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Interactions of Internet-of-Things (IoT) Devices with Augmented Reality

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ABSTRACT

Augmented reality (AR) technology today doesn't incorporate sound, nor does it enable the interactivity of AR objects with Internet-of-Things (IoT) devices. This results in user experiences that are less engaging than would be possible with accurate sound or IoT device interactions. This disclosure describes techniques that enable information from IoT devices to be classified along multiple dimensions. Such information can be used to obtain classifications to trigger an action in AR or physical space. In an AR scene, the action can be taken by a virtual object such as a virtual or AR assistant. In a physical scene, the action can be taken by, e.g., a physical robot or assistant. Physical and/or digital signals generated by IoT devices are used to trigger actions by virtual or physical objects.

KEYWORDS

- Augmented reality (AR)
- Internet of things (IoT)
- Viewport
- Ambient signal
- AR object
- AR assistant
- Robot assistant

BACKGROUND

Augmented reality (AR) incorporates the display of virtual objects in the real world through a viewport, e.g., smart glasses, a handheld device, or other equipment. AR rarely incorporates sound as a way to interact with the AR objects, resulting in user experiences less engaging than would be possible with accurate sound interactions. Currently, spatial attributes of audio signals are not utilized to enhance AR experiences to make the experiences more realistic and enjoyable.

Internet-of-things (IoT) devices are household or office devices, e.g., doorbells, speakers, coffee makers, toasters, toys, TVs, etc., that are connected to the internet and produce ambient signals in real life and in the digital world. Although IoT devices are ubiquitous, they do not participate in AR scenes.

DESCRIPTION

This disclosure describes techniques that, with user permission, receive information such as ambient signals from IoT devices and classify it along multiple dimensions. Based on the ambient signals, their associated data, and the classification, an action is triggered in an AR or a physical space. In an AR scene, the action can be performed by a virtual object such as a virtual assistant. In a physical scene, the action can be performed by a physical robot or other assistive device.

Ambient signals produced by IoT devices can be physical, e.g., exist in the real world or digital. Digital signals can be the interconnect protocols used by IoT devices, which can be based on communication via cellular, Zigbee, WiFi, Bluetooth, NFC, or other technology. Physical signals include sounds created by IoT devices, e.g., a doorbell chiming, a smart speaker playing music, a toaster popping up bread, a coffeemaker starting to make coffee, etc.; light produced by IoT devices, e.g., a thermostat reaching (or adjusting) a certain temperature, a bulb lighting up part of the room; etc.

Example

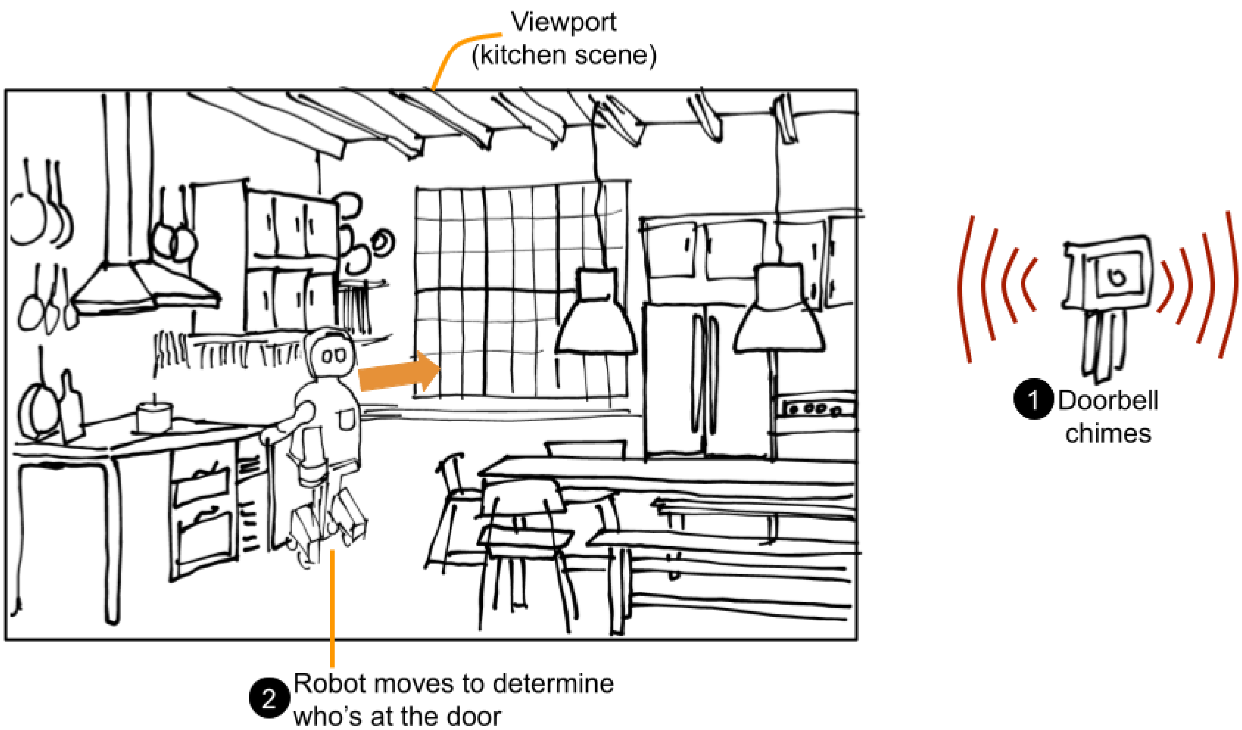

Fig. 1: A user sees a kitchen through an AR viewport. An IoT doorbell outside the viewport chimes (1). An IoT-connected robot checks the door camera, detects via computer vision a package, and announces its arrival (2).

In this example, illustrated in Fig. 1, an IoT doorbell that is outside the AR viewport chimes. In response to the chime (or its associated digital signal), a personal assistant (which could be a physical or virtual robot) checks the door camera, detects via computer vision a package, and announces the arrival of the package. Note that the sequence of actions in the AR world, which are triggered by an IoT-generated signal, can happen even if the IoT device (the doorbell) is not in the current AR viewport

Example

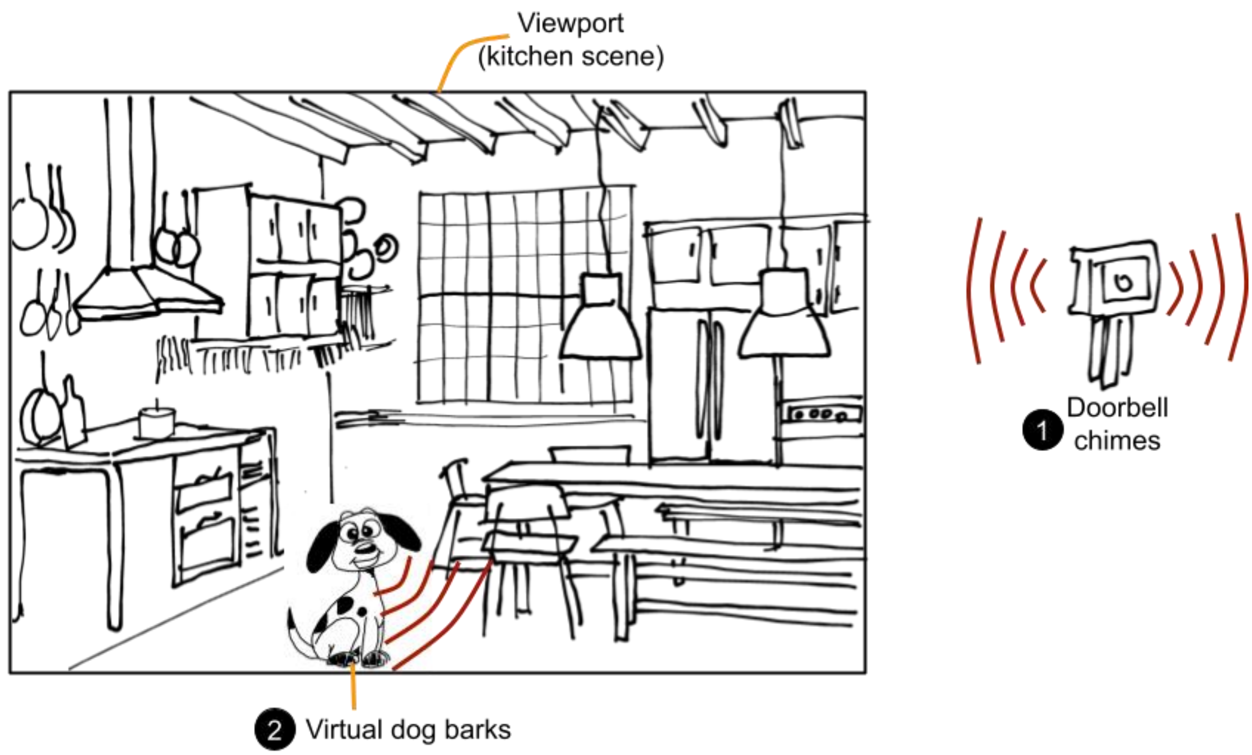

Fig. 2: A user sees a kitchen through an AR viewport. An IoT doorbell outside the viewport chimes (1). A virtual dog in the AR scene barks (2).

In this example, illustrated in Fig. 2, an IoT doorbell chimes. In response to the chime (or its associated digital signal), a virtual dog in the AR scene barks.

Example

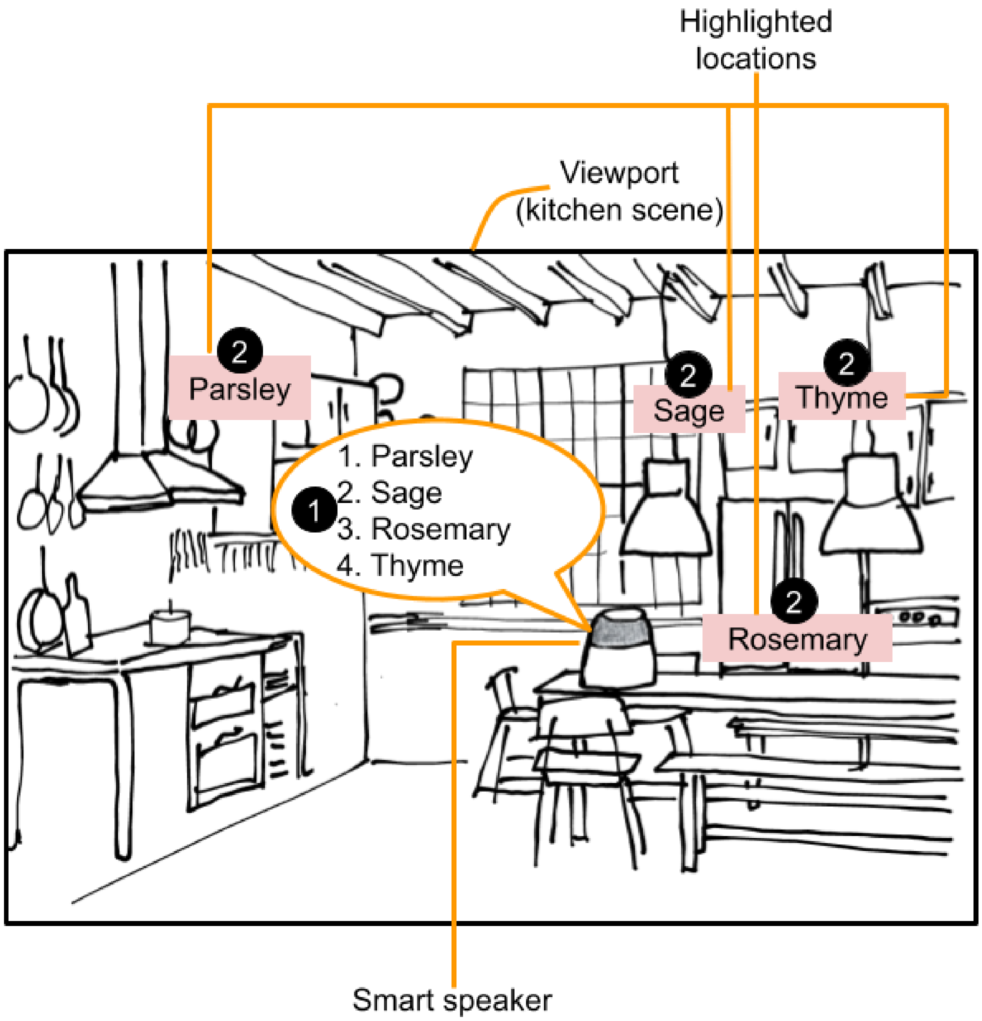

Fig. 3: A smart speaker in the viewport announces the names of spices and ingredients (1). An AR assistant highlights locations in the kitchen where the spices can be found (2).

In this example, illustrated in Fig. 3, a smart speaker announces the names of spices and ingredients needed for a recipe. The AR assistant in the scene uses that information to highlight storage spaces in the kitchen where the named spices and ingredients can be found.

Example

A smart speaker announces the names of spices needed for a recipe. A physical robot assistant responds by gathering up the spices for use.

<u>*Example*</u>

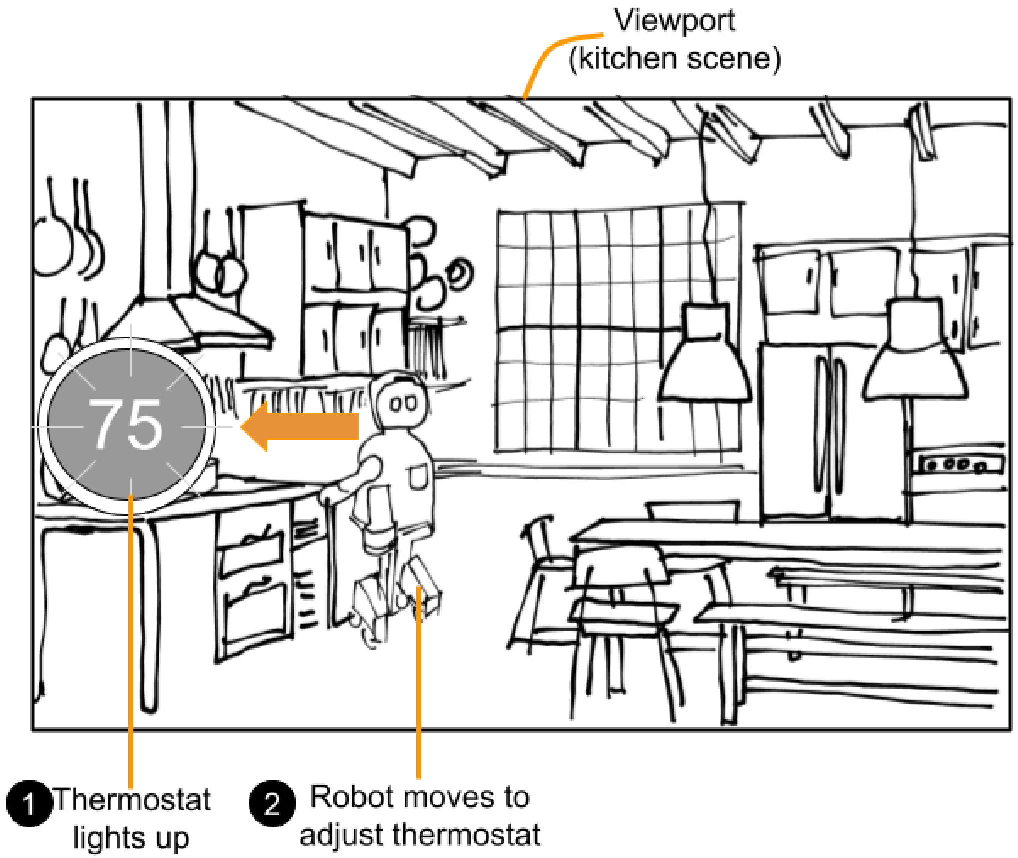

Fig. 4: An IoT-enabled thermostat lights up with a warning (1). A robot moves to the thermostat to adjust it (2).

In this example, illustrated in Fig. 4, an IoT-enabled thermostat that is visible through the viewport lights up with a warning. A physical or an AR object in the scene responds to that light, correlating it to the thermostat and performing an action. An example action can be a physical robot moving over to the thermostat to adjust it. Another example action, performed by an AR assistant, can be obtaining the current temperature from the thermostat and announcing it via an available speaker device or displaying it to the user, e.g., in the AR viewport.

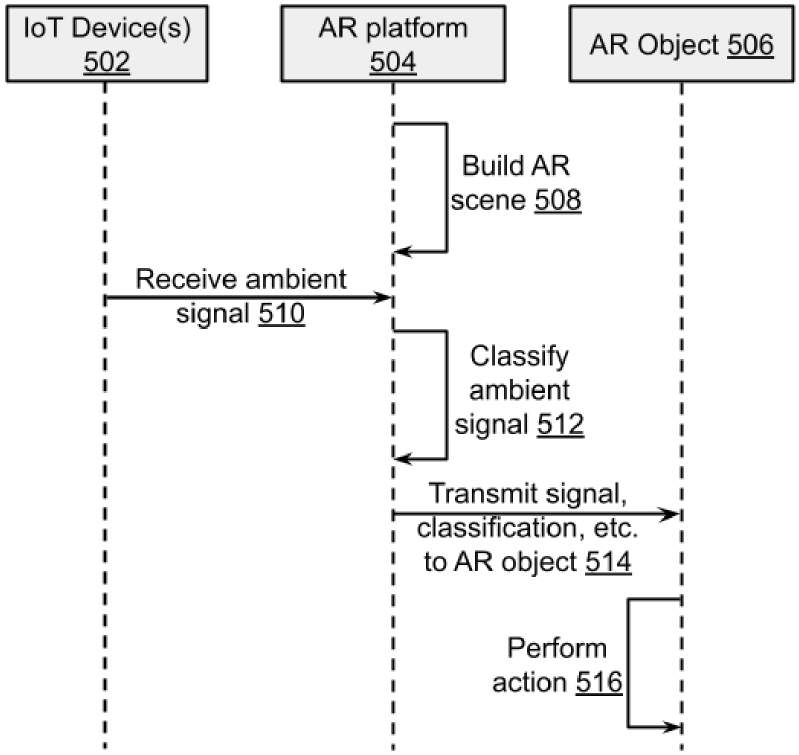

Fig. 5: Interactions of IoT devices with augmented reality

Fig. 5 illustrates the interactions of IoT devices with augmented reality, e.g., the triggering of actions in the AR (or physical) space based on events or signals generated by IoT devices. IoT devices (502) are connected to an AR platform (504) such that data can be received by the AR platform. An example AR platform is a device, e.g., smart glasses, AR headsets, etc., with a viewport through which a user can view real (physical) space with one or more inserted virtual objects. The AR platform builds (508) an augmented reality scene, which can include one or more IoT devices. The IoT devices can include devices actually present in the scene, e.g., a smart speaker on a kitchen counter in physical space, or virtual locations of devices relative to the physical scene, e.g., outside the viewport.

Ambient signals generated by the IoT devices are received (510) by the AR platform, which spatially locates and classifies them along multiple dimensions (512). Spatial classification can be done using a microphone that captures audio signals from the IoT device. The IoT device itself can provide information on its activity, e.g., a smart speaker can broadcast via WiFi or Zigbee that it is playing a musical piece by Bach at sound level 3. The position of the IoT device can be determined in multiple ways, e.g., using the video image from the AR scene to identify the IoT device (e.g., a toaster); using prior knowledge of the scene that identified the location of the IoT device in three-dimensional physical space relative to the current viewport; using Bluetooth location services; using position as reported by the device (for devices enabled with global or local positioning); using the location as set by the user at the time of device installation.

Example dimensions of signal classification include:

- Properties of audio signals from the IoT device (e.g., door chime, oven ding, toaster-finished sound, etc.), the mood of the audio (soothing classical music, upbeat rock music, an unexpected doorbell sound, etc.), the semantics of spoken words (joke, instructions, announcement, etc.).
- Actions from an IoT device, e.g., a thermostat lighting up, a bulb lighting up due to a movement; a door chime; etc.
- Status of the IoT device, e.g., on or off, based on periodic status updates or polling.
- Time at which signal was received, or the period between successive signal receipts.

The ambient signal, its classification, and its associated data are transmitted (514) to the AR (or physical) object (506). The object receives the ambient signal, the location of the origin of the signal, and a correlation to its location in (or out of) the viewport. The object utilizes the signal to generate an appropriate matching response.

The object performs an action (516) in response to the signal. In performing the action, the object determines whether the action is to be associated with a location, and, if so, incorporates the location into the action, e.g., the object can move or cause a movement towards the location, indicate or highlight location within the viewport, etc.

The action, which is a response to the ambient signal and its classification, varies for objects in the viewport space and depends on the type of object, its relationship to other objects in the viewport space, etc. The AR objects respond to the signal based on key action types designated or associated with them (e.g., AR virtual assistant, animated animal, inanimate screen, etc.).

The described interaction between IoT devices and AR (or physical) objects can be applied to AR advertisements with audio controls to enable user engagement with AR ads in more meaningful ways. The operating systems of smartphones or other devices can provide an enhanced AR development environment that factors in audio control of the environment. Map applications can use AR with audio controls while providing augmented live walking directions or other AR views. Generally, products that use AR can incorporate audio controls and IoT device interactivity to deliver a more compelling AR environment.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs, or features described herein may enable the collection of user information (e.g., information about objects in a user's visual range as captured by an AR device, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may 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 may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may 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 may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques that enable information from IoT devices to be classified along multiple dimensions. Such information can be used to obtain classifications to trigger an action in AR or physical space. In an AR scene, the action can be taken by a virtual object such as a virtual or AR assistant. In a physical scene, the action can be taken by, e.g., a physical robot or assistant. Physical and/or digital signals generated by IoT devices are used to trigger actions by virtual or physical objects.

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