December 2021

Coordinated Listening by Multiple Voice Assistants in the Smart Home to Localize Smoke Detector Low-Battery Warning Chirp

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Coordinated Listening by Multiple Voice Assistants in the Smart Home to Localize Smoke Detector Low-Battery Warning Chirp

Abstract:

This publication describes methods for coordinated listening by multiple voice assistant devices (e.g., smart home devices, smart speakers) to localize the sound of a low-battery warning chirp produced by a smoke detector. The voice assistant devices detect the sound of the low-battery warning chirp and measure the volume and timing of the chirp (generate "chirp information"). The chirp information can be provided to a processing unit of a computing device that estimates a location of the smoke detector and provides such information to a user.

Keywords:

smoke detector, carbon monoxide detector, smoke alarm, low-battery warning chirp, voice assistant device, home assistant, home automation, smart home, smart speaker, localization, estimate, microphone

Background:

It is known in the art that plural spatially distributed smart speakers or home assistant devices, each having one or more associated microphones, may be used in coordination to localize the source location of particular sounds, especially human speech. It is also known that smoke alarms, carbon monoxide detectors, and the like (collectively referred to herein as a "smoke detector"), which are battery powered or which have a backup battery power source, are configured to emit an alert (e.g., a low-battery warning chirp) when the voltage of the battery drops below a threshold value. Because such alerts are short (e.g., a single high-pitch chirp) and periodic (e.g.,

once every forty-five seconds), it can be difficult for a user to quickly locate which smoke detector is emitting the alert in a building where multiple smoke detectors are installed.

Description:

Figure 1, below, illustrates coordinated listening by multiple voice assistant devices (e.g., smart home devices, smart speakers) to localize the sound of a low-battery warning chirp produced by a smoke detector.

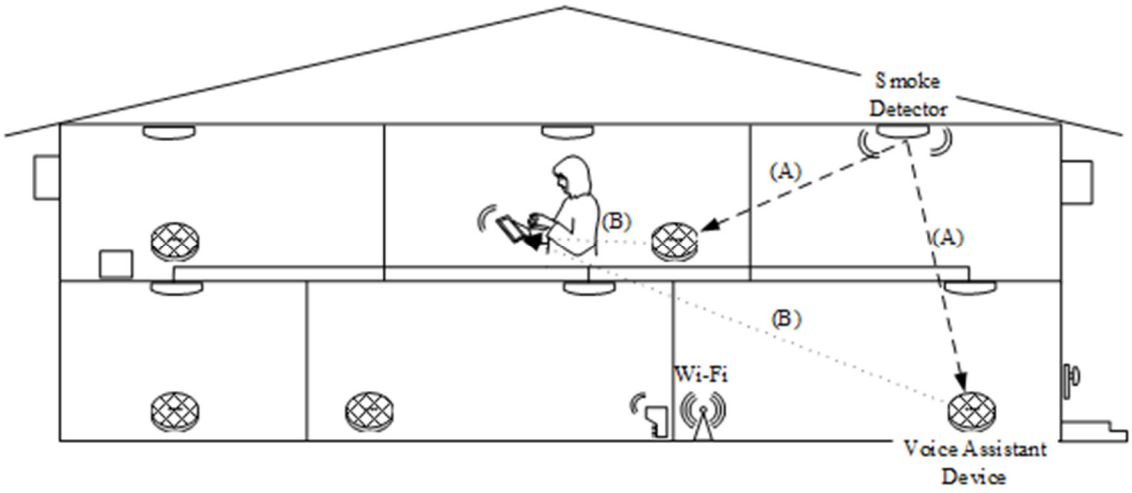

Figure 1

Figure 1 illustrates a two-story building that has multiple rooms with voice assistant devices and has smoke detectors located in multiple rooms. A user with a smartphone is present in the center room of the top floor of the building. A wireless router provides a wireless network for the voice assistant devices and the user's smartphone. The smartphone is capable of receiving information from one or more of the voice assistant devices via a connection to the wireless network.

The smoke detector located in the rightmost room of the upper floor has a low battery and makes a low-battery chirp (A). Two of the voice assistant devices, namely the voice assistant

device in the room with the user (the "upper voice assistant device") and the voice assistant device in the rightmost first floor room (the "lower voice assistant device"), detect the low-battery chirp. Any of a variety of other forms of chirp source localization, including but not limited to triangulation based on known, computed, or presumed locations of the two or more voice assistant devices (or other network-connected audio receiving devices), and including but not limited to the use of audio signal amplitude and audio signal phase information, are within the scope of the present teachings. Upon a microphone of a voice assistant device detecting a low-battery chirp, the device generates "chirp information" relating to the detected chirp. Chirp information may include sound measurement information (e.g., the measured decibels of the chirp), time information (e.g., the time the chirp was detected), and other information.

A voice assistant device may be calibrated to detect a low-battery chirp and distinguish it from ambient noise based on a variety of factors, including the frequency of the chirp, the volume of the chirp, and a time period between chirps. A voice assistant device may determine that the noise detected is a smoke detector low-battery chirp or it may filter out the sound as ambient noise unrelated to a low-battery chirp.

A processing unit of a computing device (e.g., one of the voice assistant devices, another voice assistant device, the user's smartphone) is configured to receive chirp information from voice assistant devices. For example, the two voice assistant devices may send chirp information (B) to the user's smartphone or another computing device, which utilizes the chirp information to determine (predict) which of the voice assistant devices is the closest to the chirp (e.g., a room, a floor, a side of a house, a generalized location). The user may designate the room location of the voice assistant device (e.g., a voice assistant device located in a downstairs dining room). Additional voice assistant devices and smoke detectors may be added or removed while

maintaining functionality of the overall alert detection system. A voice assistant device may send information identifying the voice assistant device (e.g., "Upstairs Wireless Speaker") with the chirp information. The voice assistant device may receive multiple sounds (e.g., four consecutive "chirps") before providing the indication to the user. The voice assistant device may provide information to the user in the form of an "in progress" notification after detecting one or more chirps. In aspects, the indication may appear in an application on a user's computing device or the voice assistant device may provide the indication as an audio indication to the user.

In a first example, the upper voice assistant device sends its chirp information to the smartphone of the user and the lower voice assistant device sends its chirp information to the smartphone of the user, whereas, none of the other voice assistant devices send chirp information to the smartphone of the user because the other voice assistant devices did not detect the chirp. The smartphone receives the chirp information from the first device and the second device, determines which is the closest one to the chirp, and displays a notification to the user that provides the user with information that assists the user in determining which smoke detector emitted the chirp (e.g., a notification of "Upstairs Wireless Speaker detected a smoke detector low-battery chirp").

In a second example, the upper voice assistant device and the lower voice assistant device, through their connection to the wireless network, send their chirp information to a remote computing device. The remote computing device receives the chirp information from the first device and the second device, determines which is the closest one to the chirp, and triggers a notification on the user's smartphone that provides the user with information that assists the user in determining which smoke detector emitted the chirp (e.g., a notification of "Upstairs Wireless Speaker detected a smoke detector low-battery chirp").

The determination of whether a particular sound is indicative of which smoke detector made the low-battery chirp may be based on the chirp information. For example, a first voice assistant has a timestamp indicating that it received the chirp one millisecond earlier than a second voice assistant device, thereby suggesting the first voice assistant is closer in proximity to the origination of the chirp than the second voice assistant device. The processing unit may use this information to output or trigger a notification informing the user as to a predicted location of the smoke detector emitting the chirp. In aspects, one of the voice assistant devices provides the notification as a sound or voice cue informing the user as to the predicted location of the smoke detector. In other aspects, a user's smartphone provides the notification as a visual display regarding the predicted location of the smoke detector.

In still other aspects, by identifying the time between sounds produced by a smoke detector, a voice assistant device may be able to distinguish among multiple smoke alarms simultaneously producing sounds. For example, if two smoke detectors were producing chirps relating to a low battery, the processing unit could better distinguish timestamp differences for chirp information relating to the location of one of the multiple smoke detectors.

Throughout this disclosure, examples are described where a computing system (e.g., a voice assistant device, a computing device) may detect the sound of a smoke detector low-battery chirp. 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, and/or features described herein may enable the collection of information (e.g., information about a user's building, a user's current location), and if the user is sent content or communications from a server. The computing system can be configured to only use the information after the computing system receives explicit permission from the user of the computing system to use the data. For example, in situations where

the voice assistant device listens for sounds associated with a smoke detector having a low battery, individual users may be provided with an opportunity to provide input to control whether programs or features of the voice assistant device can collect and make use of the data. Further, individual users may have constant control over what programs can or cannot do with the information. In addition, information collected may be pre-treated in one or more ways before it is transferred, stored, or otherwise 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 (for example, 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 whether information is collected about the user and the user's device, and how such information, if collected, may be used by the voice assistant device or computing device.