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(54) VEHICLE SYSTEM FOR INTERACTIVE AUDIO PLAY

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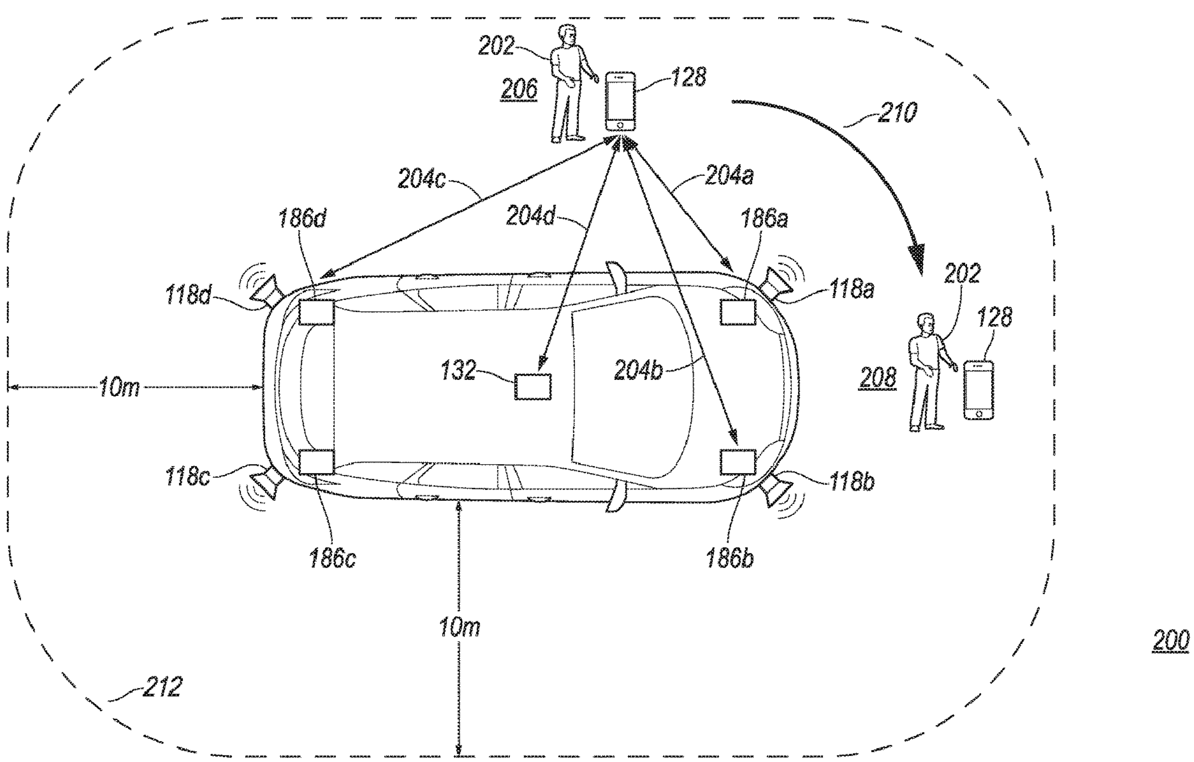
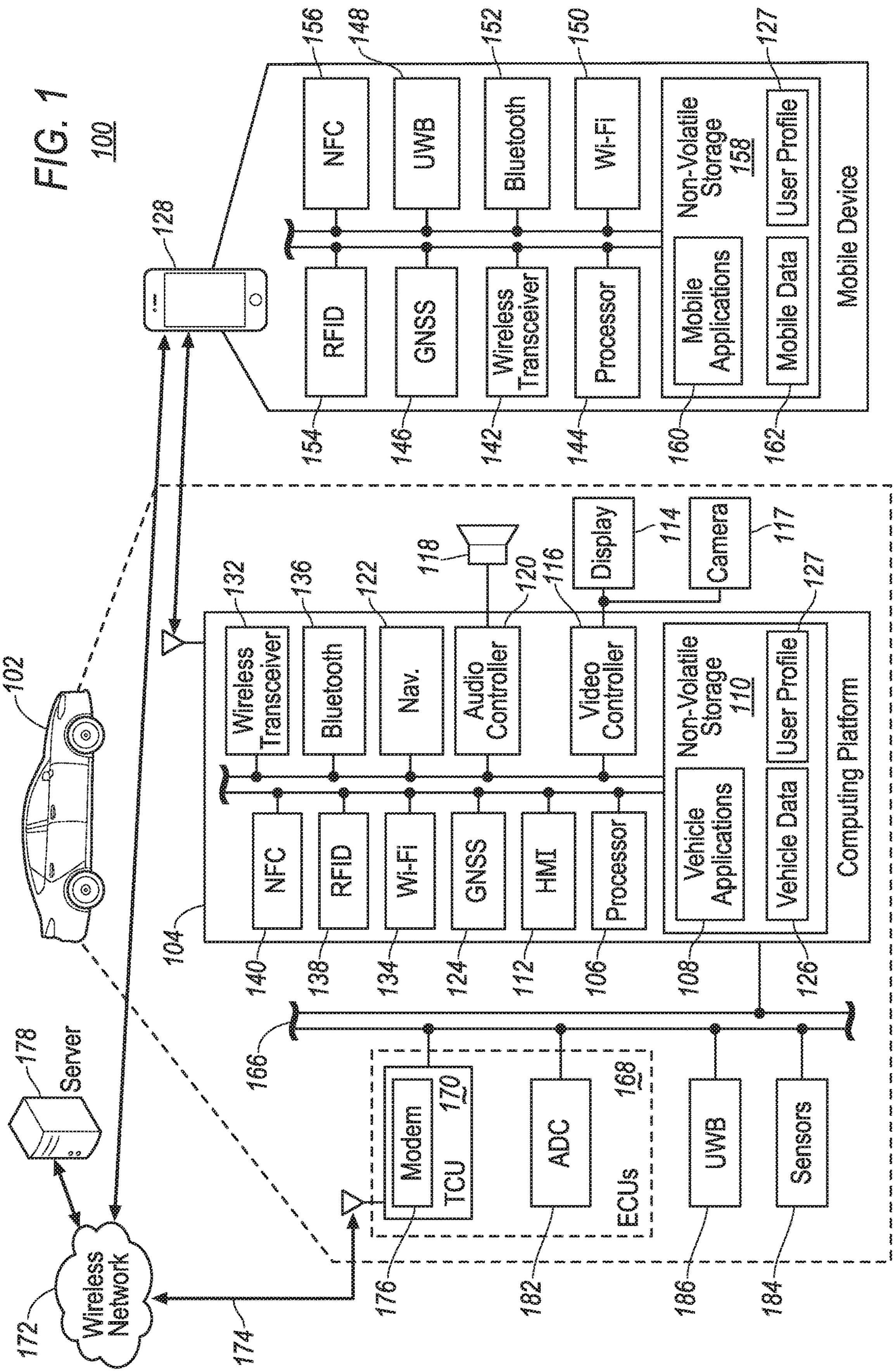
(57) ABSTRACT

A vehicle includes one or more wireless transceivers configured to establish one or more wireless communications with a mobile device; a plurality of speakers configured to output an audio; and a controller programmed to measure a location of a user carrying the mobile device within a predefined range from the vehicle using the one or more wireless communications, and adjust a volume of the one or more speakers using the location of the user.





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142
144
146
148
150
152
154
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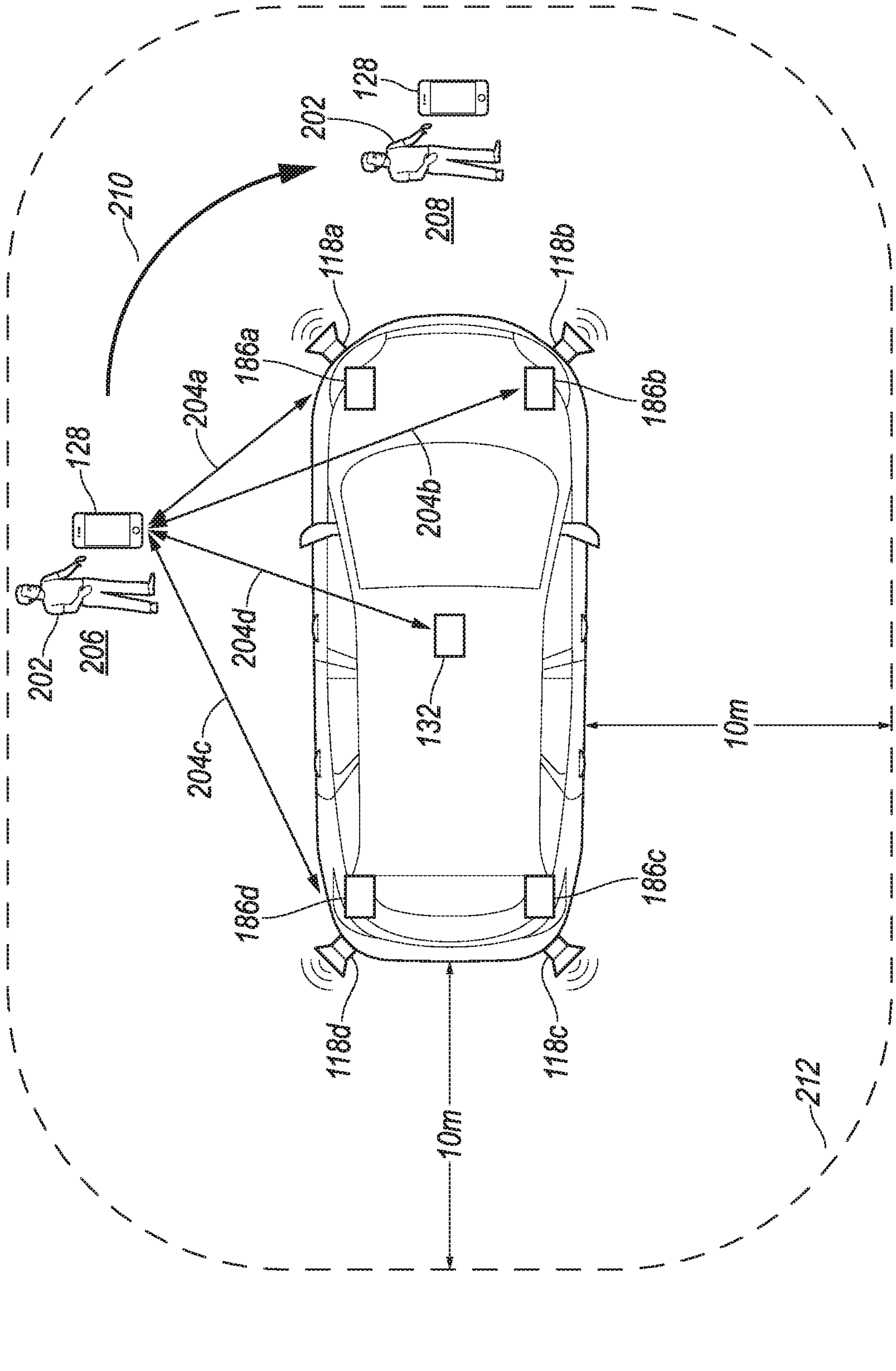
162
166
168
170
172
174
176
178
182
184
186
Server
Wireless Network
Wireless Transceiver
Bluetooth
Nav.
Audio Controller
Video Controller
Display
Camera
NFC
RFID
Wi-Fi
GNSS
HMI
Processor
Non-Volatile Storage
Vehicle Applications
Vehicle Data
User Profile
Computing Platform
Modem
TCU
ADC
ECUs
UWB
Sensors
Bluetooth
Wireless Transceiver
Mobile Applications
Mobile Data
Mobile Device

FIG. 1

200
FIG. 2



210
202
128
208
118a
118b
186a
186b
204a
204b
128
202
206
204d
132
204c
10m
186d
186c
118d
118c
10m
212

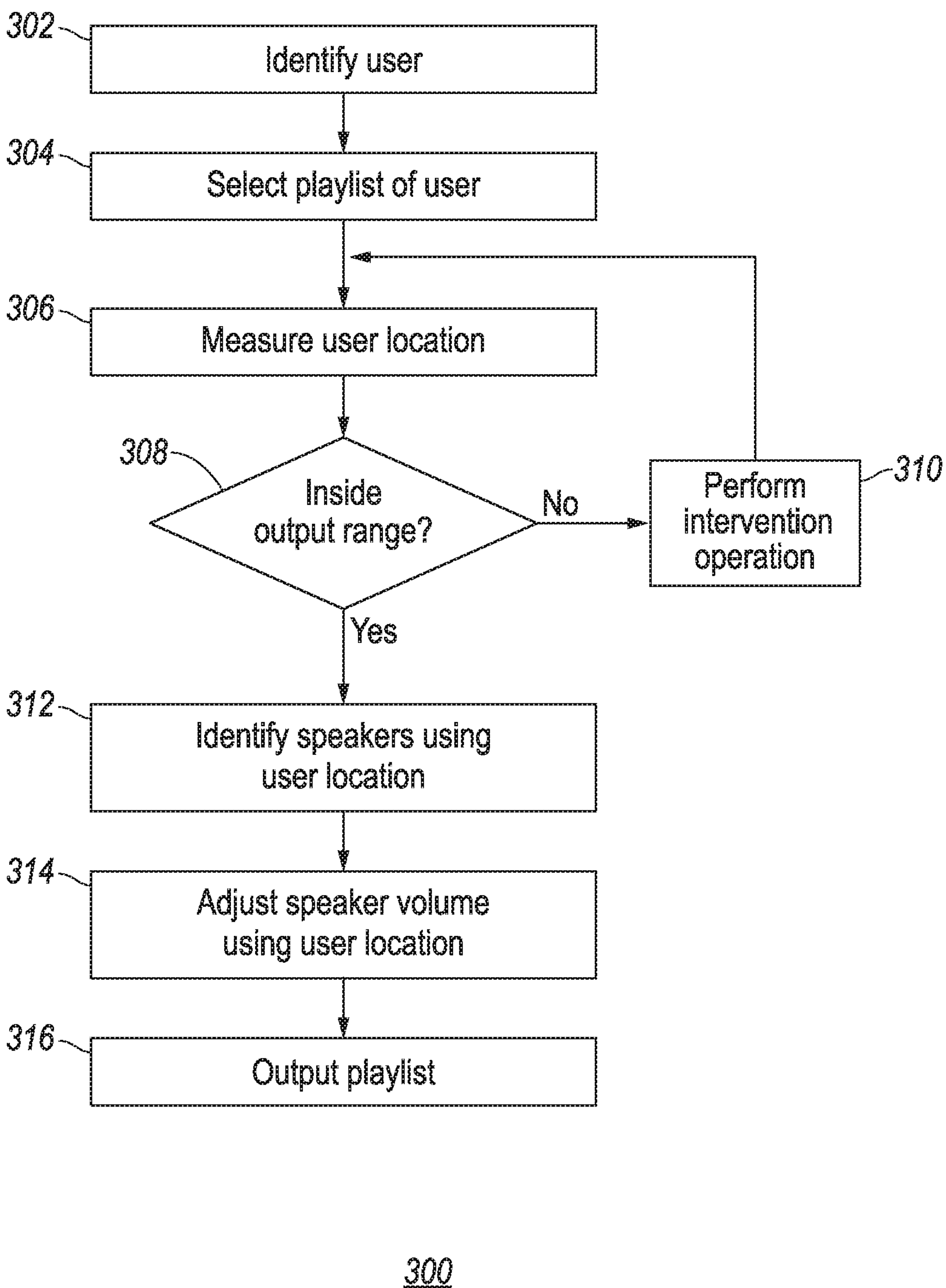

302
Identify user
304
Select playlist of user
306
Measure user location
308
Inside output range?
No
310
Perform intervention operation
Yes
312
Identify speakers using user location
314
Adjust speaker volume using user location
316
Output playlist
300

FIG. 3

VEHICLE SYSTEM FOR INTERACTIVE AUDIO PLAY

TECHNICAL FIELD

[0001] The present disclosure generally relates to a vehicle audio system. More specifically, the present disclosure relates to an interactive audio system of a vehicle based on a location of a user.

BACKGROUND

[0002] Modern vehicles may be provided with an infotainment system configured to provide video and audio output to one or more vehicle users. Some vehicles may be provided with exterior speakers configured to provide audio output to vehicle users outside the vehicle.

SUMMARY

[0003] A vehicle includes one or more wireless transceivers configured to establish one or more wireless communications with a mobile device; a plurality of speakers configured to output an audio; and a controller programmed to measure a location of a user carrying the mobile device within a predefined range from the vehicle using the one or more wireless communications, and adjust a volume of the one or more speakers using the location of the user.

[0004] A method for a vehicle includes establishing, via a plurality of transceivers, wireless connections with a mobile device; measuring, via one or more controllers, a location of the mobile device using the wireless connections through trilateration; adjusting, via the one or more controllers, volumes of a plurality of speakers exterior to the vehicle using the location of the mobile device; and outputting, via the plurality of speakers, an audio using the volume.

[0005] A non-transitory computer-readable medium includes instruction when executed by a vehicle, cause the vehicle to establish a plurality of wireless connections with a mobile device, wherein at least one of the wireless connections is under an ultra-wide band (UWB) protocol; measure a location of the mobile device exterior to the vehicle by trilaterating the plurality of wireless connections; adjust volumes of a plurality speakers exterior to the vehicle using the location of the mobile device; and output an audio of a playlist at the volumes of the plurality of speakers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a better understanding of the invention and to show how it may be performed, embodiments thereof will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

[0007] FIG. **1** illustrates an example block topology of a vehicle system of one embodiment of the present disclosure;

[0008] FIG. **2** illustrates an example schematic diagram of the vehicle communication system of one embodiment of the present disclosure; and

[0009] FIG. **3** illustrates an example flow diagram of a process for operating the vehicle audio system of one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0010] Embodiments are described herein. It is to be understood, however, that the disclosed embodiments are merely examples and other embodiments may take various and alternative forms. The figures are not necessarily to scale. Some features could be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art.

[0011] Various features illustrated and described with reference to any one of the figures may be combined with features illustrated in one or more other figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for typical applications. Various combinations and modifications of the features consistent with the teachings of this disclosure, however, could be desired for particular applications or implementations.

[0012] The present disclosure, among other things, proposes a vehicle audio system. More specifically, the present disclosure proposes a system for adjusting vehicle audio output based on locations of one or more vehicle users at the vicinity of the vehicle.

[0013] Referring to FIG. **1**, an example block topology of a vehicle system **100** of one embodiment of the present disclosure is illustrated. A vehicle **102** may include various types of automobile, crossover utility vehicle (CUV), sport utility vehicle (SUV), truck, recreational vehicle (RV), boat, plane, or other mobile machine for transporting people or goods. In many cases, the vehicle **102** may be powered by an internal combustion engine. As another possibility, the vehicle **102** may be a battery electric vehicle (BEV), a hybrid electric vehicle (HEV) powered by both an internal combustion engine and one or move electric motors, such as a series hybrid electric vehicle (SHEV), a plug-in hybrid electric vehicle (PHEV), a parallel/series hybrid vehicle (PSHEV), or a fuel-cell electric vehicle (FCEV), a boat, a plane or other mobile machine for transporting people or goods. It should be noted that the illustrated system **100** is merely an example, and more, fewer, and/or differently located elements may be used.

[0014] As illustrated in FIG. **1**, a computing platform **104** may include one or more processors **106** configured to perform instructions, commands, and other routines in support of the processes described herein. For instance, the computing platform **104** may be configured to execute instructions of vehicle applications **108** to provide features such as multimedia operations, remote controls, and wireless communications. Such instructions and other data may be maintained in a non-volatile manner using a variety of types of computer-readable storage medium **110**. The computer-readable medium **110** (also referred to as a processor-readable medium or storage) includes any non-transitory medium (e.g., tangible medium) that participates in providing instructions or other data that may be read by the processor **106** of the computing platform **104**. Computer-executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java, C, C++, C#, Objective C, Fortran, Pascal, Java Script, Python, Perl, and structured query language (SQL).

[0015] The computing platform **104** may be provided with various features allowing the vehicle users to interface with the computing platform **104**. For example, the computing platform **104** may receive input from human machine interface (HMI) controls **112** configured to provide for user interaction with the vehicle **102**. As an example, the computing platform **104** may interface with one or more buttons, switches, knobs, or other HMI controls configured to invoke functions on the computing platform **104** (e.g., steering wheel audio buttons, a push-to-talk button, instrument panel controls, etc.).

[0016] The computing platform **104** may also drive or otherwise communicate with one or more displays **114** configured to provide visual output to vehicle users by way of a video controller **116**. In some cases, the display **114** may be a touch screen further configured to receive user touch input via the video controller **116**, while in other cases the display **114** may be a display only, without touch input capabilities. The computing platform **104** may also drive or otherwise communicate with one or more cameras **117** configured to provide visual input to the vehicle **102** by way of the video controller **116**. The cameras **117** may include one or more cabin cameras configured to capture images inside the vehicle cabin, and/or one or more exterior cameras configured to capture images outside the vehicle cabin. The computing platform **104** may also drive or otherwise communicate with one or more speakers **118** configured to provide audio output and input to vehicle users by way of an audio controller **120**. The speakers **118** may include one or more interior speaker located within the vehicle cabin and configured to play audio sound to vehicle user inside the vehicle **102**. Additionally or alternatively, the speakers **118** may include one or more exterior speakers located outside the vehicle cabin and configured to output audio sound to users outside the vehicle **102**. For instance, the exterior speakers may be placed and/or integrated with various exterior components of the vehicle **102** at different body locations to provide the audio output to various directions.

[0017] The computing platform **104** may also be provided with navigation and route planning features through a navigation controller **122** configured to calculate navigation routes responsive to user input via e.g., the HMI controls **112**, and output planned routes and instructions via the speaker **118** and the display **114**. Location data that is needed for navigation may be collected from a global navigation satellite system (GNSS) controller **124** configured to communicate with multiple satellites and calculate the location of the vehicle **102**. The GNSS controller **124** may be configured to support various current and/or future global or regional location systems such as global positioning system (GPS), Galileo, Beidou, Global Navigation Satellite System (GLONASS) and the like. Map data used for route planning may be stored in the storage **110** as a part of the vehicle data **126**. Navigation software may be stored in the storage **110** as one the vehicle applications **108**.

[0018] The storage **110** may be further configured to store one or more user profiles **127** associated with one or more vehicle users. The user profile **127** may include a variety of information entries associated with the respective vehicle user. For instance, the user profile **127** may be indicative of one or more preselected audio playlist associated with each vehicle user such that the audio playlist may be automatically played responsive to detecting the user is at the vicinity of the vehicle **102**. The audio playlist may include one or more audio entries associated with the preference of the respective user. For instance, the audio playlist may include one or more radio channels, podcasts, digital music, white noise that may be output via the one or more speakers **118** of the vehicle **102**. The user profile **127** may further include biometric information about the one or more users. As an example, facial images of the users may be stored as a part of the user profile and the computing platform **104** may identify the users based on images captured via the cameras **117**.

[0019] The computing platform **104** may be configured to wirelessly communicate with a mobile device **128** of the vehicle users via a wireless connection and/or communication. The mobile device **128** may be any of various types of portable computing devices, such as cellular phones, tablet computers, wearable devices, smart watches, smart fobs, laptop computers, portable music players, or other device capable of communication with the computing platform **104**. A wireless transceiver **132** may be in communication with a Wi-Fi controller **134**, a Bluetooth controller **136**, a radio-frequency identification (RFID) controller **138**, a near-field communication (NFC) controller **140**, and other controllers such as a Zigbee transceiver, an IrDA transceiver, and configured to communicate with a compatible wireless transceiver **142** of the mobile device **128**.

[0020] The mobile device **128** may be provided with a processor **144** configured to perform instructions, commands, and other routines in support of the processes such as navigation, telephone, wireless communication, and multi-media processing. For instance, the mobile device **128** may be provided with location and navigation functions via a GNSS controller **146**. The mobile device **128** may be provided with a wireless transceiver **142** in communication with an ultra-wide band (UWB) controller **148**, a Wi-Fi controller **150**, a Bluetooth controller **152**, a RFID controller **154**, an NFC controller **156**, and other controllers (not shown), configured to communicate with the wireless transceiver **132** of the computing platform **104**. The mobile device **128** may be further provided with a non-volatile storage **158** to store various mobile application **160** and mobile data **162**. The storage **158** may be further configured to store the user profile **127** associated with the user associated with the mobile device **128**.

[0021] The computing platform **104** may be further configured to communicate with various components of the vehicle **102** via one or more in-vehicle network **166**. The in-vehicle network **166** may include, but is not limited to, one or more of a controller area network (CAN), an Ethernet network, and a media-oriented system transport (MOST), as some examples. Furthermore, the in-vehicle network **166**, or portions of the in-vehicle network **166**, may be a wireless network accomplished via Bluetooth low-energy (BLE), Wi-Fi, or the like.

[0022] The computing platform **104** may be configured to communicate with various electronic control units (ECUs) **168** of the vehicle **102** configured to perform various operations. For instance, the computing platform **104** may be configured to communicate with a telematics control unit (TCU) **170** configured to control telecommunication between vehicle **102** and a wireless network **172** through a wireless connection **174** using a modem **176**. The wireless connection **174** may be in the form of various communication network e.g., a cellular network. Through the wireless network **172**, the vehicle may access one or more servers **178** to access various content for various purposes. It is noted that the terms wireless network and server are used as general terms in the present disclosure and may include any computing network involving carriers, router, computers, controllers, circuitry or the like configured to store data and perform data processing functions and facilitate communication between various entities.

[0023] The ECUs **168** may further include an autonomous driving controller (ADC) **182** configured to control autonomous driving features of the vehicle **102**. Driving instructions may be received remotely from the server **178**. The ADC **182** may be configured to perform the autonomous driving features using the driving instructions combined with navigation instructions from the navigation controller **122**.

[0024] The vehicle **102** may be provided with various sensors **184** to provide signal input to the computing platform **104** and the ECUs **168**. As a few non-limiting examples, the sensors **184** may include one or more ultrasonic radar sensors and/or lidar sensors to detect object at the vicinity of the vehicle **102**.

[0025] In addition, the vehicle **102** may be further provided with one or more UWB transceivers **186** configured to communicate with one or more entities using UWB communications. For instance, the vehicle **102** may be configured to communicate with the mobile device **128** via the one or more UWB transceivers **186** in addition to or in lieu of the wireless transceivers **132**. When multiple UWB transceivers **186** are provided, the UWB transceivers **186** may be placed at various locations of the vehicle **102** to perform various operations such as determining the location of the connected device via trilateration and/or triangulation.

[0026] Referring to FIG. **2**, an example schematic diagram **200** of the vehicle communication system of one embodiment of the present disclosure is illustrated. With continuing reference to FIG. **1**, the vehicle **102** in the present example may be provided with a plurality of UWB transceivers **186** at various locations of the vehicle **102**. For instance, the vehicle **102** may be provided with a first UWB transceiver **186*a*** located near a front-left corner of the vehicle **102**. The vehicle **102** may be further provided with a second UWB transceiver **186*b*** located near a front-right corner of the vehicle **102**. The vehicle **102** may be further provided with a third UWB transceiver **186*c*** located near a rear-right corner of the vehicle **102**. The vehicle **102** may be further provided with a fourth UWB transceiver **186*d*** located near a rear-left corner of the vehicle **102**. It is noted that locations of the vehicle UWB transceivers **186** in the present example are only for demonstrative purpose and one or more of the UWB transceivers **186** may be provided at different locations of the vehicle **102** such as the rear-view mirrors, front/rear bumper, door panels or the like.

[0027] As discussed above, the UWB transceivers **186** may establish UWB wireless connections and/or communications with the mobile device **128** associated with a vehicle user **202** at a given time. Once three or more wireless connections are established, the computing platform **104** may use the timing of each wireless connections to determine the location of the mobile device **128** (and thus the location of the user **202**) via trilateration. More specifically, it is assumed that the mobile device **128** is carried by the user **202** in the present example. The mobile device **128** may establish a first wireless connection **204*a*** with the first UWB transceiver **186*a*** of the vehicle **102**. The mobile device **128** may establish a second wireless connection **204*b*** with the first UWB transceiver **186*b*** of the vehicle **102**. The mobile device **128** may establish a third wireless connection **204*c*** with the fourth UWB transceiver **186*d*** of the vehicle **102**. Additionally or alternatively, the mobile device **128** may establish a fourth wireless connection with the wireless transceiver **132** of the vehicle **102**. The fourth wireless connection may be established via wireless communication protocols other than UWB. For instance, the fourth wireless connection may be established via Bluetooth, NFC or the like.

[0028] Each of the wireless connections **204** may be associated with an individual time of flight (TOF) indicative of a measurement of time taken by the wireless signal to travel between the mobile device **128** and each respective UWB transceivers **186** and/or wireless transceiver **132**. Since the travel speed of the wireless signal is known, the distance between the mobile device **128** and each respective transceiver **186**, **132** may be determined based on the TOF. In general, the TOF may be proportional to the distance travel by the UWB signal. E.g., a short TOF may be associated with a shorter distance between the mobile device **128** and the respective transceiver **186**, **132**, and a longer TOF may be associated with a longer distance between the mobile device **128** and the respective transceiver **186**, **132**. Once the distance between the mobile device **128** and each respective transceiver **186**, **132** is determined, the computing platform **104** may calculate the relative location of the mobile device **128** with reference to the vehicle **102** based on the distances using trilateration and/or triangulation. In the present example, the computing platform **104** may determine the mobile device **128** (and thus the user **202**) is at a first location **206** to the left side of the vehicle **102**.

[0029] The computing platform **104** may continuously monitor the location of the user **202** by updating the trilateration and/or triangulation of the mobile device **128** at a periodical interval (e.g., every 100 ms). For instance, the user **202** may walk from the first location **206** toward the front of the vehicle **102** and stop at the second location **208**. The computing platform **104** may measure and track the trajectory **210** of the user **202** accordingly.

[0030] As discussed above, the vehicle **102** may be provided with a plurality of exterior speakers **118** at various locations of the vehicle **102**. For instance, the vehicle **102** may be provided with a first speaker **118*a*** located near a front-left corner of the vehicle **102**. The vehicle **102** may be further provided with a second speaker **118*b*** located near a front-right corner of the vehicle **102**. The vehicle **102** may be further provided with a third speaker **118*c*** located near a rear-right corner of the vehicle **102**. The vehicle **102** may be further provided with a fourth speaker **118*d*** located near a rear-left corner of the vehicle **102**. It is noted that locations of the vehicle speakers **118** in the present example are only for demonstrative purpose and one or more of the speakers **118** may be provided at different locations of the vehicle **102** such as the rear-view mirrors, front/rear bumper, door panels, inside the vehicle cabin or the like.

[0031] The computing platform **104** may be configured to provide the vehicle user **202** with a consistent audio experience via the plurality of speakers **118** based on the locations of the vehicle user **202** as measured via the wireless connections **204**. More specifically, the computing platform **104** may adjusts the volume of one or more of the speakers **118** based on the location of the mobile device **128** such that the user **202** experiences a consistent and smooth audio output from the speakers **118** even if the user **202** is in motion at the vicinity of the vehicle **102**. For instance, responsive to detecting the user **202** being at the first location **206** to the left of the vehicle **102** on the driver door side, the computing platform **104** may output the audio sound via the first speaker **118***a* and the fourth speaker **118***d* that are the closest to the user **202**. The second speaker **118***b* and the third speaker**118***c* are not in use in this situation since they are farther away from the first location **206**. The audio controller **120** of the computing platform **104** may control the volume of the first speaker **118***d* and the fourth speaker **118***d* using the following equations:

$$\alpha f_1 + (1 - \alpha) f_4 = V \quad (1)$$

wherein V denotes the total volume selected by the user **202**, f_1 denotes the volume control function for operating the first speaker **118***a*, and f_4 denotes the volume control function for operating the fourth speaker **118***d*. α denote a location variable indicative of the location of the user **202** relative to the location of one of the speakers as a reference speaker (e.g., the first speaker **118***a* in the present example). For instance, the speaker **118** that is the closest to the location of the user **202** may be selected as the reference speaker. The location variable a is inversely proportional to the distance between the location of the user **202** and the reference speaker varied between 0 and 1.

[0032] For instance, if the location of the user **202** is measured at the front-left corner of the vehicle **102** next to the first speaker (e.g., zero distance), the audio controller **120** may set the location variable a to be 1 (e.g., the maximum) such that the first speaker **118***a* is used to output the entire volume V and no other speakers **118** is used to output the audio sound. In contrast, if the location of the user **202** is at halfway between the first speaker **118***a* and the fourth speaker at an equal distance, the audio controller **120** may set the location variable a to be 0.5 such that both the first speaker **118***a* and the fourth speaker **118***d* outputs a half of the total volume V. In this way, the user **202** may experience a consistent audio volume at various locations at the vicinity of the vehicle **102**.

[0033] As discussed above, the computing platform **104** may tract the trajectory **210** of the user **202** from the first location **206** to the second location **208** that is in front of the vehicle **102**. The audio controller **120** may adjust the audio output volume at various speakers **118** based on the trajectory **210** of the user **202**. In the present example, as the user relocates from the first location **206** to the second location **208**, the audio controller may gradually reduce the volume of the fourth speaker **118***d* and increase the volume of the second speaker **118***b* such that the user **202** receives a consistent audio experience and smooth transition while in motion on the trajectory **210** from the first location **206** to the second location **208**.

[0034] The vehicle **102** may be associated with an audio output range **212** defining an area centered around the vehicle **102** that are effectively covered by the one or more speakers **118**. Within the audio output range **212**, the user **202** may perceive a desired the audio experience from the speakers **118**. The audio experience outside the audio output range **212** may be undesirable as the distance between the user **202** and the closest one of the speakers **118** is too far. If the computing platform detects the user **202** has exited the audio output range **212**, the audio controller **120** may suspend the audio output until the user reenters the audio output range **212**. In one example, the audio output range **212** may be 10 meters.

[0035] Referring to FIG. **3**, an example flow diagram of a process **300** for operating the vehicle audio output based on the location of one or more users of one or more embodiments of the present disclosure is illustrated. With continuing reference to FIGS. **1** and **2**, the process **300** may be implemented via various components of the vehicle **102**. For instance, the process **300** may be individually or collectively implemented via the computing platform **104**, one or more ECUs **168**, UWB transceivers **186** or the like. For simplicity, the following description will be made with reference to the computing platform **104**.

[0036] At operation **302**, the computing platform **104** identifies one or more vehicle users **202** at the vicinity of the vehicle **102**. The user identification operation may be performed in various manners. For instance, the computing platform **104** may determine the user identity using the user profile **127** stored in the associated mobile device **128**. Responsive to establishing the one or more wireless connections **204** with the mobile device **128**, the computing platform **104** may identify the user identity using the user profile **127** stored therein. Additionally or alternatively, the computing platform **104** may identify the user **202** using the biometric information stored as a part of the user profile **127** in the storage **110**. As an example, responsive to capturing a facial image of the user **202** via one or more of the cameras **117**, the computing platform **104** may compare the facial image with the biometric information of the user profile **127** such that the identity of the vehicle user may be identified.

[0037] In response to identifying the user **202**, at operation **304**, the computing platform **104** selects one of the audio playlists associated with the user **202** as identified using the user profile **127** in preparation of the audio output. As discussed above, the playlist may include a radio channel and/or a music soundtrack preselected by the user **202**. Additionally or alternatively, the playlist may include one or more white noise preselected by the user **202**. The white noise may be used for various purposes. For instance, the white noise may be associated with the benefit of promoting relaxation and reducing stress levels of the user **202**. The white noise may also increase privacy of the user **202** while engaging a conversation, e.g., the white noise covers up the user speech within the audio output range.

[0038] At operation **306**, the computing platform **104** measures the location of the user **202** relative to the vehicle **102**. As discussed above, the computing platform **104** may locate the user **202** via wireless connection trilateration and/or triangulation through the plurality of UWB transceivers **186** and/or the wireless transceiver **132**. Additionally or alternatively, the computing platform **104** may locate the user **202** via the vehicle sensors **184** and/or cameras **117**. For instance, the computing platform **104** may use one or more of the lidar sensors **184** and ultrasonic sensors **184** to determine the location of the user **202** relative to the vehicle **102** in addition to or in lieu of using the wireless connections **204**. Images captured by the camera **117** may be further used to improve the accuracy of the user location determination. Additionally or alternatively, the computing platform **104** may locate the user **202** via the location information determined via the GNSS controller **146** of the mobile device carried by the user **202**. The mobile device **128** may send the location information to the vehicle **102** via the wireless connections **204** and/or the wireless network **172**. Once the location of the user **202** is determined, at operation **308**, the computing platform **104** determines if the location of the user **202** within the audio output range **212** centered around the vehicle **102**.

[0039] If the computing platform **104** determines that the user **202** is located outside the audio output range **212**, the process proceeds to operation **310**, and the computing platform **104** performs intervention operations. The intervention operations may include various examples. For instance, if the audio is currently being played by one or more of the speakers **118**, the computing platform **104** may suspend the audio play in response to detecting the user is outside the audio output range **212**. This intervention operation may be applicable to an example in which the user **202** walks away from the vehicle **102** while the audio is being played. Additionally or alternatively, the intervention operation may include autonomously operating the vehicle **102** via the ADC **182** to drive toward the user **202** such that the user **202** subsequently become within the audio output range **212**. This intervention operation may be applicable to an example that the user **202** walks along a trajectory and the vehicle follows the user **202** as the driving condition allows and continue to play the audio once the user **202** is inside the audio output range **212** again.

[0040] If the computing platform **104** determines the user **202** is inside the audio output range **212** at operation **308**, the process proceeds to operation **312** and the computing platform **104** identifies the one or more of the speakers **118** to be used for audio outputting using the location of the user **202** as determined. As discussed in the example with reference to FIG. **2**, different speakers **118** may be activated to output the audio depending on the relative location of the user **202** with reference to the vehicle **102**. As a generally rule, speakers closer to the location of the user **202** (e.g., with shorter distance) may be preferred for audio outputting.

[0041] At operation **314**, the computing platform **104** adjusts the volume of each of the identified speakers **118** using the location of the user **202**. For instance, the volume of each speaker may be adjusted using equation (1) discussed above based on the distance between the location of the user **202** and each respective speaker.

[0042] At operation **316**, the computing platform **104** outputs the audio associated with the selected playlist via the identified speakers **118** at the adjusted volume. As discussed above, the audio may be a soundtrack preferred by the user **202**. Additionally or alternatively, the audio may be a white noise sound focused toward the location of the user **202** for relaxation and privacy purposes.

[0043] The operations of the process **300** may be automatically repeated until none of the one or more users **202** is in the audio output range **212**.

[0044] The operations of the process **300** may be applied to various situations. In one example, there may be two users **202** riding in the vehicle **102** (e.g., a driver and a passenger). While inside the vehicle cabin, the computing platform **104** may output the audio associated with a playlist of one of the users via one or more interior speakers **118**. As the vehicle is parked, both users **202** exit the vehicle **102** cabin and the computing platform **104** may switch the audio output from the interior speakers to exterior speakers corresponding to the location of the users **202**. For instance, as the driver **202** exits the vehicle **102**, the computing platform **104** may continue to output the audio via the first speaker **118*a*** and the fourth speaker **118*d*** located on the left side (e.g., driver side) using the volume continuously adjusted based on the location of the first user **202**. In this case, the first speaker **118*a*** being closer to the driver **202** may output the audio at a higher volume compared with the fourth speaker **118*d*** being farther from the driver **202** such that the driver experiences a consistent audio output.

[0045] As the passenger **202** exists from the rear-right side (e.g., passenger side), the computing platform **104** may continue to output the audio via the second speaker **118*b*** and the third speaker **118*c*** both located on the right side of the vehicle **102**. The second speaker **118*b*** being farther from the passenger **202** may output the audio at a lesser volume compared with the third speaker **118*c*** being closer to the passenger **202**.

[0046] The computing platform **104** may continuously track the locations of both the driver and the passenger **202** and adjusts the speaker volume accordingly until both of the driver and passenger **202** have exited the audio output range **212** at which point the computing platform **104** may suspend the audio output. Upon detecting one or more of the driver and passenger **202** reentering the audio output range **212**, the computing platform **104** may resume the audio output of the playlist.

[0047] In an alternative example, the multiple user **202** of the vehicle **102** may be associated with different playlists having different audios. E.g., the first user **202*a*** may prefer a radio new channel and the second user **202*b*** may prefer a music audio. The computing platform **104** may coordinate the playlists and output the different audios simultaneously using different speakers based on the location of each user **202**. For instance, the computing platform **104** may detect the first user **202*a*** located on the driver side (e.g., left side) outside the vehicle **102** while a second user **202*b*** is detected on the passenger side (e.g., right side) of the vehicle **102**. Based on the detected location of the users **202**, the computing platform **104** may use the first speaker **118*a*** and the fourth speaker **118*d*** to output the audio associated with the first user **202*a***, and user the second speaker **118*b*** and the third speaker **118*c*** to output the audio associated with the second user **202*b***.

[0048] The algorithms, methods, or processes disclosed herein can be deliverable to or implemented by a computer, controller, or processing device, which can include any dedicated electronic control unit or programmable electronic control unit. Similarly, the algorithms, methods, or processes can be stored as data and instructions executable by a computer or controller in many forms including, but not limited to, information permanently stored on non-writable storage media such as read only memory devices and information alterably stored on writeable storage media such as compact discs, random access memory devices, or other magnetic and optical media. The algorithms, methods, or processes can also be implemented in software executable objects. Alternatively, the algorithms, methods, or processes can be embodied in whole or in part using suitable hardware components, such as application specific integrated circuits, field-programmable gate arrays, state machines, or other hardware components or devices, or a combination of firmware, hardware, and software components.

[0049] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the disclosure. The words processor and processors may be interchanged herein, as may the words controller and controllers.

[0050] As previously described, the features of various embodiments may be combined to form further embodiments of the invention that may not be explicitly described or illustrated. While various embodiments could have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics may be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. These attributes may include, but are not limited to strength, durability, marketability, appearance, packaging, size, serviceability, weight, manufacturability, ease of assembly, etc. As such, embodiments described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics are not outside the scope of the disclosure and may be desirable for particular applications.

What is claimed is:

1. A vehicle, comprising:

one or more wireless transceivers configured to establish one or more wireless communications with a mobile device;

a plurality of speakers configured to output audio; and

a controller programmed to

measure a location of a user carrying the mobile device within a predefined range from the vehicle using the one or more wireless communications, and

adjust a volume of one or more of the plurality speakers using the location of the user.

2. The vehicle of claim **1**, wherein the one or more wireless transceivers include at least three wireless transceivers each configured to establish one of the wireless communications with the mobile device; and

the controller is further programmed to:

measure the location of the user carrying the mobile device by trilaterating the wireless communications.

3. The vehicle of claim **1**, wherein the one or more wireless transceivers are located at different locations of the vehicle and configured to support an ultra-wide band (UWB) protocol.

4. The vehicle of claim **1**, wherein the controller is further programmed to adjust the volume of the one or more speakers such that the volume output by one of the speakers is inversely proportional to a distance between the user and the one of the speakers.

5. The vehicle of claim **4**, wherein the controller is further programed to adjust the volume of the one or more speakers such that a sum of volume output via each of the speaker is equal to a total volume.

6. The vehicle of claim **1**, wherein the controller is further programmed to:

responsive to detecting the location of the user is beyond a predefined range from the vehicle, suspend outputting the audio.

7. The vehicle of claim **1**, wherein the controller is further programmed to:

responsive to detecting the location of the user is beyond a predefined range from the vehicle, autonomously operate the vehicle to drive toward the location of the user.

8. The vehicle of claim **1**, wherein the controller is further programmed to:

determine an identity of the user using a user profile stored in the mobile device;

select a playlist using the identity of the user; and

play the playlist through the audio.

9. The vehicle of claim **8**, further comprising:

one or more cameras, configured to capture images of the user;

wherein the controller is further configured to:

determine the identity of the user using the images.

10. The vehicle of claim **1**, further comprising:

one or more sensors, configured to detect the user and generate sensor data;

wherein the controller is further configured to:

measure the location of the user using the sensor data.

11. A method for a vehicle, comprising:

establishing, via a plurality of transceivers, wireless connections with a mobile device;

measuring, via one or more controllers, a location of the mobile device using the wireless connections through trilateration;

adjusting, via the one or more controllers, volumes of a plurality of speakers exterior to the vehicle using the location of the mobile device; and

outputting, via the plurality of speakers, an audio using the volumes.

12. The method of claim **11**, wherein the wireless connections are established using ultra-wide band (UWB) protocol.

13. The method of claim **12**, wherein at least one of the wireless connections are established using a wireless communication protocol other than UWB.

14. The method of claim **11**, wherein the volumes of the plurality of speakers are adjusted such that the volume output by one of the speakers is inversely proportional to a distance between the location of the mobile device and a location of the one of the speakers.

15. The method of claim **14**, wherein the volumes of the plurality of speakers are adjusted such that a sum of volume output via each of the speaker is equal to a total volume set by a user associated with the mobile device, and at least one of the plurality of the speakers is inactive with zero volume.

16. The method of claim **11**, further comprising:

responsive to detecting the location of the mobile device is beyond a predefined range from the vehicle, suspend outputting the audio.

17. A non-transitory computer-readable medium, comprising instructions that when executed by a vehicle, cause the vehicle to:

establish a plurality of wireless connections with a first mobile device, wherein at least one of the wireless connections is under an ultra-wide band (UWB) protocol;

measure a first location of the first mobile device exterior to the vehicle by trilaterating the plurality of wireless connections;

adjust volumes of a first set of a plurality of speakers exterior to the vehicle using the first location of the first mobile device; and

output a first audio of a playlist at the volumes via the first set.

18. The non-transitory computer-readable medium of claim **17**, further comprising instruction when executed by a vehicle, cause the vehicle to:

responsive to detecting the first location of the first mobile device is beyond a predefined range from the vehicle, autonomously operate the vehicle to drive toward the first location of the first mobile device.

19. The non-transitory computer-readable medium of claim **17**, further comprising instruction when executed by a vehicle, cause the vehicle to:

responsive to establishing a plurality of wireless connections with a second mobile device, measure a second location of the second mobile device; and

output a second audio different from the first audio via a second set of the plurality of speakers, wherein the second set includes at least one speaker that is not included in the first set.

20. The non-transitory computer-readable medium of claim **17**, wherein the audio includes a white noise to increase privacy of a user of the first mobile device.

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