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Determining Device Position Using Ultrawideband to Customize Surround Sound

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ABSTRACT

Traditional surround sound experiences require precise placement of speakers at positions that are optimal for audio playback. Even after a careful setup, the audio experience may suffer depending on where the user sits relative to the speakers, since there is no way to intelligently adjust the equalizers for the different speakers distributed in space without localization information about the speakers. The techniques described in this disclosure utilize ultrawideband ranging to determine the relative position of different audio playback devices in an environment and the position of the user. A central node customizes the audio streams provided to each speaker device based on the determined position. If any of the speaker devices are moved to a different position or removed from the environment, if new speaker devices are added, or if the user's position changes significantly to a different fixed location during playback, the central node can automatically adjust the audio stream for the new environment, without the user having to perform manual reconfiguration.

KEYWORDS

- Surround sound
- Speaker position
- Listener position
- Equalizer adjustment
- Ultrawideband
- UWB ranging
- Radar
- Audio playback

BACKGROUND

Surround sound enhances the experience of watching video content and listening to audio by providing audio playback from speakers placed at different locations around a user. However, traditional surround sound experiences require precise placement of speakers at positions that are optimal for audio playback. The user needs to set up a set of speakers in a specific arrangement. Even after such a careful setup, the audio experience may suffer depending on where the user sits relative to the speakers, since there is no way to intelligently adjust the equalizers for the different speakers distributed in space without localization information about the speakers. Further, traditional surround sound setup cannot be tailored for all environments.

DESCRIPTION

Ultrawideband (UWB) technology enables ranging, angle of arrival estimation, and communication between two devices. A device that combines UWB with radar can also be used to determine where a person is with reference to the radar-enabled UWB device. Such information can be shared between different devices (e.g., speakers) in the physical area, e.g., a particular room or home.

Information regarding speaker locations and the location of the listening user can be used to determine how best to tune audio effects to enhance the user's perception of where a sound is coming from in a 3D space. The speakers can be part of a single setup, e.g., a surround sound system from a single company, or from a setup that includes different speaker devices from different providers. Since UWB is a standard protocol, third-party devices such as soundbars or speakers can be tuned via use of UWB to determine location.

Per techniques of this disclosure, any UWB device (e.g., speaker, amplifier, soundbar, set-top box, video dock with a tablet or other playback device, or other device within the audio/video playback system) that has sufficient computational capabilities can act as the central node. The central node directs individual audio tracks or streams to different speakers based on the available location information from the speakers and the user's position. This allows creation of a spatial audio experience in the physical environment that is tailored to the physical environment.

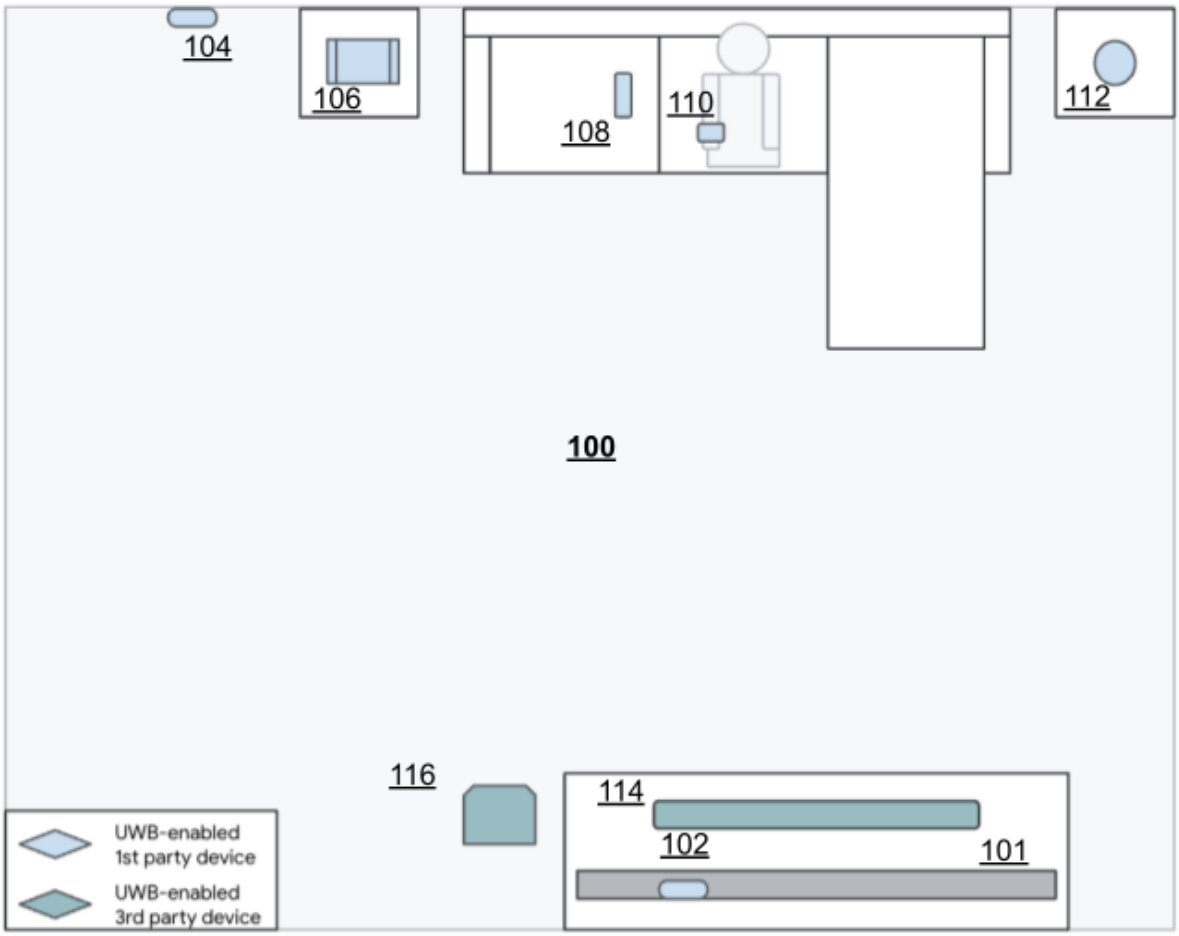

Fig. 1: Example physical environment

Fig. 1 illustrates an example physical environment 100 in which UWB-based location determination can be performed to detect locations of various devices. The environment includes a user viewing a television set (101). A playback device (102), e.g., a set-top box, a video streaming device, a video dock with a smart device (tablet/phone) connected to it, an audio amplifier, or other such device, is coupled to the television. Speakers from the same provider as that of the playback device are at different locations within the environment. For example, speakers 104, 106, and 108 are to the user's right, while another speaker 112 is to the user's left. Additionally, third-party speakers (from a different provider than that of the playback device) - a soundbar (114) and a subwoofer (116) are near the television set. Further, the user is holding a remote control (110) to control the television set and/or the audio playback.

Per techniques of this disclosure, any of the devices (e.g., any of first party devices 102-112) with sufficient computational power and UWB capabilities can act as a central node to determine the positions of other devices that act as remote nodes (e.g., speakers, soundbar, remote control, etc.). Based on the determined positions, the device acting as a central node can adjust the audio streams provided to individual remote nodes. Fig. 2 illustrates an example of a central node and a single remote node.

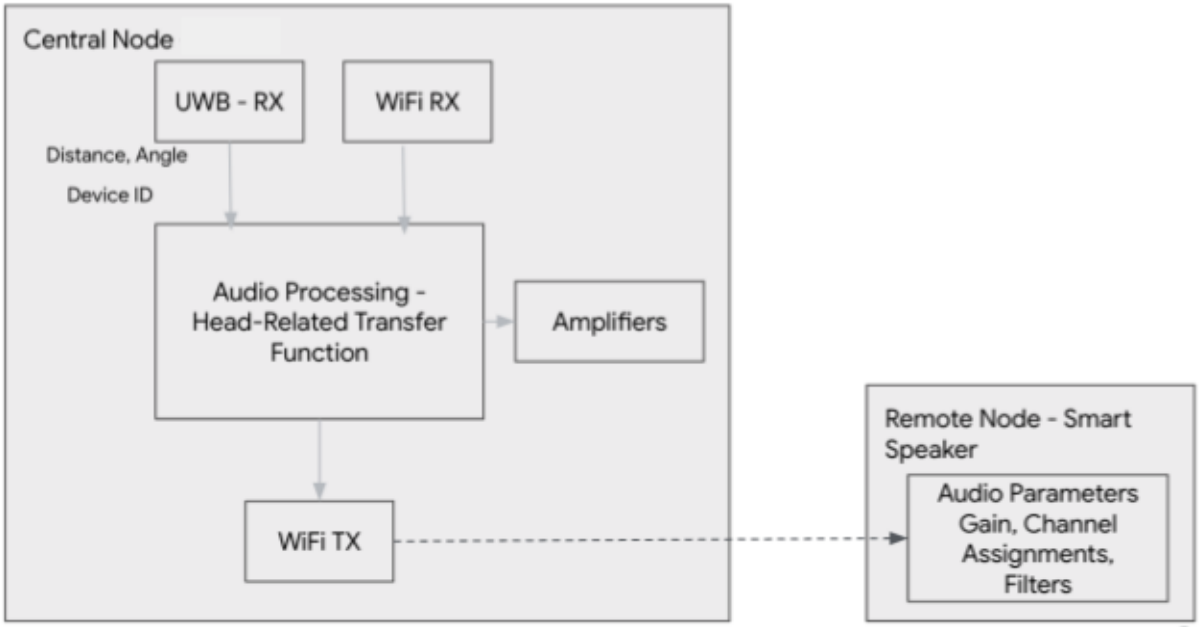

Fig. 2: Example central node with a remote node

As illustrated in Fig. 2, the central node performs UWB ranging (and radar, if available) to obtain position information regarding each remote node, including a distance to the remote node, an angle to the remote node, and a device identifier of the remote node. The remote nodes can include audio playback devices (speakers, soundbars, etc.) as well as devices such as a remote control or other devices (smartwatch, wearable devices, etc.) that are held by or are likely near the user. The central node can communicate with other nodes via a suitable wireless protocol, e.g., WiFi.

After obtaining the position of the remote node and the user, the central node performs audio processing, e.g., using a head-related transfer function, to generate custom audio streams for each remote node. The custom audio stream can specify audio parameters for the remote nodes, e.g., gain, channel assignment, audio filters, etc. The custom audio stream is provided to the remote node for playback.

If the user position changes relative to the speakers, the central node can automatically adjust the stream for the new position. The new position is detected using the UWB+radar system. The head head-related transfer function is recalculated for the new position. The audio streams and equalizer are then adjusted to provide a surround sound experience that is tailored to the user's new position. This operation can be repeated for any number of position changes that may occur, e.g., when the user leaves the room and returns to an observably different position, or shifts to a different position while remaining within the room.

In this manner, the described techniques provide an improved surround-sound experience for users that have multiple UWB/ UWB+radar capable devices in their environment. By automatically determining position information for audio playback devices and the user, the audio experience is improved. If any of the speaker devices are moved to a different position or removed from the environment, or if new speaker devices are added, the central node can automatically adjust the audio stream for the new environment, without the user having to perform manual reconfiguration.

The described techniques can be used in any audio setup. Any device with sufficient computational power and UWB+radar capability can act as a central node. For example, such devices can include set-top boxes, streaming devices, smartphones/tablets, etc. The described techniques can also be implemented in smart televisions, speakers, or other UWB-enabled devices.

CONCLUSION

Traditional surround sound experiences require precise placement of speakers at positions that are optimal for audio playback. Even after a careful setup, the audio experience may suffer depending on where the user sits relative to the speakers, since there is no way to

intelligently adjust the equalizers for the different speakers distributed in space without localization information about the speakers. The techniques described in this disclosure utilize ultrawideband ranging to determine the relative position of different audio playback devices in an environment and the position of the user. A central node customizes the audio streams provided to each speaker device based on the determined position. If any of the speaker devices are moved to a different position or removed from the environment, if new speaker devices are added, or if the user's position changes significantly to a different fixed location during playback, the central node can automatically adjust the audio stream for the new environment, without the user having to perform manual reconfiguration.

REFERENCES

1. Giusti, Leonardo, Ivan Poupyrev, Brandon Barbello, and Patrick M. Amihood. "Smartphone-based radar system for facilitating awareness of user presence and orientation." U.S. Patent 10,930,251, issued February 23, 2021.