **105**A sends the video stream to the other client devices **102**B-N, **104**, and receives the video streams from the other client devices **102**B-N, **104**, and the applications **105**A-**105**N can generate their respective virtual meeting UIs **106**A-**106**N or can finalize their respective UIs **106**A-**106**N, which may have been partially generated by the UI controller **136**.

[0033] In some implementations, the data store **140** is a persistent storage that is capable of storing data as well as data structures to tag, organize, and index the data. A data item can include audio data and/or video stream data, in accordance with implementations described herein. The data store **140** can be hosted by one or more storage devices, such as main memory, magnetic or optical storage-based disks, tapes, hard drives, flash memory, and so forth. In some implementations, the data store **140** is a network-attached file server, while in other implementations, the data store **140** is some other type of persistent storage such as an object-oriented database, a relational database, and so forth, that can be hosted by the virtual meeting platform **120** or one or more different machines (e.g., the server **130**) coupled to the virtual meeting platform **120** using the network **150**. In some implementations, the data store **140** stores portions of audio and video streams received from one or more client devices **102**A-**102**N, **104** for the virtual meeting platform **120**. Moreover, the data store **140** can store various types of documents, such as a slide presentation, a text document, a spreadsheet, or any suitable electronic document (e.g., an electronic document including text, tables, videos, images, graphs, slides, charts, software programming code, designs, lists, plans, blueprints, maps, etc.). These documents can be shared with users of the client devices **102**A-**102**N, **104** and/or concurrently editable by the users.

[0034] In some implementations, the network **150** includes a public network (e.g., the Internet), a private network (e.g., a local area network (LAN) or wide area network (WAN)), a wired network (e.g., Ethernet network), a wireless network (e.g., an 802.11 network or a Wi-Fi network), a cellular network (e.g., a Long Term Evolution (LTE) network), routers, hubs, switches, server computers, and/or a combination thereof.

[0035] It should be noted that in some implementations, the functions of the virtual meeting platform **120** or the server **130** are provided by a fewer number of machines. For example, in some implementations, the server **130** is integrated into a single machine, while in other implementations, the server **130** is integrated into multiple machines. In addition, in one or more implementations, the server **130** is integrated into the virtual meeting platform **120**.

[0036] In general, one or more functions described in the several implementations as being performed by the virtual meeting platform **120** or server **130** can also be performed by the client devices **102**A-N, **104** in other implementations, if appropriate. In addition, in some implementations, the functionality attributed to a particular component can be performed by different or multiple components operating together. The virtual meeting platform **120** or the server **130** can also be accessed as a service provided to other systems or devices through appropriate application programming interfaces, and thus is not limited to use in websites.

[0037] Although implementations of the disclosure are discussed in terms of the virtual meeting platform **120** and users of the virtual meeting platform **120** participating in a virtual meeting **122**, implementations can also be generally applied to any type of telephone call, conference call, or other technological communications methods between users. Implementations of the disclosure are not limited to virtual meeting platforms that provide virtual meeting tools to users.

[0038] FIG. **2** is a flowchart illustrating one embodiment of a method **200** for detecting the presence of a participant during a virtual meeting **122**, in accordance with some implementations of the present disclosure. A processing device, having one or more central processing units (CPU(s)), one or more graphics processing units (GPU(s)), and/or memory devices communicatively coupled to the one or more CPU(s) and/or GPU(s) can perform the method **200** and/or one or more of the method's **200** individual functions, routines, subroutines, or operations. In certain implementations, a single processing thread can perform the method

200. Alternatively, two or more processing threads can perform the method **200**, each thread executing one or more individual functions, routines, subroutines, or operations of the method. In an illustrative example, the processing threads implementing the method **200** can be synchronized (e.g., using semaphores, critical sections, and/or other thread synchronization mechanisms). Alternatively, the processing threads implementing the method **200** can be executed asynchronously with respect to each other. Various operations of the method **200** can be performed in a different (e.g., reversed) order compared with the order shown in FIG. **2**. Some operations of the method **200** can be performed concurrently with other operations. Some operations can be optional. In some implementations, the participant presence manager **138** performs one or more of the operations of the method **200**.

[0039] At block **210**, processing logic obtains a first frame of a video stream generated by a camera of a client device **102**A of a participant of a virtual meeting **122**. In some implementations, the application **105**A of the client device **102**A, **104** obtains the first frame from the camera of the client device **102**A and provides the first frame to the participant presence manager **138**.

[0040] In some implementations, the first frame includes an image of the background of the participant. The background may include objects in an area where the client device **102**A-N, **104** is located (e.g., furniture, walls, a floor, a ceiling, etc.). In some implementations, the first frame includes an image of the participant in an area of the first frame. The application **105**A can remove the image of the participant from the area, or the application **105**A can provide the first frame to the participant presence manager **138**, and the participant presence manager **138** can remove the image of the participant. As a result, the first frame may include an image of the background with a blank space in the area where the image of the participant used to be located.

[0041] As used herein, the term "background" may refer to an area in a virtual meeting participant's visual item that surrounds the image of the participant. The background may include a real physical background, which may include a location and one or more objects near the participant and that are viewable from the participant's video camera. The background may include a virtual background, which may include an image over which an image of the participant is superimposed and replaces the participant's real physical background during the virtual meeting.

[0042] In one implementation, the participant presence manager **138** causes a trained AI model **139**A-M to fill the area. FIG. **3** illustrates an example AI subsystem **300** that can be used to train the AI model **139**A-M, in accordance with implementations of the present disclosure. As illustrated in FIG. **3**, the AI subsystem **300** can include a training subsystem **310**, which may include a training data engine **312**, a training engine **314**, a validation engine **316**, a selection engine **318**, or a testing engine **320**. The AI subsystem **300** may include one or more AI models **139**A-M.

[0043] In one implementation, an AI model **139**A-M includes one or more of artificial neural networks (ANNs), decision trees, random forests, support vector machines (SVMs), clustering-based models, Bayesian networks, or other types of machine learning models. ANNs generally include a feature representation component with a classifier or regression layers that map features to a target output space. The ANN can include multiple nodes ("neurons") arranged in one or more layers, and a neuron may be connected to one or more neurons via one or more edges ("synapses"). The synapses can perpetuate a signal from one neuron to another, and a weight, bias, or other configuration of a neuron or synapse can adjust a value of the signal. Training the ANN may include adjusting the weights or other features of the ANN based on an output produced by the ANN during training.

[0044] An ANN may include, for example, a convolutional neural network (CNN), recurrent neural network (RNN), or a deep neural network. A CNN, a specific type of ANN, hosts multiple layers of convolutional filters. Pooling is performed, and non-linearities may be addressed, at lower layers, on top of which a multi-layer perceptron is commonly appended, mapping top layer features extracted by the convolutional layers to decisions (e.g., classification outputs). A deep network may include an ANN with multiple hidden layers or a shallow network with zero or a few (e.g., 1-2) hidden layers. Deep learning is a class of machine learning algorithms that use a cascade of multiple layers of nonlinear processing units for feature extraction and transformation. Each successive layer uses the output from the previous layer as input. An RNN is a type of ANN that includes a memory to enable the ANN to capture temporal dependencies. An RNN is able to learn input-output mappings that depend on both a current input and past inputs. The RNN will address past and future measurements and make predictions based on this continuous measurement information. One type of RNN that can be used is a long short term memory (LSTM) neural network.

[0045] ANNs can learn in a supervised (e.g., classification) or unsupervised (e.g., pattern analysis) manner. Some ANNs (e.g., such as deep neural networks) may include a hierarchy of layers, where the different layers learn different levels of representations that correspond to different levels of abstraction. In deep learning, each level learns to transform its input data into a slightly more abstract and composite representation.

[0046] In one implementation, an AI model **139**A-M includes a generative AI model. A generative AI model can deviate from a machine learning model based on the generative AI model's ability to generate new, original data, rather than making predictions based on existing data patterns. A generative AI model can include a generative adversarial network (GAN), a variational autoencoder (VAE), a large language model (LLM), or a diffusion model. In some instances, a generative AI model can employ a different approach to training or learning the underlying probability distribution of training data, compared to some machine learning models. For instance, a GAN can include a generator network and a discriminator network. The generator network attempts to produce synthetic data samples that are indistinguishable from real data, while the discriminator network seeks to correctly classify between real and fake samples. Through this iterative adversarial process, the generator network can gradually improve its ability to generate increasingly realistic and diverse data.

[0047] Generative AI models also have the ability to capture and learn complex, high-dimensional structures of data. One aim of generative AI models is to model underlying data distribution, allowing them to generate new data points that possess the same characteristics as training data.

Some machine learning models (e.g., that are not generative AI models) focus on optimizing specific prediction of tasks.

[0048] In some implementations, an AI model **139**A-M is an AI model that has been trained on a corpus of data. For example, the AI model **139**A-M can be an AI model that is first pre-trained on a corpus of data to create a foundational model, and afterwards fine-tuned on more data pertaining to a particular set of tasks to create a more task-specific, or targeted, model. The foundational model can first be pre-trained using a corpus of data that can include data in the public domain, licensed content, and/or proprietary content. Such a pre-training can be used by the AI model **139**A-M to learn broad elements including, image or speech recognition, general sentence structure, common phrases, vocabulary, natural language structure, and other elements. In some implementations, this first foundational model is trained using self-supervision, or unsupervised training on such datasets.

[0049] In some implementations, the second portion of training, including fine-tuning, includes unsupervised, supervised, reinforced, or any other type of training. In some implementations, this second portion of training includes some elements of supervision, including learning techniques incorporating human or machine-generated feedback, undergoing training according to a set of guidelines, or training on a previously labeled set of data, etc. In a non-limiting example associated with reinforcement learning, the outputs of the AI model **139**A-M while training may be ranked by a user, according to a variety of factors, including accuracy, helpfulness, veracity, acceptability, or any other metric useful in the fine-tuning portion of training. In this manner, the AI model **139**A-M can learn to favor these and any other factors relevant to users when generating a response. Further details regarding training are provided below.

[0050] In some implementations, an AI model **139**A-M includes one or more pre-trained models, or fine-tuned models. In a non-limiting example, in some implementations, the goal of the "fine-tuning" can be accomplished with a second, or third, or any number of additional models. For example, the outputs of the pre-trained model may be input into a second AI model that has been trained in a similar manner as the "fine-tuned" portion of training above. In such a way, two more AI models may accomplish work similar to one model that has been pre-trained, and then fine-tuned.

[0051] As indicated above, an AI model **139**A-M may be one or more generative AI models, allowing for the generation of new and original content. In one implementation, a generative AI model includes a diffusion model. A diffusion model may include a deep generative model that can be used to generate images, edit existing images, and create new image styles. The diffusion model may have been trained by iteratively applying a diffusion process to an input image, which may include gradually adding noise to the image until it becomes unrecognizable. The diffusion model then learns to reverse this process, starting from the noisy image and gradually denoising it until it becomes a recognizable image. In some implementations, the diffusion model may have been trained on multiple virtual meeting backgrounds by using different virtual meeting backgrounds as input images during the training process.

[0052] In one implementation, the training subsystem **310** manages the training and testing of an AI model **139**A-M. The training data engine **312** can generate training data (e.g., a set of training inputs such as noisy virtual meeting background images and a set of target outputs such as respective denoised virtual meeting background images) to train an AI model **139**A-M. In an illustrative example, the training data engine **312** can initialize a training set T to null (e.g., { }). The training data engine **312** can add the training data to the training set T and can determine whether training set T is sufficient for training a AI model **139**A-M. The training set T can be sufficient for training the AI model **139**A-M if the training set T includes a threshold amount of training data, in some implementations. In response to determining that the training set T is not sufficient for training, the training data engine **312** can identify additional data to use as training data. In response to determining that the training set T is sufficient for training, the training data engine **312** can provide the training set T to the training engine **314**.

[0053] The training engine **314** can train an AI model **139**A-M using the training data (e.g., training set T). The AI model **139**A-M may refer to the model artifact that is created by the training engine **314** using the training data, where such training data can include training inputs and, in some implementations, corresponding target outputs. The training engine **314** can input the training data into the AI model **139**A-M so that the AI model **139**A-M can find patterns in the training data and configure itself based on those patterns.

[0054] Where the AI model **139**A-M uses supervised learning, the training engine **314** can assist the AI model **139**A-M in determining whether the AI model **139**A-M maps the training input to the target output. Where the AI model **139**A-M uses unsupervised learning, the training engine **314** can input the training data into the AI model **139**A-M The AI model **139**A-M can configure itself based on the input training data, but since the training data may not include a target output, the training engine **314** may not assist the AI model **139**A-M in determining whether the AI model **139**A-M provided a correct output during the training process.

[0055] The validation engine **316** may be capable of validating a trained AI model **139**A-M using a corresponding set of features of a validation set from the training data engine **312**. The validation engine **316** can determine an accuracy of each of the trained AI models **139**A-M based on the corresponding sets of features of the validation set. Where the training data may not include a target output, validating a trained AI model **139**A-M may include obtaining an output from the AI model **139**A-M and providing the output to another entity for evaluation. The other entity may include another AI model configured to evaluation the output of the AI model **139**A-M that is undergoing training. The other entity may include a human. The validation engine **316** can discard a trained AI model **139**A-M that has an accuracy that does not meet a threshold accuracy or that otherwise fails evaluation. In some implementations, the selection engine **318** is capable of selecting a trained AI model **139**A-M that has an accuracy that meets a threshold accuracy. In some implementations, the selection engine **318** may be capable of selecting the trained AI model **139**A-M that has the highest accuracy of multiple trained AI models **139**A-M. In some implementations, the selection engine **318** receives input from another AI model or a human and can select a trained AI model **139**A-M based on the input.

[0056] The testing engine **320** may be capable of testing a trained AI model **139**A-M using a corresponding set of features of a testing set from the training data engine **312**. For example, a first trained AI model **139**A that was trained

using a first set of features of the training set may be tested using the first set of features of the testing set. The testing engine **320** can determine a trained AI model **139**A-M that has the highest accuracy or other evaluation of all of the trained AI models **139**A-M based on the testing sets.

[0057] In one implementation, the training engine **314** trains an AI model **139**A. The training data engine **312** can generate training data that includes images of virtual meeting backgrounds, and the training engine **314** can cause the AI model **139**A to undergo a diffusion model training process using the training data. The AI model **139**A can undergo a validation and testing process using the validation engine **316** and testing engine **320**.

[0058] In some implementations, the AI subsystem **300** and/or the participant presence manager **138** include a predictive component. The predictive component can be configured to feed data as input to an AI model **139**A-M, e.g., training data or an image from the participant presence manager **138**. The predictive component can be configured to obtain one or more outputs from the one or more AI models **139**A-M and provide the one or more outputs to the AI subsystem **300** or the participant presence manager **138**.

[0059] In some implementations, the AI subsystem **300** is part of the server **130**, the virtual meeting manager **132**, or the participant presence manager **138**. Alternatively, the AI subsystem **300** may be part of another server, system, sub-system, or it may be an independent system. In some implementations, the AI subsystem **300** provides the trained one or more AI models **139**A-M to the participant presence manager **138**.

[0060] Returning to block **210** of FIG. **2**, in some implementations, an AI model **139**A fills an area of the first frame where the image of the participant used to be located. In one implementation, the predictive component of the participant presence manager **138** receives the first frame with the image of the background and the blank area from the participant presence manager **138** and provides the first frame as input to the AI model **139**A. The AI model **139**A can fill the area with image data such that the area is not blank and blends into the original portion of the image of the background. The resulting filled-in first frame that is output by the AI model **139**A can be obtained by the predictive component, which can provide the resulting filled-in first frame to the participant presence manager **138**.

[0061] In one implementation, block **210** occurs at a virtual meeting preparation phase of the virtual meeting **122**. The preparation phase may include a UI **108**A of the application **105**A where the participant prepares to enter the virtual meeting **122**. While in the preparation screen, video stream processor **134** may not stream video or audio from the participant's client device **102**A to one or more other client devices **102**B-N, **104**. The preparation screen can allow the participant to adjust audio or microphone levels, get positioned in front of the camera of the client device **102**A, or perform other virtual meeting **122** preparation tasks. The preparation screen can allow the participant presence manager **138** to obtain the first frame of the video stream of the client device **102**A. The preparation screen can allow for the participant presence manager **138** to modify the first frame to remove the image of the participant and fill in the image of the background, as discussed above.

[0062] At block **220**, processing logic generates a depth map of the first frame. The depth map may include an image representing a three-dimensional area. Each pixel of the image includes data indicating a distance from the point in the three-dimensional area represented by that pixel to a viewpoint (e.g., the camera of the client device **102**A). In a visual version of the image, each pixel may include a greyscale value where a darker shade indicates that the corresponding point is closer to the camera, and a lighter shade indicates that the corresponding point is further away from the camera.

[0063] FIG. **4** depicts an example depth map **400** generated from the first frame. As can be seen in FIG. **4**, different points in a three-dimensional space are represented by different pixels with different grayscale values. Darker pixels indicate that the point is closer to the camera, and lighter pixels indicate that the point is further away from the camera. As can also be seen in FIG. **4**, the pixels can indicate the presence of objects in the background of the participant. For example, the depth map **400** depicts a floor **402** of the room, a table **404**, a couch **406**, a lamp **408**, and a potted plant **410**.

[0064] Referring back to FIG. **2**, in some implementations, at block **220**, processing logic further includes the participant presence manager **138** using a first generative AI model to generate the depth map **400** of the first frame. The first generative AI model can use the first frame as input. The first generative AI model may include a diffusion model. The first generative AI model may include an AI model **139**B of the AI subsystem **300**.

[0065] Referring back to FIG. **3**, in some implementations, the training engine **314** trains the AI model **139**B. The training data engine **312** can generate training data for training the AI model **139**B. Each piece of training data may include an image and a corresponding ground truth that includes a depth map **400** that corresponds to the image. The training engine **314** can cause the AI model **139**B to undergo a diffusion model training process using the training data. In this manner, the AI model **139**B can learn to generate depth maps **400** from images. The AI model **139**B can undergo a validation and testing process using the validation engine **316** and testing engine **320**.

[0066] Referring back to block **220** of FIG. **2**, in one implementation, the predictive component of the participant presence manager **138** receives the first frame and provides the first frame to the AI model **139**B. The AI model **139**B can execute and generate a depth map **400** based on the first frame. The AI model **139**B can apply a diffusion denoising process to the input first frame to generate an output image. The output image may be similar to the input first frame, but since the AI model **139**B applied the diffusion denoising process configured to generate depth map **400**, the output image may resemble a depth map **400** slightly more than the input image. The AI model **139**B can use the output image as input and can apply another diffusion denoising process and output a second output image. The AI model **139**B can iteratively repeat this process until a stop condition is detected (e.g., a predetermined number of iterations have executed, the differences between the input and output images are below a threshold difference, etc.). The AI model **139**B can provide the output depth map **400** to the predictive component **139**, which can provide it to the participant presence manager **138**.

[0067] For each of one or more second frames of the video stream, at block **230**, processing logic generates a point cloud of an image of the participant. The image of the participant may be located in a respective second frame of

the video stream. A point cloud may include a data structure that includes multiple data points in a three-dimensional space. Each point may include data indicating the location of that point in the three-dimensional space (e.g., X, Y, and Z coordinates). In some implementations, the point cloud includes a dense point cloud. A dense point cloud may include a point cloud with a high concentration of points.

[0068] In one implementation, generating the point cloud of an image of the participant includes generating a point cloud of the image of the second frame. Generating a point cloud of the image of the second frame may include generating points in the point cloud for objects in the second frame other than the participant. FIG. **5** depicts an example point cloud **500** generated in block **230**. The point cloud **500** includes points for the various objects shown in FIG. **4** (e.g., points **504** corresponding to the table **404**, points **506** corresponding to the couch **406**, points **508** corresponding to the lamp **408**, and points **510** corresponding to the potted plant **410**). The point cloud **500** may include points **512** that correspond to the participant.

[0069] Referring back to FIG. **2**, in one implementation, block **230** of the method **200** includes the participant presence manager **138** using a second generative AI model to generate the point cloud **500**. The second generative AI model can use the second frame as input. In some implementations, the second generative AI model includes a generative diffusion model. The second generative AI model may include an AI model **139**C of the AI subsystem **300**.

[0070] Referring back to FIG. **3**, in some implementations, the training engine **314** trains the AI model **139**C. The training data engine **312** can generate training data for training the AI model **139**C. Each piece of training data may include an image and a corresponding ground truth that includes a point cloud **500** that corresponds to the image. The training engine **314** can cause the AI model **139**C to undergo a diffusion model training process using the training data. In this manner, the AI model **139**B can learn to generate point clouds **500** from images. The AI model **139**C can undergo a validation and testing process using the validation engine **316** and testing engine **320**.

[0071] Referring back to block **230** of FIG. **2**, in one implementation, the predictive component receives the second frame and provides the second frame to the AI model **139**C. The AI model **139**C can execute and generate a point cloud **500** based on the first frame. The AI model **139**C can apply a diffusion denoising process to the input second frame to generate an output image. The output image may be similar to the input second frame, but since the AI model **139**C applied the diffusion denoising process configured to generate a point cloud **500**, the output image can resemble a point cloud **500** slightly more than the input image. The AI model **139**C can use the output image as input and can apply another diffusion denoising process and output a second output image. The AI model **139**C can iteratively repeat this process until a stop condition is detected. The AI model **139**C can provide the output point cloud **500** to the predictive component **139**, which can provide it to the participant presence manager **138**.

[0072] In some implementations, the first generative AI model is larger than the second generative AI model. For example, where the first and second generative AI models include ANN-based generative AI models, the first generative AI model may include more neurons, more synapses, or more layers than the second generative AI model. Where the first and second generative AI models are diffusion generative models, the first generative AI model can perform more diffusion steps than the second generative AI model. In some implementations, the first generative AI model is larger than the second because the first can execute once on the first frame while the second generative AI model can execute multiple times on multiple second frames. In one implementation, processing logics perform block **230** multiple times per second (e.g., 10 times per second).

[0073] In one implementation, the participant presence manager **138** compares the point cloud **500** to the depth map **400** to determine which points of the point cloud **500** correspond to the participant. The participant presence manager **138** can determine that a point of the point cloud **500** corresponds to an object in the depth map **400** by determining that the location of the point is within a threshold value of a pixel of the depth map **400**. Responsive to a point of the point cloud **500** corresponding to an object of the depth map **400**, the participant presence manager **138** can remove the point from the point cloud **500**. After the comparison of the point cloud **500** to the depth map **400**, the only points remaining in the point cloud **500** can correspond to the participant.

[0074] For each of one or more second frames of the video stream, at block **240**, processing logic determines whether the participant is in front of the camera. Determining that the participant is in front of the camera may be based on an overlap between a selected zone of the depth map **400** and the point cloud **500** of the image of the participant located in the respective second frame.

[0075] In one implementation, the selected zone of the depth map **400** includes a portion of the depth map **400** designated as the area in which at least some of the participant is located in order to have the participant's camera and audio active. FIG. **6** depicts one implementation of the depth map **400** with a selected zone designated in the depth map **400**. As can be seen in FIG. **6**, the depth map **400** is shown with the various objects **402-410**. Boundaries **602**A-E of the selected zone area are also shown. The boundaries **602**A-E may be represented by vertical planes. For example, the first boundary **602**A may include a vertical plane located partially in front of the couch **406**. The second boundary **602**B may include a vertical plane located in front of a side of the table **404**. The third boundary **602**C may include a vertical plane located in front of another side of the table **404**. The fourth boundary **602**D and the fifth boundary **602**E may include vertical planes located in front of the potted plant **410**. The selected zone may include the area between the boundaries **602**A-E and the camera.

[0076] Returning to block **240** of FIG. **2**, in one implementation, the participant provides user input, and the participant presence manager **138** can designate the selected zone based on the user input. For example, the participant presence manager **138** can cause the depth map **400** to be displayed on the UI **108**A of the participant's client device **102**A. The UI **108**A may include functionality allowing the participant to select portions of the depth map **400** (e.g., one or more of the boundaries **602**A-E) to be designated as the selected zone.

[0077] In some implementations, the participant presence manager **138** automatically designates a portion of the depth map **400** as the selected zone. The participant presence manager **138** can designate a portion of the depth map **400** that is in front of one or more objects indicated in the depth

map **400** as the selected zone. As an example, in FIG. **6**, the participant presence manager **138** can designate a portion of the space in front of the table **404** as the selected zone since that portion is in front of the table **404**. However, the participant presence manager **138** may not designate the area between the table **404** and the couch **406** or the area between the table **404** and the potted plant **410** as part of the selected zone because those areas are behind the table **404**. In some implementations, the participant presence manager **138** designates, as the selected zone, the portion of the area that is within a threshold distance from the camera. The threshold distance may include a predetermine distance (e.g., 5 feet (approx. 1.5 meters) from the camera) or a distance from the camera to the closest object. In some implementations, the participant provides user input, and the participant presence manager **138** adjusts a boundary of the selected zone based on the user input.

[0078] In one implementation, determining whether the participant is in front of the camera based on the overlap between the selected zone and the point cloud **500** includes determining whether a threshold amount of the multiple points of the point cloud **500** are located within the selected zone of the depth map **400**. The threshold amount may include a majority of the points of the point cloud **500**. The threshold amount may include at least one point of the point cloud **500**.

[0079] Referring back to FIG. **2**, in some implementations, the method **200** further includes, responsive to determining that the participant is not in front of the camera, causing a first audio/video setting action to be performed. The first audio/video setting action may include muting a microphone and/or camera of the client device **102**A. Muting the microphone may include the application **105**A not streaming audio to the virtual meeting manager **132**, or the virtual meeting manager **132** not streaming the audio associated with the participant's client device **102**A to other client devices **102**B-N, **104**. Muting the camera may include the application **105**A not providing a video stream to the virtual meeting manager **132**, or the virtual meeting manager **132** not providing the video stream associated with the participant's client device **102**A to other client devices **102**B-N, **104**.

[0080] In one implementation, the method **200** includes, responsive to determining that the participant is in front of the camera, causing a second audio/video setting action to be performed. The second audio/video setting action may include unmuting the microphone and/or camera of the client device **102**A. The application **105**A can cause the client device **102**A to perform an alert action to inform the user that the camera or audio are active. The alert may include an auditory or a visual alert presented on the UI **108**A-N. In some implementations, causing the second audio/video setting action to be performed is in further response to previously causing the first audio/video setting action to be performed. For example, during the virtual meeting **122**, the participant associated with the client device **102**A may step away from the camera. The participant presence manager **138** can perform block **240** and determine that the participant is not in front of the camera and, in response, can cause the application **105**A to automatically mute the client device's **102**A microphone and camera. The participant may step back in front of the camera at a later time. The participant presence manager **138** can perform block **240** again and determine that the participant is now in front of the camera and, in response, can cause the application **105**A to automatically unmute the client device's **102**A microphone and camera.

[0081] In some implementations, blocks **230** and **240** occur during a live phase of the virtual meeting **122**. A live phase may refer to a phase in which virtual meeting participants are able to interact with each other (e.g., view or hear each other in real-time (or near real-time due to transmission delays, etc.) during the virtual meeting **122**). The live phase may include the client devices **102**A-N, **104** of the virtual meeting participants providing their respective video streams and/or respective audio streams to the virtual meeting manager **132**, and the virtual meeting manager **132** broadcasting the video and audio streams to the one or more client devices **102**A-N, **104** such that the participants can view or hear each other in the virtual meeting **122**.

[0082] In some implementations, the participant presence manager **138** re-performs the method **200** after a first execution of the method **200**. This may be responsive to receiving user input from the participant indicating that the participant presence manager **138** is to re-perform the method **200**. The participant can provide the user input, for example, in response to the user moving the client device **102**A to another location and, thus, the depth map **400**, as originally created, may no longer apply or be up to date. In some implementations, the participant presence manager **138** automatically re-performs the method **200** responsive to detecting that the depth map **400** no longer applies or is out-of-date. The participant presence manager **138** can detect that the depth map **400** no longer applies responsive to the point cloud **500** varying significantly from the depth map **400**.

[0083] FIG. **7** is a flowchart illustrating one embodiment of a method **700** for detecting the presence of a participant during a virtual meeting **122**, in accordance with some implementations of the present disclosure. A processing device, having one or more CPU(s), one or more (s), and/or memory devices communicatively coupled to the one or more CPU(s) and/or GPU(s) can perform the method **700** and/or one or more of the method's **700** individual functions, routines, subroutines, or operations. In certain implementations, a single processing thread can perform the method **700**. Alternatively, two or more processing threads can perform the method **700**, each thread executing one or more individual functions, routines, subroutines, or operations of the method. In an illustrative example, the processing threads implementing the method **700** can be synchronized (e.g., using semaphores, critical sections, and/or other thread synchronization mechanisms). Alternatively, the processing threads implementing the method **700** can be executed asynchronously with respect to each other. Various operations of the method **700** can be performed in a different (e.g., reversed) order compared with the order shown in FIG. **7**. Some operations of the method **700** can be performed concurrently with other operations. Some operations can be optional. In some implementations, the participant presence manager **138** can perform one or more of the operations of the method **700**.

[0084] At block **710**, processing logic obtains a first frame of a video stream generated by a camera of a client device **102**A of a participant of a virtual meeting **122**. Block **710** may include functionality similar to the functionality of block **210** of the method **200**. At block **720**, processing logic

generates a depth map **400** of the first frame. Block **720** may include functionality similar to the functionality of block **220** of the method **200**.

[0085] At block **730**, processing logic designates a selected zone of the depth map **400** based on content of the depth map **400**. As discussed above, the content of the depth map **400** may include objects (e.g., the objects **402**-**410**) indicated by pixels of the depth map **400**. As discussed above, in some implementations, the participant presence manager **138** automatically designates a portion of the depth map **400** as the selected zone. Designating the selected zone may include the participant presence manager **138** including one or more boundaries **602**A-N in the depth map **400**, as discussed above. In some implementations, designating the selected zone of the depth map **400** based on content of the depth map **400** may include designating a portion of the depth map **400** within a threshold distance as within the selected zone, as discussed above. In one implementation, designating the selected zone of the depth map **400** based on content of the depth map **400** includes designating a portion of the depth map **400** located behind a piece of furniture as outside the selected zone, as discussed above. In one or more implementations, the participant presence manager **138** adjusts a boundary **602** of the selected zone of the depth map **400** based on user input received from the client device **102**A.

[0086] For each of one or more second frames of the video stream, at block **740**, processing logic generates a point cloud **500** of an image of the participant located in a respective second frame. Block **740** may include functionality similar to the functionality of block **230** of the method **200**. For each of one or more second frames of the video stream, at block **750**, processing logic determines whether the participant is in front of the camera. The processing logic may do this based on an overlap between a selected zone of the depth map **400** and the point cloud **500** of the image of the participant located in the respective second frame. Block **750** may include functionality similar to the functionality of block **240** of the method **200**.

[0087] FIG. **8** is a block diagram illustrating an exemplary computer system, in accordance with implementations of the present disclosure. The computer system **800** can include a client device **102**A-N, **104**, the virtual meeting platform **120**, or the server **130** in FIG. **1**. The machine can operate in the capacity of a server or an endpoint machine, in an endpoint-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The machine can be a television, a personal computer (PC), a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web appliance, a server, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

[0088] The example computer system **800** includes a processing device (processor) **802**, a main memory **804** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM), double data rate (DDR SDRAM), or DRAM (RDRAM), etc.), a static memory **806** (e.g., flash memory, static random access memory (SRAM), etc.), and a data storage device **816**, which communicate with each other via a bus **830**.

[0089] The processing device **802** represents one or more general-purpose processing devices such as a microprocessor, central processing unit, or the like. More particularly, the processing device **802** can be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, or a processor implementing other instruction sets or processors implementing a combination of instruction sets. The processing device **802** can also be one or more special-purpose processing devices such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a digital signal processor (DSP), network processor, or the like. The processing device **802** is configured to execute the processing logic **822** for performing the operations discussed herein (e.g., the operations of the participant presence manager **138**).

[0090] The computer system **800** can further include a network interface device **808**. The computer system **800** also can include a video display unit **810** (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)), an input device **812** (e.g., a keyboard, and alphanumeric keyboard, a motion sensing input device, touch screen), a cursor control device **814** (e.g., a mouse), and a signal generation device **818** (e.g., a speaker).

[0091] The data storage device **816** can include a non-transitory machine-readable storage medium **824** (sometimes referred to as a "computer-readable storage medium") on which is stored one or more sets of instructions **826** (e.g., the instructions to carry out one or more operations of the participant presence manager **138**) embodying any one or more of the methodologies or functions described herein. The instructions can also reside, completely or at least partially, within the main memory **804** and/or within the processing device **802** during execution thereof by the computer system **800**, the main memory **804** and the processing device **802** also constituting machine-readable storage media. The instructions can further be transmitted or received over the network **150** via the network interface device **808**.

[0092] In one implementation, the instructions **826** include instructions for determining visual items for presentation in a user interface of a virtual meeting. While the computer-readable storage medium **824** (machine-readable storage medium) is shown in an exemplary implementation to be a single medium, the terms "computer-readable storage medium" and "machine-readable storage medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The terms "computer-readable storage medium" and "machine-readable storage medium" shall also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present disclosure. The terms "computer-readable storage medium" and "machine-readable storage medium" shall accordingly be taken to include, but not be limited to, solid-state memories, optical media, and magnetic media.

[0093] Reference throughout this specification to "one implementation," or "an implementation," means that a

particular feature, structure, or characteristic described in connection with the implementation is included in at least one implementation. Thus, the appearances of the phrase "in one implementation," or "in an implementation," in various places throughout this specification can, but are not necessarily, referring to the same implementation, depending on the circumstances. Furthermore, the particular features, structures, or characteristics can be combined in any suitable manner in one or more implementations.

[0094] To the extent that the terms "includes," "including," "has," "contains," variants thereof, and other similar words are used in either the detailed description or the claims, these terms are intended to be inclusive in a manner similar to the term "comprising" as an open transition word without precluding any additional or other elements.

[0095] As used in this application, the terms "component," "module," "system," or the like are generally intended to refer to a computer-related entity, either hardware (e.g., a circuit), software, a combination of hardware and software, or an entity related to an operational machine with one or more specific functionalities. For example, a component can be, but is not limited to being, a process running on a processor (e.g., digital signal processor), a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a controller and the controller can be a component. One or more components can reside within a process and/or thread of execution and a component can be localized on one computer and/or distributed between two or more computers. Further, a "device" can come in the form of specially designed hardware; generalized hardware made specialized by the execution of software thereon that enables hardware to perform specific functions (e.g., generating interest points and/or descriptors); software on a computer readable medium; or a combination thereof.

[0096] The aforementioned systems, circuits, modules, and so on have been described with respect to interact between several components and/or blocks. It can be appreciated that such systems, circuits, components, blocks, and so forth can include those components or specified sub-components, some of the specified components or sub-components, and/or additional components, and according to various permutations and combinations of the foregoing. Sub-components can also be implemented as components communicatively coupled to other components rather than included within parent components (hierarchical). Additionally, it should be noted that one or more components can be combined into a single component providing aggregate functionality or divided into several separate sub-components, and any one or more middle layers, such as a management layer, can be provided to communicatively couple to such sub-components in order to provide integrated functionality. Any components described herein can also interact with one or more other components not specifically described herein but known by those of skill in the art.

[0097] Moreover, the words "example" or "exemplary" are used herein to mean serving as an example, instance, or illustration. Any aspect or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects or designs. Rather, use of the words "example" or "exemplary" is intended to present concepts in a concrete fashion. As used in this application, the term "of" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

[0098] Finally, implementations described herein include collection of data describing a user and/or activities of a user. In one implementation, such data is only collected upon the user providing consent to the collection of this data. In some implementations, a user is prompted to explicitly allow data collection. Further, the user can opt-in or opt-out of participating in such data collection activities. In one implementation, the collect data is anonymized prior to performing any analysis to obtain any statistical patterns so that the identity of the user cannot be determined from the collected data.

What is claimed is:

1. A method, comprising:

obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting;

generating a depth map of the first frame; and

for each of one or more second frames of the video stream:

generating a point cloud of an image of the participant located in a respective second frame, and

determining whether the participant is in front of the camera based on an overlap between a selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

2. The method of claim **1**, wherein generating the depth map of the first frame comprises using a first generative artificial intelligence (AI) model to generate the depth map of the first frame using the first frame as input.

3. The method of claim **2**, wherein the first generative AI model comprises a first generative diffusion model.

4. The method of claim **1**, wherein generating the point cloud of the image of the participant comprises using a second generative AI model to generate the point cloud of the image of the participant using the respective second frame as input.

5. The method of claim **4**, wherein the second generative AI model comprises a second generative diffusion model.

6. The method of claim **1**, wherein:

the point cloud comprises a plurality of points; and

determining whether the participant is in front of the camera comprises determining whether a threshold amount of the plurality of points are located within the selected zone of the depth map.

7. The method of claim **6**, wherein the threshold amount comprises a majority of the plurality of points.

8. The method of claim **1**, further comprising, responsive to determining that the participant is not in front of the camera, causing an audio/video setting action to be performed, wherein the audio/video setting action comprises at least one of:

muting a microphone of the client device of the participant in the virtual meeting; or

deactivating the camera of the client device of the participant in the virtual meeting.

9. A system, comprising:

a memory; and

one or more processing devices, coupled to the memory, configured to perform one or more operations, comprising:

obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting;

generating a depth map of the first frame; and

for each of one or more second frames of the video stream:

generating a point cloud of an image of the participant located in a respective second frame, and

determining whether the participant is in front of the camera based on an overlap between a selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

10. The system of claim **9**, wherein generating the depth map of the first frame comprises using a first generative artificial intelligence (AI) model to generate the depth map of the first frame using the first frame as input.

11. The system of claim **10**, wherein the first generative AI model comprises a first generative diffusion model.

12. The system of claim **9**, wherein generating the point cloud of the image of the participant comprises using a second generative AI model to generate the point cloud of the image of the participant using the respective second frame as input.

13. The system of claim **12**, wherein the second generative AI model comprises a second generative diffusion model.

14. The system of claim **9**, wherein:

the point cloud comprises a plurality of points; and

determining whether the participant is in front of the camera comprises determining whether a threshold amount of the plurality of points are located within the selected zone of the depth map.

15. The system of claim **14**, wherein the threshold amount comprises a majority of the plurality of points.

16. The system of claim **9**, further comprising, responsive to determining that the participant is not in front of the camera, causing an audio/video setting action to be performed, wherein the audio/video setting action comprises at least one of:

muting a microphone of the client device of the participant in the virtual meeting; or

deactivating the camera of the client device of the participant in the virtual meeting.

17. A method, comprising:

obtaining a first frame of a video stream generated by a camera of a client device of a participant of a virtual meeting;

generating a depth map of the first frame;

designating a selected zone of the depth map based on content of the depth map; and

for each of one or more second frames of the video stream:

generating a point cloud of an image of the participant located in a respective second frame, and

determining whether the participant is in front of the camera based on an overlap between the selected zone of the depth map and the point cloud of the image of the participant located in the respective second frame.

18. The method of claim **17**, wherein designating the selected zone of the depth map based on content the depth map comprises designating a portion of the depth map within a threshold distance as within the selected zone.

19. The method of claim **17**, wherein designating the selected zone of the depth map based on content of the depth map comprises designating a portion of the depth map behind a piece of furniture as outside the selected zone.

20. The method of claim **17**, further comprising adjusting a boundary of the selected zone of the depth map based on user input received from the client device.

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