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Same User Vs. Different User Detection

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SAME USER VS. DIFFERENT USER DETECTION

ABSTRACT

The technology relates to detecting whether a pair of wireless earbuds are being worn by the same person or two different persons. Doing so may include detecting a signal from a sensor in each of the two wireless earbuds, finding a correlation between the signals from the two wireless earbuds, and determining, based on the correlation, whether the two wireless earbuds are being worn by a same person, or by two different persons. Based on this determination, a setting of one or both of the wireless earbuds may be adjusted, such as audio broadcasting, noise cancellation, and/or language settings.

BACKGROUND

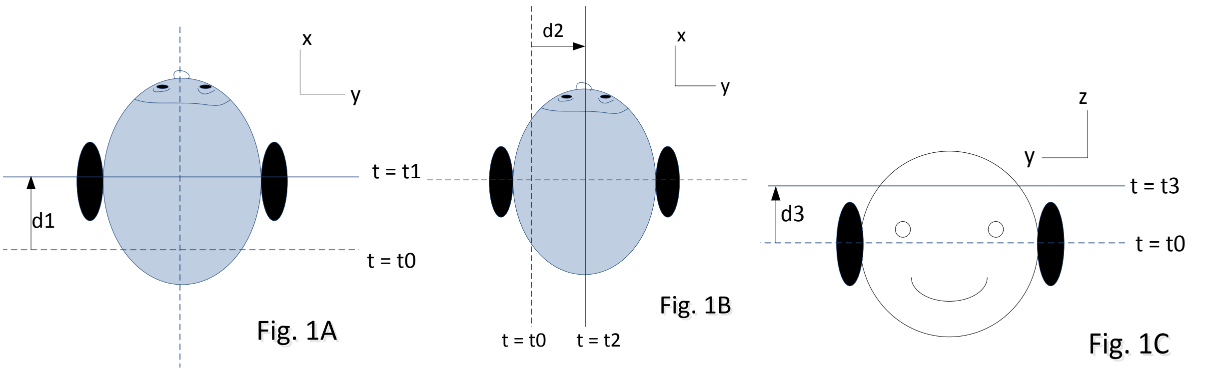
"Truly wireless" earbuds are earbuds that connect to each other wirelessly. A pair of such wireless earbuds may be used for a number of purposes, such as audio broadcasting, noise cancelation, voice calls, and translation. Sensors are often included in these wireless earbuds for detecting different conditions, such as whether the wireless earbuds are loose or inserted into ears. A number of different experiences may be envisioned for a pair of wireless earbuds depending on if both of the wireless earbuds are being worn by the same person, or if each wireless earbud is being worn by a different person. For example, when the wireless earbuds are used for translation, it may be desirable that both of the wireless earbuds have the same language setting when worn by the same person, but it may be desirable that the two wireless earbuds have different language settings when worn by two different persons who speak different languages. As another example, when the wireless earbuds are used for audio broadcasting, it may be desirable that the two wireless earbuds have different audio settings (e.g., stereophonic) when worn by the same person, but it may be desirable that the two wireless earbuds have the same audio setting (e.g., monophonic) when worn by two different persons.

DETAILS

The technology relates to detecting whether a pair of wireless earbuds are being worn by the same person or two different persons. Doing so may include detecting a signal from a sensor in each of two wireless earbuds, finding a correlation between the signals from the two wireless earbuds, and determining, based on the correlation, whether the two wireless earbuds are being worn by a same person, or by two different persons. Based on this determination, a setting of one or both of the wireless earbuds may be adjusted, such as audio broadcasting, noise cancellation, and language settings.

FIGS. 1A-3 illustrate example situations in which one or more motion sensors of each wireless earbud is used to detect whether the wireless earbuds are being worn by the same person or two different persons. Any of a number of motion sensors may be used to detect a motion of the wireless earbud, such as a gyroscope, an accelerometer, etc. Vibration sensors, such as microphones, can also be used as motion sensors. The motion sensors could be selected or configured for detecting movements having a large magnitude, such as when a user walks or lies down, or could be selected or configured to detect movements having a small magnitude, such as the user's breathing patterns or small head tilts. By correlating the movements detected by the sensors of the two wireless earbuds, the wireless earbuds may determine whether they are being worn by the same person or different persons.

For example, FIGS. 1A-C below show a person wearing both wireless earbuds and moving in a forward/backwards x-direction (FIG. 1A), a left/right y-direction (FIG. 1B), and an up/down z-direction (FIG. 1C). In these example situations, both wireless earbuds experience the same movements as they are both attached to a same rigid object—the person's head, and thus both sensors would detect approximately the same magnitude of movement in approximately the same direction at or about the same time. In contrast, if the wireless earbuds are being worn by two different persons, it would be a lot less likely that both persons would move their heads in approximately the same direction with approximately the same magnitude at or about the same time. Although FIGS. 1A-C each shows a translation along a single direction for simplicity, the motion sensors may detect movements having elements in all of x-, y-, and z-directions.



As another example, FIGS. 2A-C below show a person wearing both wireless earbuds and rotates his/her head about a vertical z-axis (FIG. 2A), a horizontal x-axis (FIG. 2B), and a horizontal y-axis (FIG. 2C). In these example situations, both sensors would detect approximately the same magnitude of movement that have directional elements in either approximately the same or approximately the opposite directions at or about the same time. For example, referring to FIG. 2A, while the left wireless earbud may be detected to move forwards and right with a clockwise rotation, the right wireless earbud may be detected to move backwards and left with a clockwise rotation. As another example, referring to FIG. 2C, both sensors would detect approximately the same magnitude of movement in approximately the same direction (rotate counterclockwise) at or about the same time. In contrast, if the wireless earbuds are being worn by two different persons, it would be a lot less likely that both persons would rotate their heads at or about the same time such that the movements detected by both sensors have approximately the same magnitude and have directional elements in either approximately the same or approximately the opposite directions. Although FIGS. 2A-C each shows a head rotation about a single axis, the motion sensors may detect movements having rotational elements about all of x-, y-, and z-axes. Further, although FIGS. 1A-C show translations and FIGS. 2A-C show rotations, the motion sensors may detect movements having both translational and rotational elements.

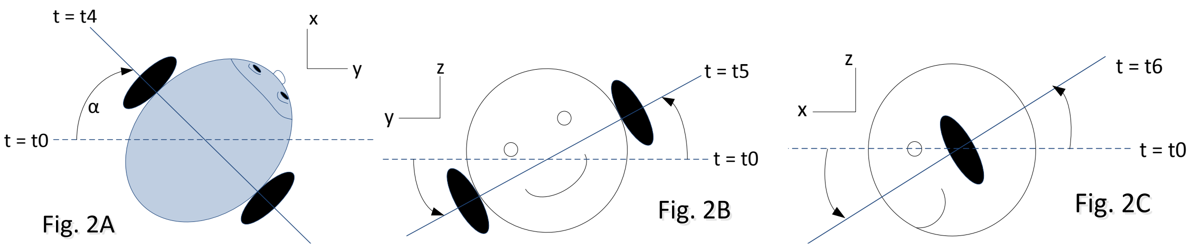


Fig. 2A Fig. 2B Fig. 2C

Thus, as shown in FIGS. 1A-C and 2A-C, detected movements having approximately the same magnitudes and directional elements in either approximately the same or approximately the opposite directions are likely to indicate that the two wireless earbuds are worn by the same person, if these related movements occurred at or about the same time. Therefore, time-correlations of the two motion signals from the two motion sensors would indicate whether the two wireless earbuds are being worn by the same person.

As yet another example as noted above, referring to FIG. 3 below, a vibration sensor may be included in each wireless earbud to function as a motion sensor. For example, the vibration sensor may be a microphone configured to detect a person's voice or breathing pattern. In this regard, when the wireless earbuds are being worn by the same person, both microphones would detect approximately the same magnitude of vibration having approximately the same frequency at or about the same time. In contrast, if the wireless earbuds are being worn by two different persons, it would be very unlikely that both persons would produce approximately the same voice or breathing patterns at or about the same time. For example, one person may have a higher voice or a quicker breathing pattern than the other person. As another example, even if the two persons have very similar voices and breathing patterns, they may not speak or breathe completely in sync. Therefore, time-correlations of the two vibration signals from the two vibration sensors would indicate whether the two wireless earbuds are being worn by the same person or two different persons.

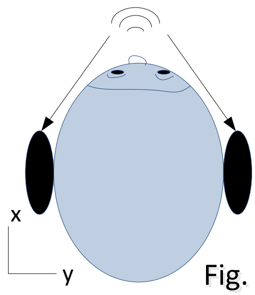


Fig. 3

FIGS. 4-6 illustrate example situations where an electrical or magnetic sensor in each wireless earbud is used to detect whether the wireless earbuds are being worn by the same person or two different persons. Any of a number of electrical or magnetic sensors may be used to detect an electrical or magnetic signal at the wireless earbud, such as a capacitive sensor, an inductive sensor, a Hall Effect sensor, etc. Grounding may be provided in the wireless earbud. While FIG. 4 shows an example of passive detection, FIGS. 5 and 6 show examples of active detection.

Referring to FIG. 4 below, electrical or magnetic sensors may detect electrical or magnetic signals encountered by the two wireless earbuds, and by correlating these signals from the two wireless earbuds, the wireless earbuds may determine whether they are being worn by the same person or different persons. For example, an electrical sensor may be included in each wireless earbud to detect electrical waves generated by human skin. As another example, an electrical sensor may be included in each wireless earbud to detect electrical waves generated by a human heart. In either example, if the wireless earbuds are being worn by the same person, both electrical sensors would detect waveforms that are approximately the same in magnitude, frequency, and phase. In contrast, if the wireless earbuds are being worn by two different persons, the electrical sensor in one wireless earbud would likely detect a waveform that is different from the other wireless earbud in some way, such as one that is different in magnitude, frequency, and/or phase. Therefore, time-correlations of the two electrical signals from the two electrical sensors would indicate whether the two wireless earbuds are being worn by the same person. In some examples, the electrical sensor may be configured to detect both electrical waves generated by the skin and the heart, and correlate these electrical signals to better determine whether the wireless earbuds are being worn by the same person or two different persons.

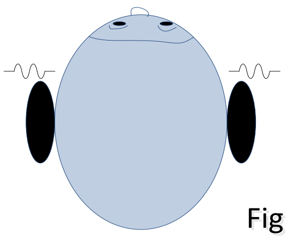


Fig. 4

FIG. 5 below illustrates another example situation where an electrical or magnetic sensor in each wireless earbud is used to detect whether the wireless earbuds are being worn by the same person or two different persons. Here, instead of passively measuring electrical or magnetic waves generated by a person, one or both of the wireless earbuds may include a device that generates an electrical or magnetic signal detectable by the electrical or magnetic sensors included in the wireless earbuds.

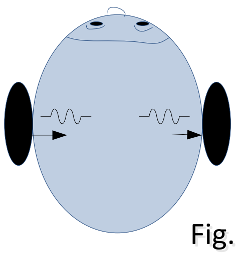


Fig. 5

Referring to FIG. 5, a device in the left wireless earbud may generate an electrical signal to the user's skin. The user's skin then acts as a conductor for the electrical signal. Since the right wireless earbud is also being worn by the same person, an electrical sensor in the right wireless earbud may detect the electrical signal conducted through the skin. In contrast, if the wireless earbuds are being worn by two different persons, it would be unlikely that the signal would be conducted between the two persons, thus, the electrical sensor in one of the wireless earbud would not be able to detect an electrical signal generated by the other wireless earbud. Further, even if the signal is conducted between the two different persons, a time-correlation may indicate whether the two wireless earbuds are being worn by the same person or two different persons. For example, the electrical signal may be more distorted when traveling through two different persons, or there may be a time-delay in detection.

FIG. 6 below illustrates yet another example situation where an electrical or magnetic sensor in each wireless earbud is used to detect whether the wireless earbuds are being worn by the same person or two different persons. Here, the magnetic sensors may have near-field magnetic induction communication (NFMI) capabilities. In the example of FIG. 6, a user's phone has a transmitter coil for modulating a magnetic field, this modulated magnetic field is then measured by a receiver coil in each of the wireless earbuds. If both of the wireless earbuds are worn by the same person, the modulated magnetic field measured by the receiver coil in both wireless earbuds at or about the same time would be approximately the same. In contrast, if the wireless earbuds are being worn by two different persons, the modulated magnetic field measured by the receiver coil in one wireless earbud would likely be different from the modulated magnetic field measured by the receiver coil in the other wireless earbud. For example, the difference may be in magnitude, frequency, and/or phase. Thus, a time-correlation of the modulated magnetic field measured by the receiver coils of the two wireless earbuds would indicate whether the two wireless earbuds are being worn by the same person or two different persons.

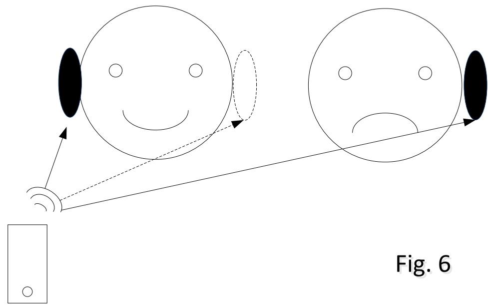


Fig. 6

Additionally or alternatively, the transceiver coil of the phone and the receiver coils in the wireless earbuds may be configured to detect a Doppler shift. For example, if both of the wireless earbuds are being worn by the same person, approximately the same Doppler shift would be detected from both wireless earbuds if the user moves towards or away from the phone. In contrast, if the wireless earbuds are being worn by two different persons, different Doppler shifts may be detected if the two users are moving in different directions or at different speeds. Further, a time of flight may be detected as a large Doppler shift, for example indicating when one of the wireless earbuds is moved from one person's ear to another person's ear.

FIG. 7 example situations where an optical sensor is included in each wireless earbud to detect whether the wireless earbuds are being worn by the same person or two different persons. For example, the optical sensor may be a camera. As shown in FIG. 7, the camera from each wireless earbud may take an image in front of the user wearing the wireless earbud. If both of the wireless earbuds are worn by the same person, the image taken by the camera in both wireless earbuds at or about the same time would be approximately the same. In contrast, if the wireless earbuds are being worn by two different persons, the image taken by the camera in one wireless earbud would like be different from the image taken by the camera in the other wireless earbud. In this regard, image analysis may be performed on the images taken by the two cameras and the results may be time-correlated to determine whether the wireless earbuds are being worn by the same person or two different persons.

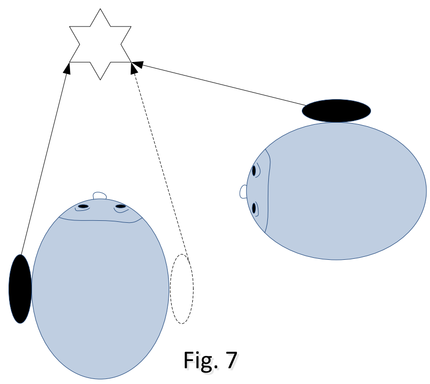


Fig. 7

In other examples, an optical sensor may be included in each wireless earbud to detect heartbeats of a user. For example, optical sensors that use light to measure blood flow—photoplethysmography (PPG)—may be included in the wireless earbuds. The heartbeats detected by the optical sensors in the two wireless earbuds may then be time-correlated to determine whether the wireless earbuds are being worn by the same person or two different persons.

FIG. 8 illustrates an example where a direction sensor is included in each wireless earbud for to detect whether the wireless earbuds are being worn by the same person or two different persons. For example, the direction sensor may be a compass. As shown in FIG. 8, a compass in each of the wireless earbud may point to a North direction. If both of the wireless earbuds are worn by the same person, both wireless earbuds would likely have approximately the same orientation with respect to their respective compass point (e.g., both wireless earbuds facing North). In contrast, if the wireless earbuds are being worn by two different persons, one wireless earbud would likely have a different orientation with respect to its compass point than the other wireless earbud (e.g., one wireless earbud facing North, the other facing South). Thus, a time-correlation of the orientations measured by the compasses of the two wireless earbuds would indicate whether the two wireless earbuds are being worn by the same person or two different persons.

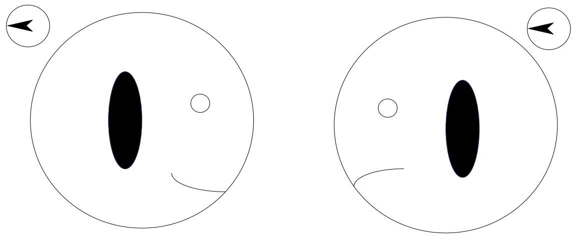


Fig. 8

Once it is determined whether the wireless earbuds are being worn by the same person or two different persons, a setting of one or both of the wireless earbuds may be adjusted, such as audio broadcasting, noise cancellation, and/or language settings. For example, when the wireless earbuds are used for audio broadcasting, the two wireless earbuds may be set to a stereophonic setting when worn by the same person, and set to a monophonic when worn by the same person. As another example, when the wireless earbuds are used for a conference call, one of the wireless earbuds may be set in a voice canceling setting when both are being worn by the same person. Alternatively, each of the wireless earbuds may be used to identify a different speaker when both are being worn by the same person. As still another example, when the wireless earbuds are used for translation, the wireless earbuds may be adjusted to have the same language setting when worn by the same person. When the wireless earbuds are worn by two different persons for translating a conversation between the two wearers, the first wireless earbud may receive audio in a first language from its wearer, route the audio to the second wireless earbud worn by the other person, the second wireless earbud then translates the audio into a second language and broadcasts it to its wearer. In the reverse direction, the wireless earbuds may have the opposite setting.