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(54) **PERSONALIZATION SYSTEM AND METHOD FOR A VEHICLE BASED ON SPATIAL LOCATIONS OF OCCUPANTS' BODY PORTIONS**

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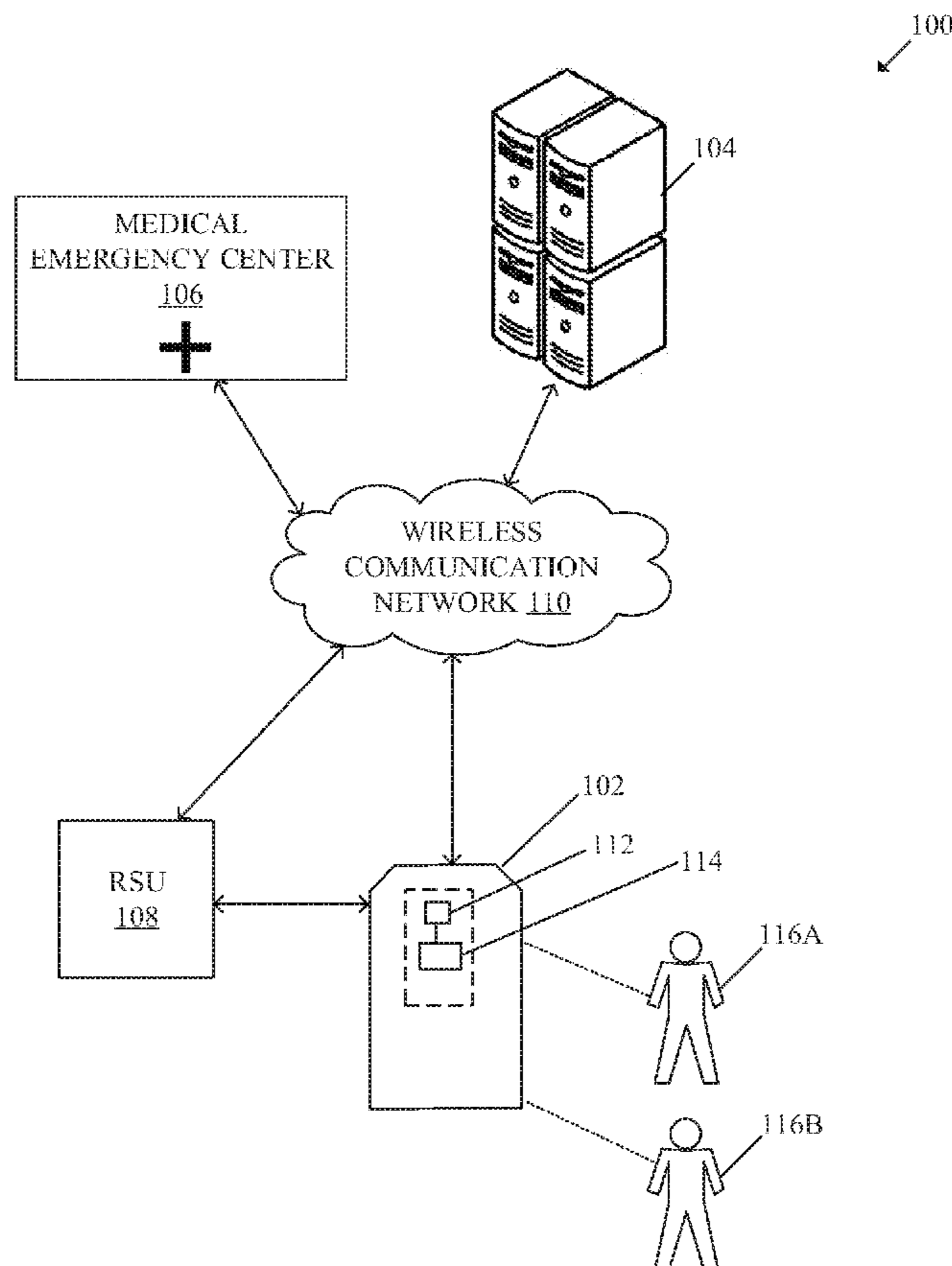
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(57) **ABSTRACT**

A personalization system for a vehicle includes an image-capture device configured to capture a plurality of images of one or more occupants in the vehicle and control circuitry configured to estimate a plurality of Z-heights of a plurality of body portions of each of the one or more occupants from a reference position in the vehicle, based on the plurality of images captured from the image-capture device, determine an associative relationship between the plurality of Z-heights of the plurality of body portions of each of the one or more occupants in the vehicle and a plurality of in-vehicle systems, based on defined user-preferences, and control the plurality of in-vehicle systems to direct an output from a corresponding in-vehicle system to a specific body portion of each of the one or more occupants in the vehicle, based on the estimated plurality of Z-heights and the determined associative relationship.



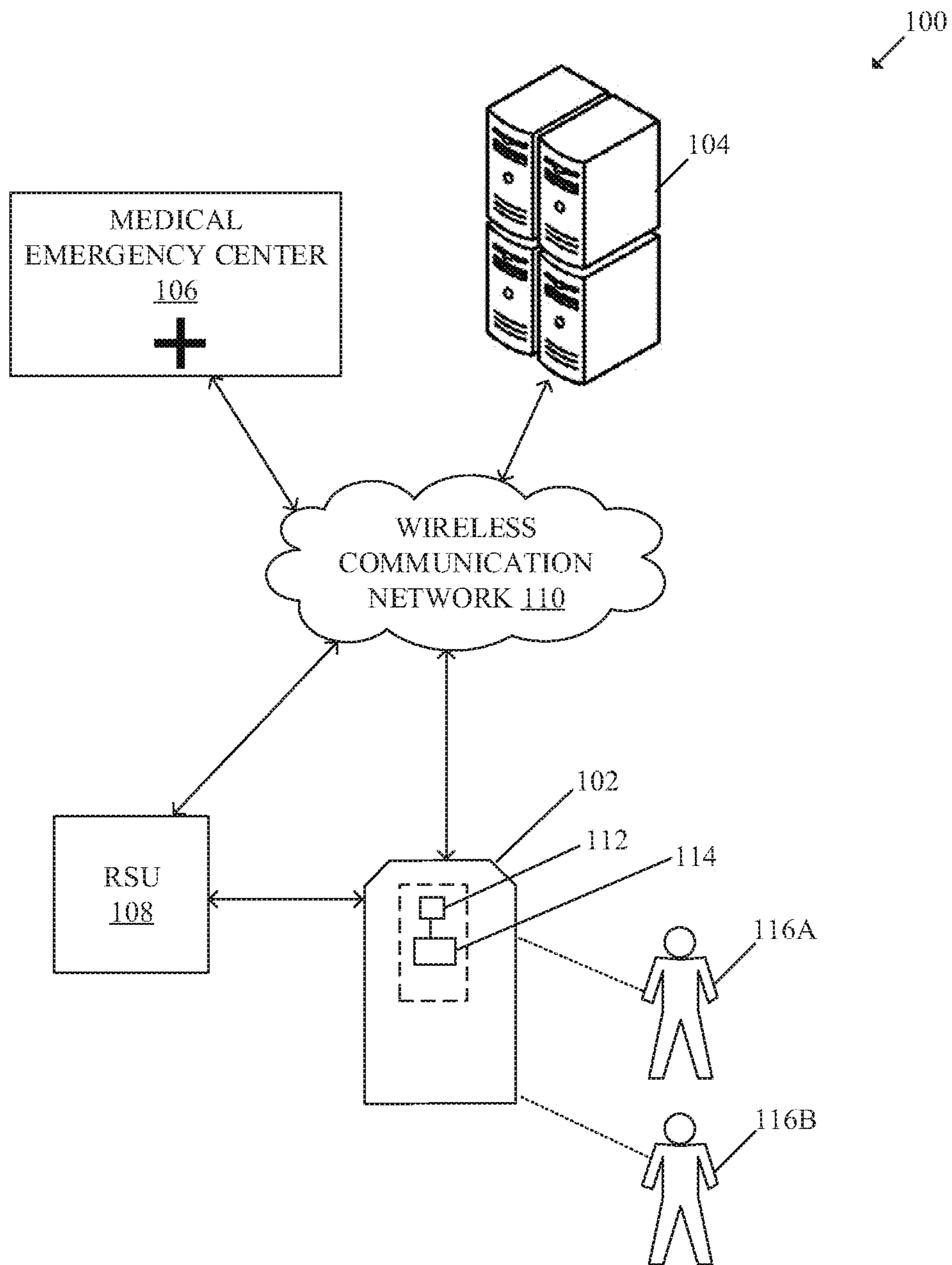


FIG. 1

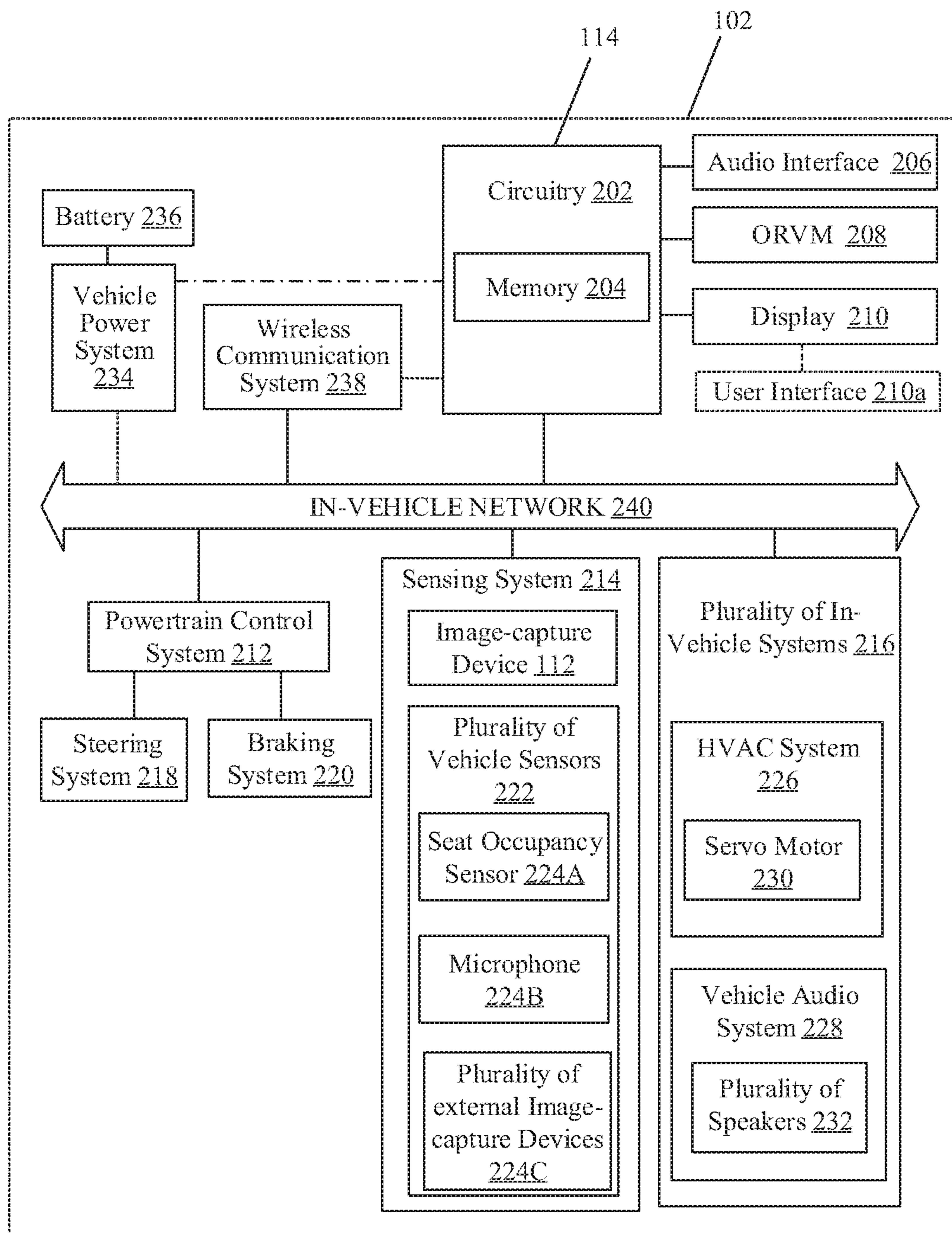


FIG. 2

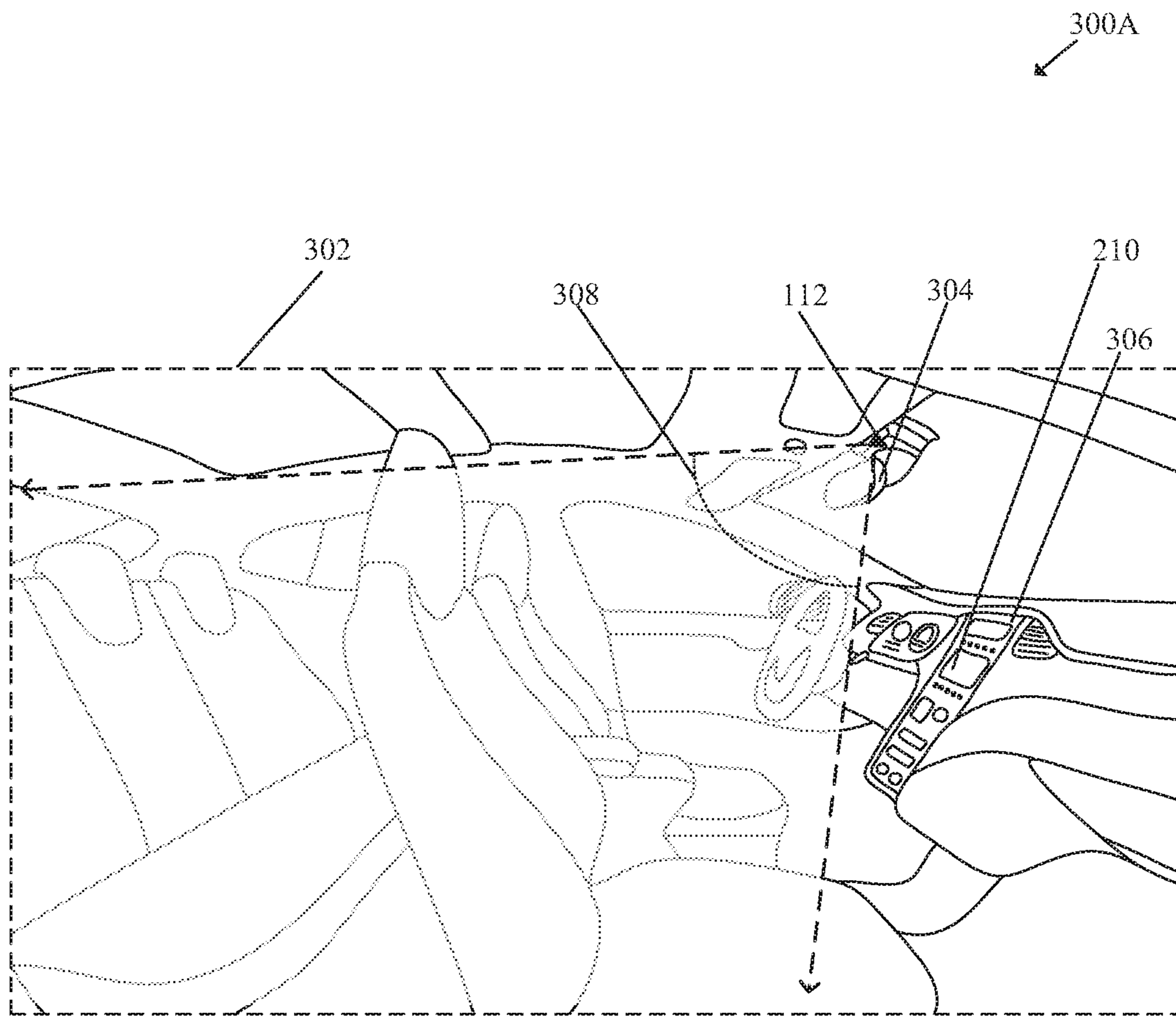


FIG. 3A

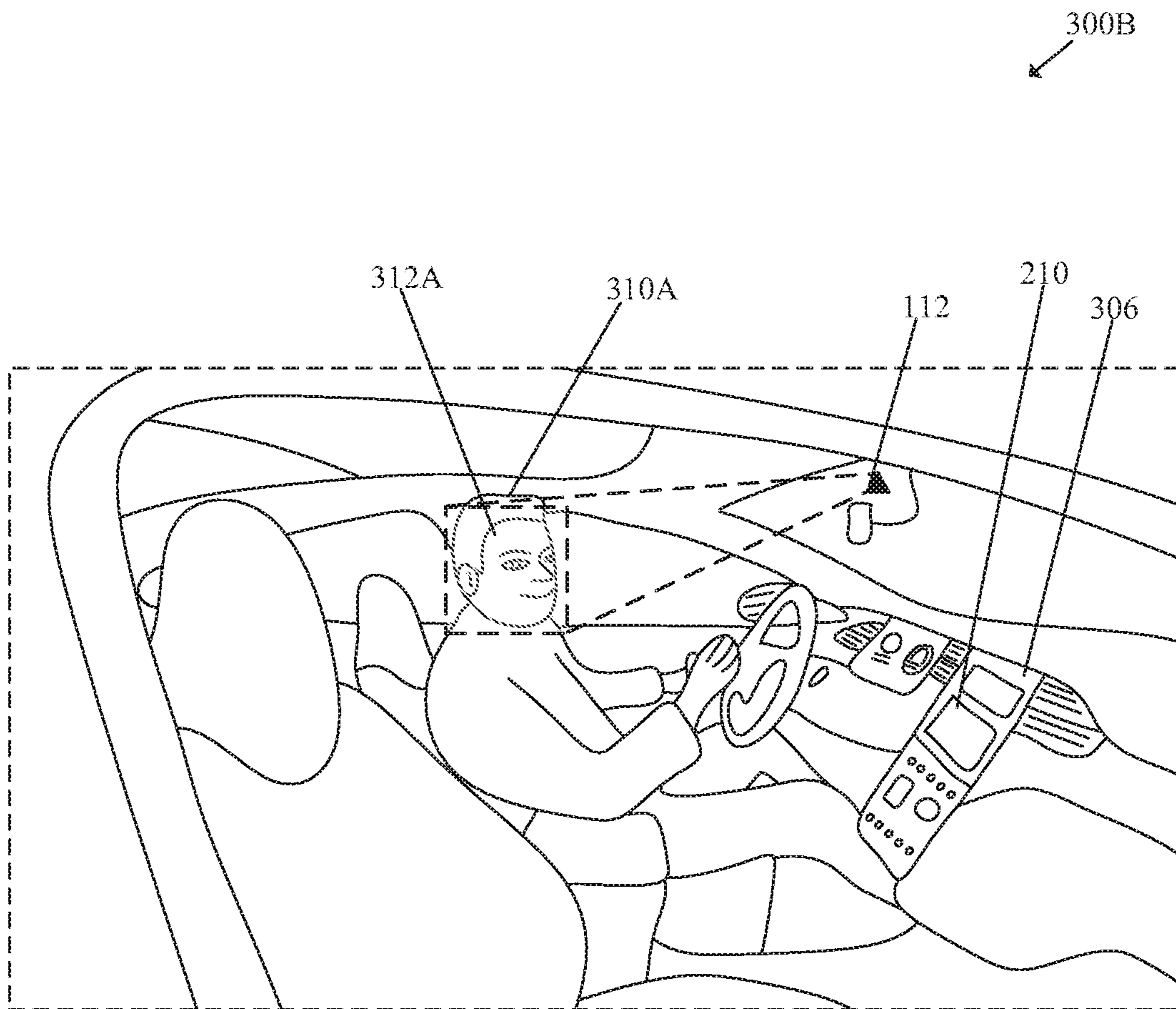


FIG. 3B

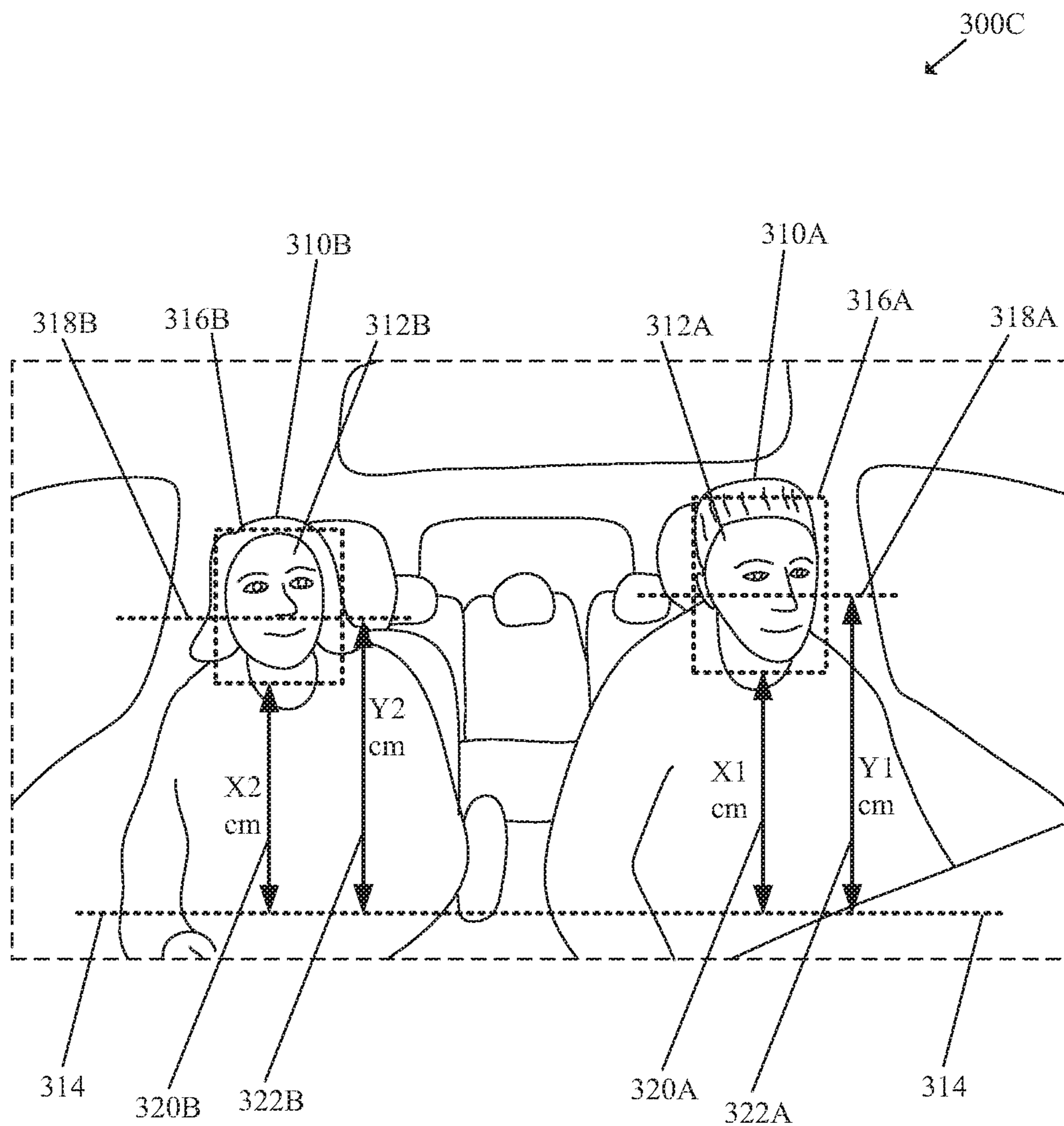


FIG. 3C

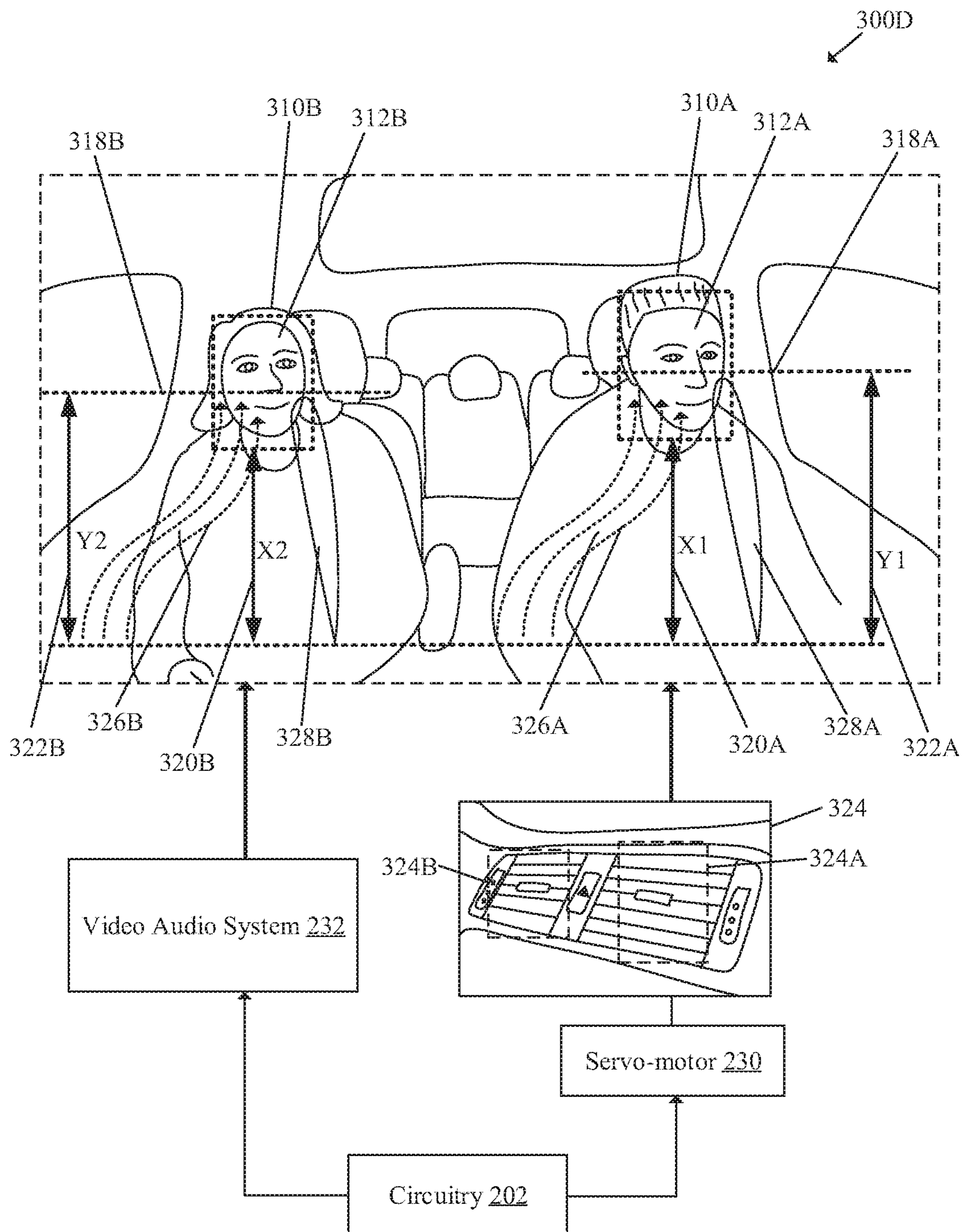


FIG. 3D

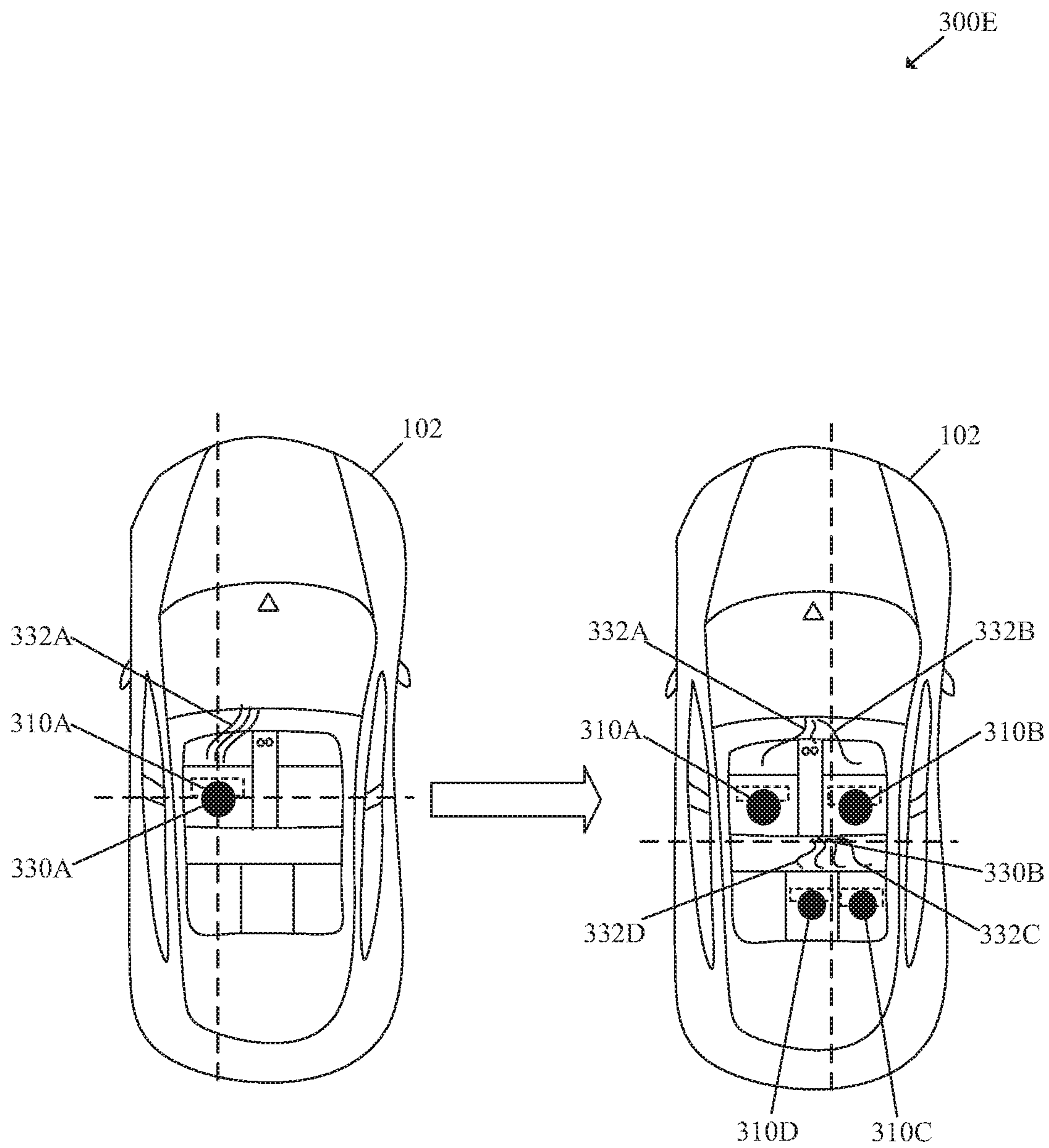


FIG. 3E



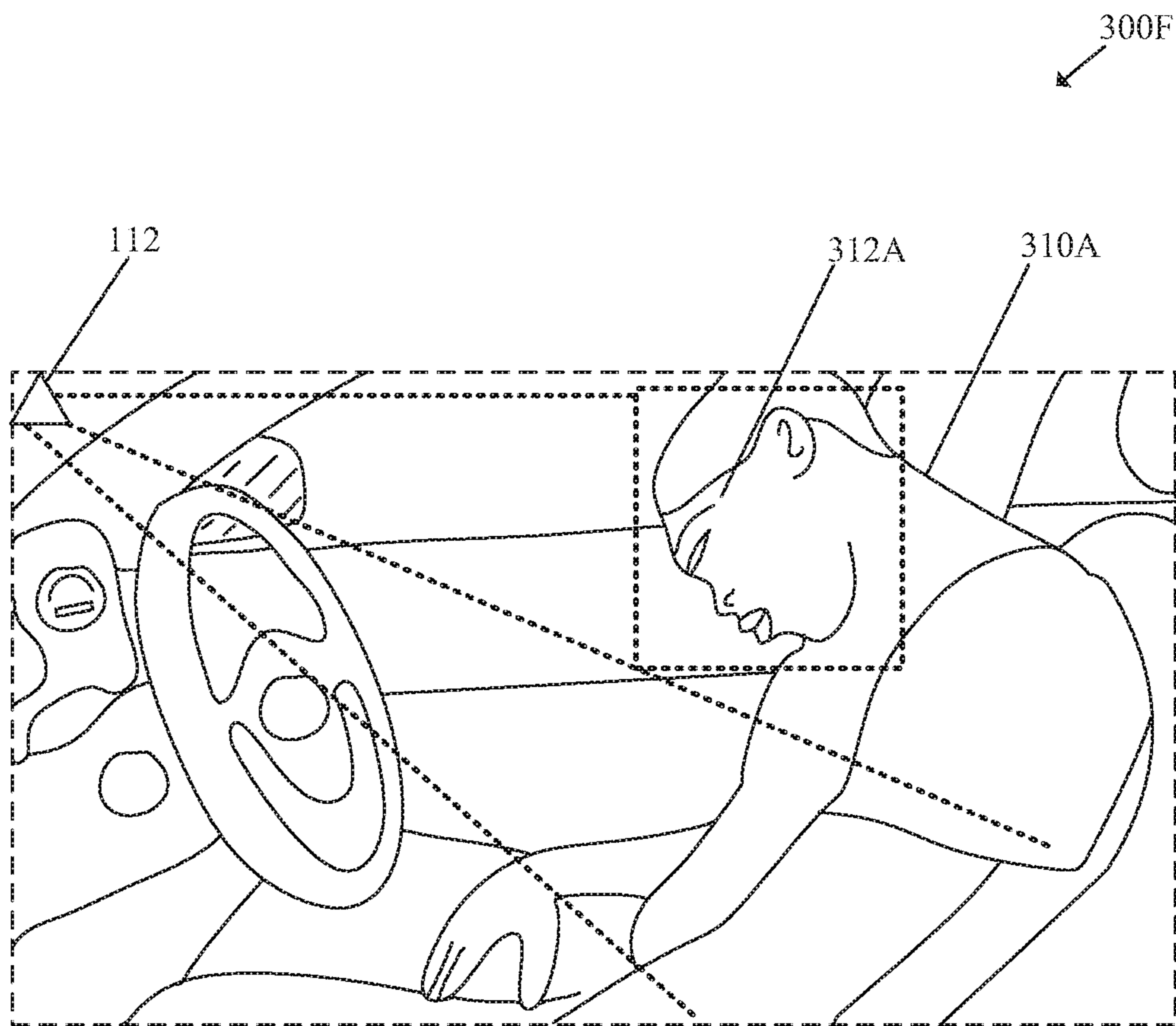


FIG. 3F

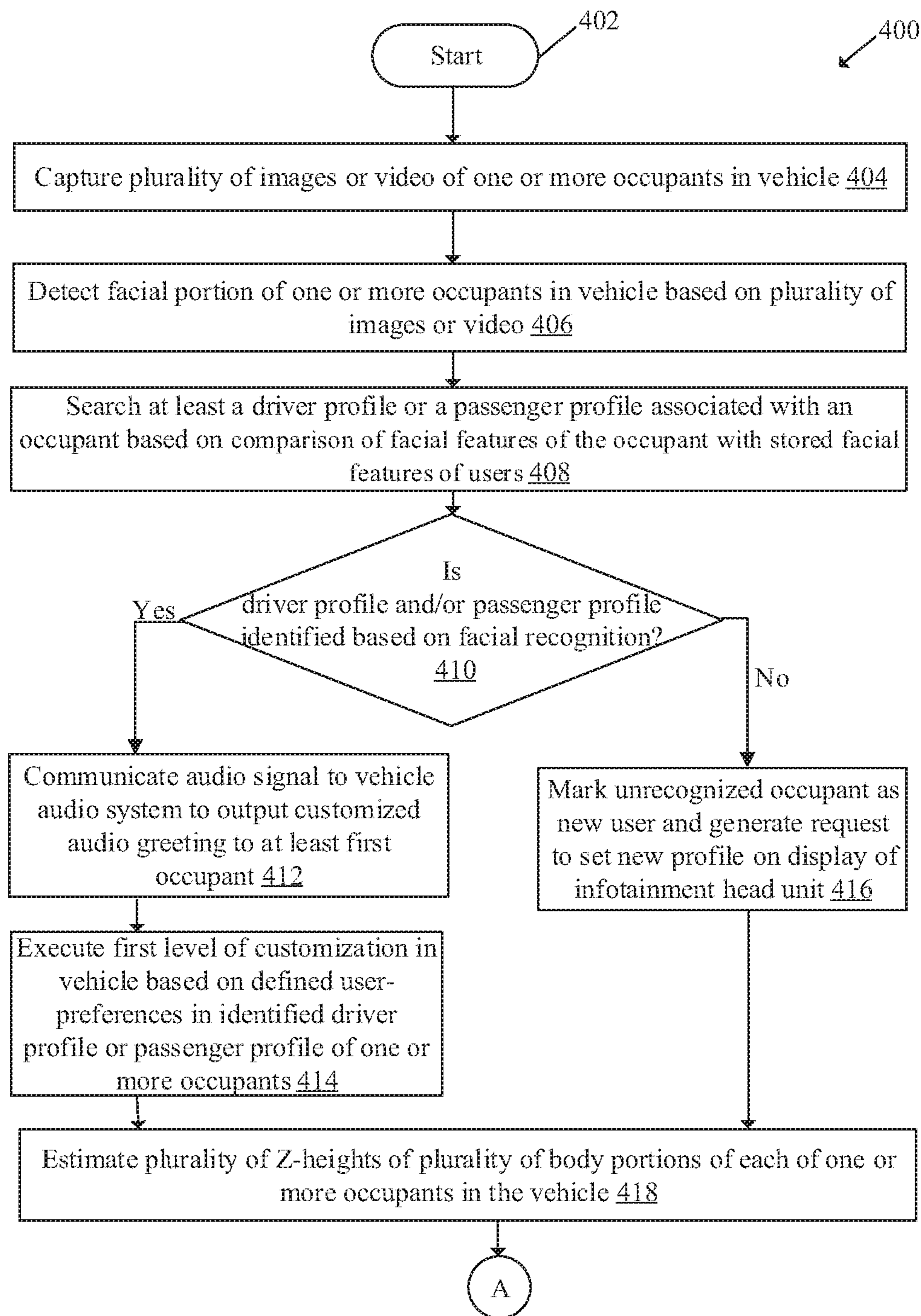


FIG. 4A

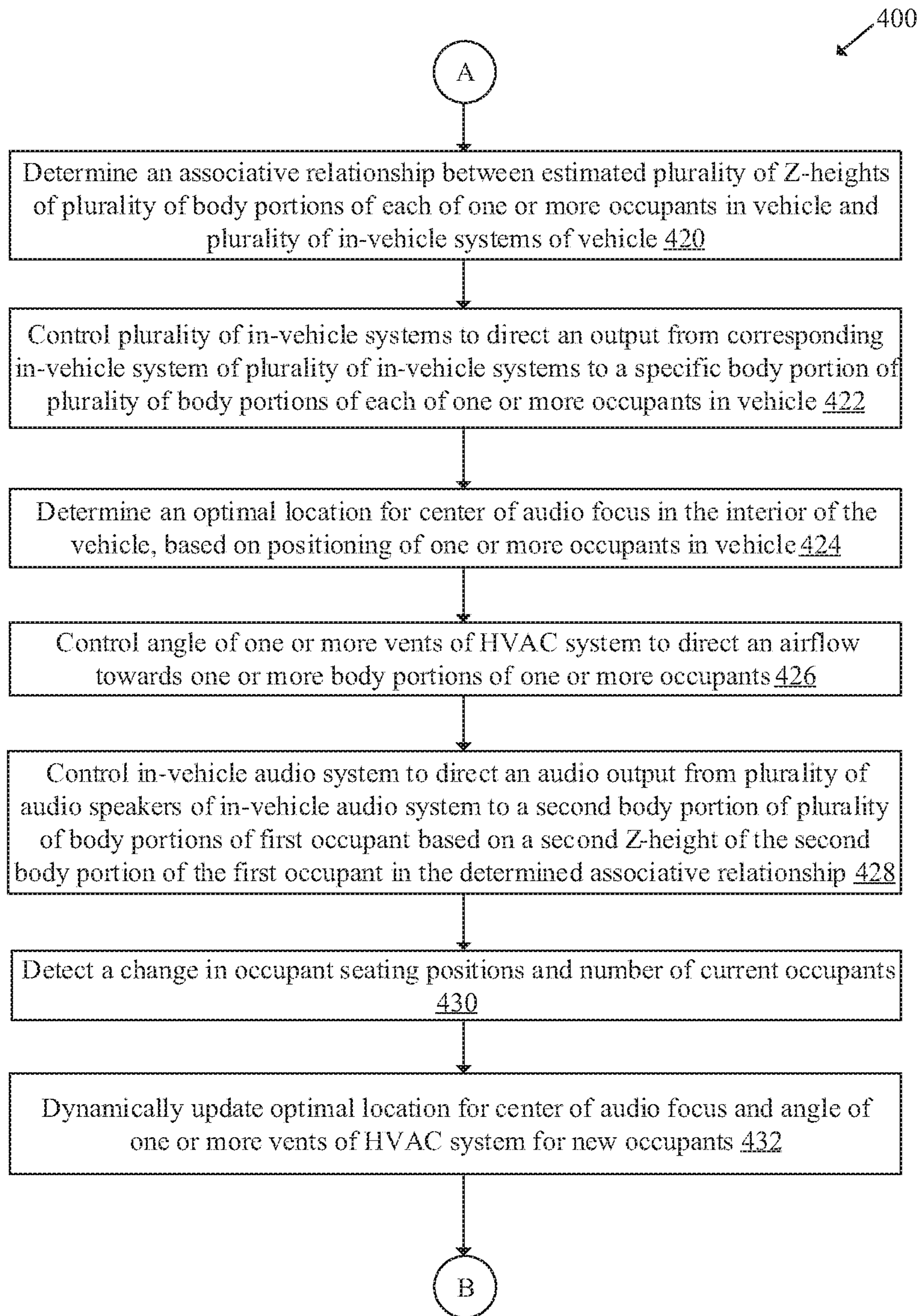


FIG. 4B

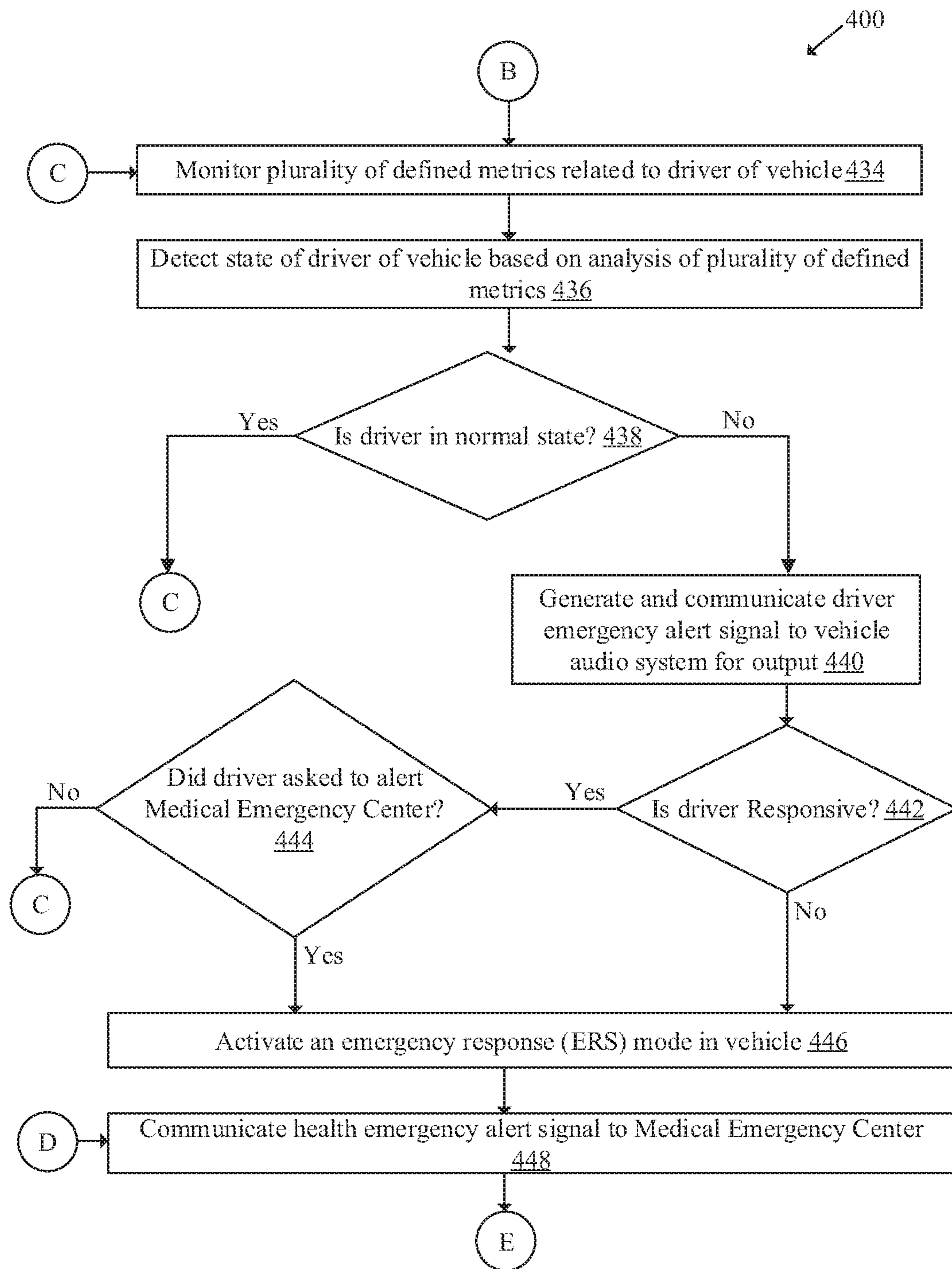


FIG. 4C

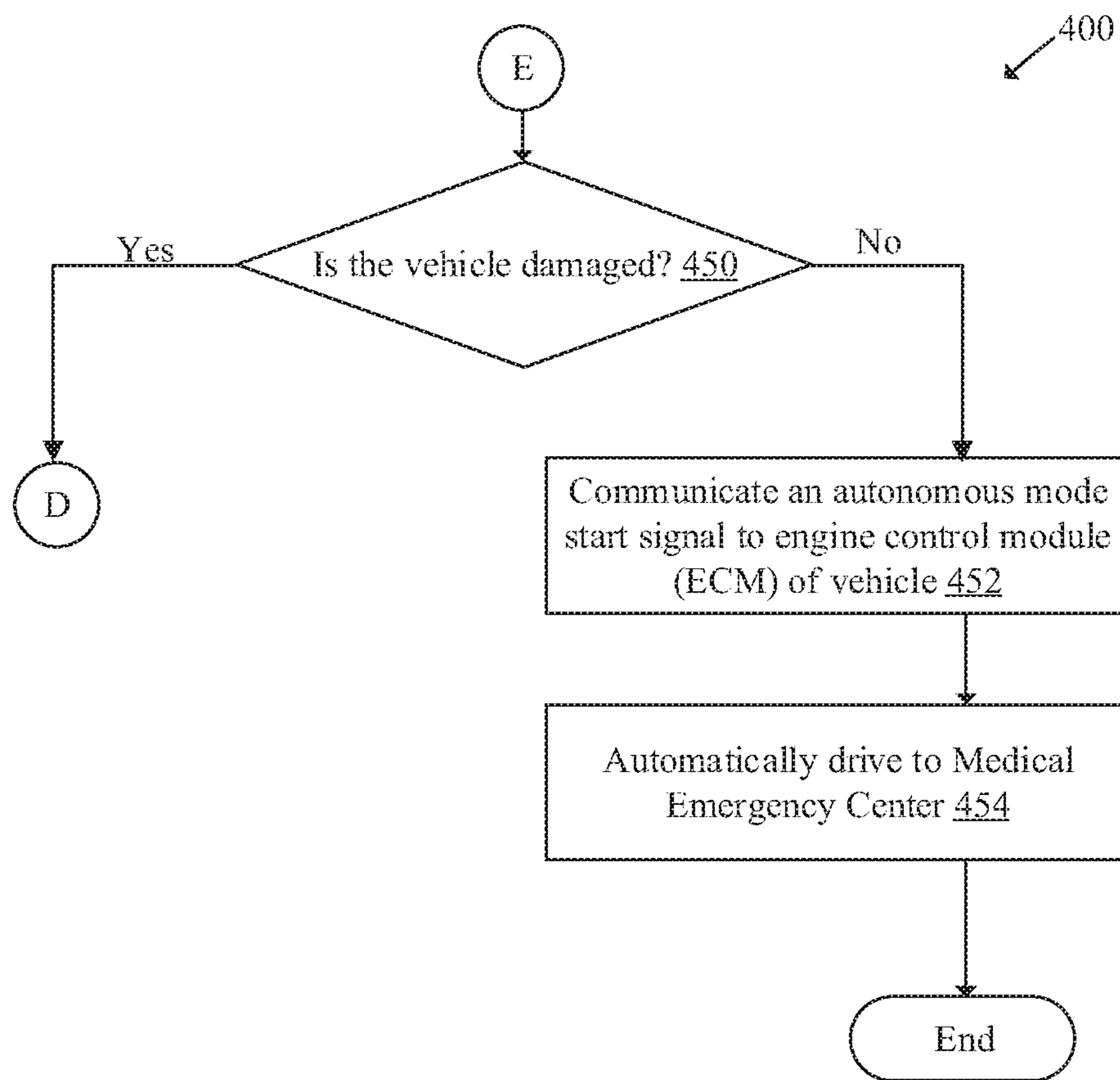


FIG. 4D

**PERSONALIZATION SYSTEM AND  
METHOD FOR A VEHICLE BASED ON  
SPATIAL LOCATIONS OF OCCUPANTS'  
BODY PORTIONS**

CROSS-REFERENCE TO RELATED  
APPLICATION

[0001] The present application claims priority benefit under 35 U.S.C. § 120 to, and is a continuation of U.S. patent application Ser. No. 17/938,799, entitled “Personalization System and Method for a Vehicle Based on Spatial Locations of Occupants’ Body Portions”, filed Oct. 7, 2022, which is a continuation of U.S. patent Ser. No. 16/211,901, entitled “Personalization System and Method for a Vehicle Based on Spatial Locations of Occupants’ Body Portions”, filed on Dec. 6, 2018, now U.S. Pat. No. 11,465,631, which claims priority pursuant to 35 U.S.C. § 119(e) to U.S. Provisional Application No. 62/596,413, entitled “Personalization System and Method for a Vehicle Based on Spatial Locations of Occupants’ Body Portions”, filed Dec. 8, 2017, which is hereby incorporated herein by reference in its entirety and made part of the present U.S. Utility patent application for all purposes.

TECHNICAL FIELD

[0002] Various embodiments of the disclosure relate to automotive technologies. More specifically, various embodiments of the disclosure relate to personalizing vehicle systems to maximize the user experience and also efficiently use vehicle resources, including stored energy, based on spatial locations of vehicle occupants or portions of their.

BACKGROUND

[0003] Vehicle occupant experience and personalization is an important aspect for creating a positive vehicle experience. Currently, vehicle personalization systems and technologies are limited to standard vehicle settings or predefined customizations, where variations in physical body dimensions of different occupants play a negligible role. For example, different occupants of a vehicle may have different physical body sizes or shapes. Therefore, when such different occupants are seated in the vehicle, standard settings or even preset user preferences for different vehicular systems, e.g., climate control systems and in-vehicle audio systems, may not be effectively tailored to each occupant or the current situation. Further, a change in one customized vehicle setting, for example, a seat position, for one occupant may interfere with other settings related to the different vehicular systems for the same occupant. This may hamper the overall in-vehicle comfort and entertainment experience for the occupant, for example, a driver. Further, even a customized setting for one occupant, for example, a driver, may not have no impact on other occupants or worse, may reduce the experience for other occupants in the vehicle. For example, if the driver typically desires all of the speakers to be directed towards the driver’s ears to maximize sound quality, the passenger have a reduced experience.

[0004] Besides impacting the user experience, resources may not be directed in an efficient manner. For example, in an electric vehicle, battery resources may be used to control air temperature. Maximizing the comfort felt by the vehicle occupants allows fewer resources to be used, thereby decreasing energy usage and increasing vehicle range. Thus,

an advanced, intelligent, and an automatic real-time or near-real-time personalization system may be desired for vehicles for enhanced in-vehicle comfort and entertainment experience for one or more vehicle occupants.

[0005] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of described systems with some aspects of the present disclosure, as set forth in the remainder of the present application and with reference to the drawings.

SUMMARY

[0006] A personalization system and method for a vehicle based on the spatial location of vehicle occupants or portions of their of body is substantially shown in, and/or described in connection with, at least one of the figures, as set forth more completely in the claims.

[0007] These and other features and advantages of the present disclosure may be appreciated from a review of the following detailed description of the present disclosure, along with the accompanying figures in which like reference numerals refer to like parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a block diagram that illustrates a network environment for personalization system for a vehicle, in accordance with an embodiment of the disclosure.

[0009] FIG. 2 is a block diagram that illustrates various exemplary components or systems of a vehicle, in accordance with an embodiment of the disclosure.

[0010] FIGS. 3A to 3F illustrate exemplary scenarios for implementation of the disclosed personalization system and method for a vehicle based on spatial locations of body portions of occupants in the vehicle, in accordance with an embodiment of the disclosure.

[0011] FIGS. 4A, 4B, 4C, and 4D collectively, depict a flow chart that illustrates exemplary operations for personalization of a vehicle based on spatial locations of body portions of occupants in the vehicle, in accordance with an embodiment of the disclosure.

DETAILED DESCRIPTION

[0012] The following described implementations may be found in the disclosed personalization system and method for a vehicle based on spatial locations of body portions of occupants in the vehicle. Exemplary aspects of the disclosure may include a personalization system that may include an image-capture device and circuitry in an in-vehicle electronic device. The disclosed personalization system, for example, the in-vehicle electronic device, increases improves an overall in-vehicle comfort and entertainment experience for the vehicle occupants. The personalization system provides an advanced, intelligent, and an automatic personalization of in-vehicle systems in real-time or near-real time for enhanced and consistent in-vehicle comfort and entertainment experience, both before and during a drive.

[0013] FIG. 1 is a block diagram that illustrates a network environment for personalization system for a vehicle, in accordance with an embodiment of the disclosure. With reference to FIG. 1, there is shown an exemplary network environment 100. The exemplary network environment 100

may include a vehicle **102**, a server **104**, a medical emergency center **106**, a road side unit (RSU) **108**, and a wireless communication network **110**.

[0014] The vehicle **102** may include an image-capture device **112** and an in-vehicle electronic device **114**. There is further shown a first user **116A** and a second user **116B** associated with the vehicle **102**. The image-capture device **112** may be installed in the interior of the vehicle **102** to capture a plurality of images or a video of one or more occupants, such as the first user **116A** and the second user **116B**, in the vehicle **102**. The in-vehicle electronic device **114** may refer to an in-vehicle infotainment (IVI) system or an electronic control unit (ECU) of the vehicle **102**.

[0015] The vehicle **102** may be an autonomous vehicle or a semi-autonomous vehicle, for example, as defined by National Highway Traffic Safety Administration (NHTSA). In some embodiments, the vehicle **102** may be a non-autonomous vehicle. Examples of the vehicle **102** include, but are not limited to, an electric vehicle, a hybrid vehicle, a gas-combustion vehicle, and/or a vehicle with autonomous drive capability that uses one or more distinct renewable or non-renewable power sources. A vehicle that uses renewable or non-renewable power sources may include a fossil fuel-based vehicle, an electric propulsion-based vehicle, a hydrogen fuel-based vehicle, a solar-powered vehicle, and/or a vehicle powered by other forms of alternative energy sources. There are a plurality of different categories or levels of vehicles of what is considered to be semi-autonomous and autonomous, for example the classification according to NHTSA. The personalization system and method of the present disclosure may be applied to the plurality of different categories or levels of vehicles that includes non-autonomous to fully-autonomous vehicles.

[0016] The server **104** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to establish a communication channel with one or more vehicles, such as the vehicle **102**. The server **104** may be configured to receive information, such as user profiles, from various vehicles, such as the vehicle **102**. The server **104** may be a cloud server, a web server, a database server, a file server, an application server, or a combination thereof. The server **104** may be implemented by use of several technologies that are well known to those skilled in the art.

[0017] The medical emergency center **106** may refer to a service provider of an ambulance or other specialized vehicles equipped to handle various medical emergencies. The medical emergency center **106** may have a facility, such as a server or a communication medium, to receive health alert notifications or emergency notifications from external devices or vehicles, such as the vehicle **102**. The medical emergency center **106** may also be associated with an emergency department of a hospital or medical clinic that may have a facility, such as a server or a communication medium, to receive health alert notifications or emergency notifications from registered external devices or vehicles, such as the vehicle **102**. When the health alert notifications are received, the medical emergency center **106** may route the health alert to suitable department, doctors, and/or other personnel to make arrangements or initiate preparation for the treatment of a patient, such as the first user **116A**.

[0018] The road side unit (RSU) **108** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to communicate with the vehicle **102**. The RSU **108** may communicate with the vehicle **102** via a dedicated

short-range communication (DSRC) channel or other short or medium range wireless communication channel. The RSU **108** may also communicate with the server **104** via the wireless communication network **110**. The RSU **108** may be configured to communicate (receive and/or transmit) various types of information from/to a wireless communication system of the vehicle **102**.

[0019] The wireless communication network **110** may include a long range communication medium through which one or more vehicles, such as the vehicle **102**, may communicate with the server **104** or external communication devices, such as the RSU **108**, or registered mobile devices. Examples of the wireless communication network **110** may include, but are not limited to, the Internet, Internet-based mobile ad hoc networks (IMANET), a cellular network, such as a 3G, 4G, or 5G network, a cloud network, and/or a Wide Area Network (WAN). Various devices in the network environment **100** may be configured to connect to the wireless communication network **110**, in accordance with various wireless communication protocols. Examples of such wireless communication protocols may include, but are not limited to, IEEE 802.11, 802.11x, 802.15, 802.16, 1609, Worldwide Interoperability for Microwave Access (WiMAX), Wireless Access in Vehicular Environments (WAVE), cellular communication protocols, Transmission Control Protocol and Internet Protocol (TCP/IP), User Datagram Protocol (UDP), Hypertext Transfer Protocol (HTTP), LTE, File Transfer Protocol (FTP), ZigBee, EDGE, Li-Fi, and/or other wireless communication protocols.

[0020] The image-capture device **112** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to capture a plurality of images or a video of the one or more occupants, such as the first user **116A** and/or the second user **116B**, in the vehicle **102**. The image-capture device **112** is positioned in the interior of the vehicle **102** such that a field-of-view of the image-capture device **112** is suitable to capture self-portrait images that include at least a face portion of all occupants (including driver and passengers) in the vehicle **102**. Thus, the image-capture device **112** may also be referred to as a selfie camera. In some embodiments, the image-capture device **112** may be installed in the vicinity of the front mirror of the vehicle **102**, as shown, for example, in FIG. 3A. Examples of the image-capture device **112** may include, but are not limited to, an image sensor, a wide-angle camera, an action camera, a closed-circuit television (CCTV) camera, a camcorder, a time-of-flight camera (ToF camera), a night-vision camera, and/or other such in-vehicle cameras or sensors.

[0021] The in-vehicle electronic device **114** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to estimate a plurality of Z-heights of a plurality of body portions of each of the one or more occupants from a reference position in the vehicle **102**. The plurality of Z-heights may be estimated based on the plurality of images captured from the image-capture device **112**. The in-vehicle electronic device **114** may be configured to access sensor data from the image-capture device **112**, one or more vehicle sensors, and/or other vehicle data associated with the vehicle **102**. The sensor data may be accessed by the in-vehicle electronic device **114**, via an in-vehicle network, such as a vehicle area network (VAN) and/or in-vehicle data bus, such as a controller area network (CAN) bus. In accordance with an embodiment, the in-vehicle electronic device **114** may be configured to communicate with various other vehicles in a

vehicle-to-vehicle (e.g., a V2V) communication, external communication devices (such as the RSU **108**) and/or a cloud server (such as the server **104**) via the wireless communication channel or via the wireless communication network **110**.

**[0022]** In operation, a driver, such as the first user **116A**, may open a vehicle door to enter into the vehicle **102**. The image-capture device **112** may be activated when the vehicle door is opened. The image-capture device **112** may be configured to capture at least one or more images or a video of the first user **116A**. In some embodiments, the image-capture device **112** may execute at least one or more face detection algorithms on the captured one or more images or the video to extract facial features for identification of a user, such as the first user **116A**. The image-capture device **112** may be configured to identify a driver profile associated with the first user **116A** based on facial recognition of the first user **116A**. In some embodiments, instead of facial recognition, other user identification methods, for example, human identification from a body shape based on human object boundary or silhouette matching, may be used. In some embodiments, the in-vehicle electronic device **114**, for example, an infotainment head unit or an ECU, may be configured to receive the captured one or more images or the video of the first user **116A** from the image-capture device **112**, via an in-vehicle network. In such a case, the in-vehicle electronic device **114** may be configured to process the captured one or more images or the video of the first user **116A** to identify the driver profile associated with the first user **116A** based on facial recognition of the first user **116A**.

**[0023]** In cases where the first user **116A** is identified based on facial recognition, a profile associated with the identified first user **116A** may be searched in a user profile database stored in a memory device of the in-vehicle electronic device **114**. In cases where the profile associated with the identified first user **116A** is found, the in-vehicle electronic device **114** may be configured to communicate an audio signal to a vehicle audio system to output a customized audio greeting to the first user **116A**. For example, the profile of first user **116A** may be the driver profile of “Fredrick”. The first user **116A** may be notified of recognition confirmation with custom audio greeting, “Hello Fredrick” via at least one of the audio speakers of the vehicle audio system.

**[0024]** In accordance with an embodiment, the in-vehicle electronic device **114** may be configured to execute a first level of customization in the vehicle **102** based on the defined user-preferences in the driver profile of the first user **116A**. For example, the driver seat, vehicle mirrors (e.g. outer rear view mirrors (ORVMs), front mirror, and the like), heating, cooling, and driving mode preferences, may be adjusted in accordance with the user preferences in the driver profile of the first user **116A**. The in-vehicle electronic device **114** may be configured to communicate a plurality of control signals to one or more other in-vehicle systems or ECUs to initiate the adjustments in accordance with the user preferences in the driver profile of the first user **116A**.

**[0025]** In cases where the first user **116A** is not identified based on facial recognition, the in-vehicle electronic device **114** may be configured to mark the first user **116A** as a new user, and a request to set a profile may be generated on a display of an infotainment head unit. In certain scenarios, a plurality of users, such as the first user **116A** and the second user **116B**, may board the vehicle **102** together for a ride. In

such scenarios, the in-vehicle electronic device **114** may be configured to communicate audio signals to the vehicle audio system to output customized audio greetings for the plurality of users based on a concurrent identification of the plurality of users. For example, in addition to custom audio greeting to the first user **116A**, the second user **116B** may also be greeted as, “Hello Nick, good to see you after a long time”, via an audio speaker that is in vicinity of the second user **116B**. The in-vehicle electronic device **114** may be configured to store a time or a day of boarding, a duration of a trip (or journey), a seating position for each identified user during each trip in the memory. The in-vehicle electronic device **114** may be further configured to track and store changes in seating position, user behavior, or body movement for each identified user during each trip for later analysis. Thus, when the second user **116B** is detected to board after a certain period of time, for example, 2-3 months based on the stored last day of boarding for the second user **116B**, the custom audio greeting “Hello Nick, good to see you after a long time” is generated accordingly for a humanized in-vehicle experience.

**[0026]** In accordance with an embodiment, the in-vehicle electronic device **114** may be configured to estimate a plurality of Z-heights of a plurality of body portions of each of the one or more occupants (e.g., the first user **116A** and the second user **116B**). The plurality of Z-heights may be estimated from a reference position in the vehicle **102**. Examples of the plurality of body portions for which the plurality of Z-heights are estimated, may include, but are not limited to a face portion, middle portion of a face from a left ear to a right ear, or other body portions. The plurality of Z-heights may be estimated based on the plurality of images captured by the image-capture device **112**. The estimation of the plurality of Z-heights from the reference position in the vehicle **102**, is described in detail, for example, in FIG. 3C. AZ-height of a body portion may correspond to a spatial location of the body portion, such as an occupant’s head or ears, of a vehicle occupant in the vehicle when the user is in a seated position.

**[0027]** In accordance with an embodiment, the in-vehicle electronic device **114** may be configured to determine an associative relationship between the estimated plurality of Z-heights of the plurality of the body portions of each occupants in the vehicle **102** and a plurality of in-vehicle systems. Examples of the plurality of in-vehicle systems may include, but are not limited to the vehicle audio system and a Heating, Ventilation, and Air Conditioning (HVAC) system. In one example, a first Z-height of “X” centimeter (cm), may be estimated from the reference position in the vehicle **102** to one side (e.g., the lower side) of a face rectangle of the detected facial portion of a first occupant (such as the first user **116A**). The first Z-height, for example, may be associated with the HVAC system of the vehicle **102**. In another example, a second Z-height of “Y” centimeter (cm) from the reference position to the middle portion of the face rectangle of the first occupant (such as the first user **116A**) may be estimated. The second Z-height, for example, may be associated with the vehicle audio system of the vehicle **102**.

**[0028]** The in-vehicle electronic device **114** may be configured to control the plurality of in-vehicle systems to direct an output from a corresponding in-vehicle system of the plurality of in-vehicle systems to a specific body portion of the plurality of body portions of each of the one or more



occupants in the vehicle **102**. The output from a corresponding in-vehicle system may be directed to the specific body portion based on the estimated plurality of Z-heights and the determined associative relationship. In some embodiments, the plurality of in-vehicle systems may be controlled concurrently to direct a plurality of output from the plurality of in-vehicle systems to corresponding body portions of each of the one or more occupants in the vehicle **102**.

**[0029]** For example, the in-vehicle electronic device **114** may be configured to control an angle of one or more vents of the HVAC system to direct an airflow toward a first body portion, such as the entire face portion, of the first occupant. The airflow may be directed toward the first body portion, such as the entire face portion, based on the estimated first Z-height (e.g., “X” cm) of the first body portion (i.e., the face portion) of the first occupant and the determined associative relationship that the first Z-height is associated with the HVAC system of the vehicle **102**. The one or more vents of the HVAC system may correspond to vents that are controlled by one or more servo motors. The one or more servo motors may be coupled to the one or more vents of the HVAC system. The in-vehicle electronic device **114** may be configured to communicate a position control signal to the one or more servo-controlled vents to automatically control positioning and/or angle of the one or more servo-controlled vents in real time or near-real time. Thus, the positioning and/or angle of the one or more servo-controlled vents may be controlled in real time or near-real time in accordance to the estimated Z-height of the first body portion (e.g., the face portion) of the first occupant (e.g., the first user **116A**).

**[0030]** In accordance with an embodiment, the image-capture device **112** may be configured to continuously or intermittently track a plurality of different spatial locations (in X, Y, and Z coordinates) of each face portion of the one or more occupants of the vehicle **102**. In cases where a change in a spatial location is detected for one face portion or a plurality of face portions, the positioning and/or angle of the one or more servo-controlled vents may be updated in real time or near-real time to target the airflow to the changed spatial location of each face portion.

**[0031]** In another embodiment, instead of an image-capture device, a thermal sensor or imager may be used to determine portions of an individual that are hot. In cases where localized hot spots are detected, the positioning and/or angle of the one or more servo-controlled vents may be updated in real time or near-real time to target the airflow to the changed spatial location of each localized hot spot. When multiple hot spots are detected, the positioning and/or angle of the one or more servo-controlled vents may focus on one hot spot until it falls below a threshold level. Alternately, the positioning and/or angle of the one or more servo-controlled vents may cycle through multiple of the hot spots, or the angle of the vents may be widened.

**[0032]** In another example, the in-vehicle electronic device **114** may be configured to control the vehicle audio system to direct an audio output from a plurality of audio speakers of the vehicle audio system to a second body portion of the first occupant. In this case, the second body portion may refer to the middle portion of the face rectangle of the detected facial portion of the first occupant (such as the first user **116A**). The audio output from the plurality of audio speakers may be directed toward the second body portion based on the estimated second Z-height (e.g., “Y” cm) of the second body portion (e.g., the middle portion of

the face rectangle) of the first occupant and the determined associative relationship that the second Z-height is associated with the vehicle audio system. Thus, similar to the first occupant, different Z-heights are estimated for each occupant from the middle portion of the face rectangle to the reference position, and the vehicle audio system may be tuned in real time or near-real time for optimum audio performance and enhanced listening experience for the one or more occupants in the vehicle **102**.

**[0033]** In accordance with an embodiment, the in-vehicle electronic device **114** may be configured to monitor, by use of the image-capture device **112**, a plurality of defined metrics related to the driver, such as the first user **116A**, of the vehicle **102**. The plurality of defined metrics related to the driver of the vehicle **102** may include, but are not limited to a facial position, body language, a seating position, eye movement, body movement, health parameters, and a tone, or pitch of driver’s voice. The in-vehicle electronic device **114** may detect a state of the driver of the vehicle **102** based on the analysis of the plurality of defined metrics. The in-vehicle electronic device **114** may be configured to utilize a machine learning system to detect if the driver is in normal state or in a distressed state when a sudden deviation in the plurality of defined metrics is detected. For example, based on historical data related to driver (such as the identified first user **116A**), a baseline behavior, body language, seating position, eye movement, body movement, health parameters, and the tone, or pitch of driver’s voice may be established as regular and tagged as normal. Thus, when a sudden deviation or anomaly in the plurality of defined metrics is detected, the in-vehicle electronic device **114** may generate and communicate a driver emergency alert signal to the vehicle audio system for output. The vehicle audio system may be activated and an audio alert, (e.g., “Are you OK, or shall I alert emergency services?”) may be outputted via one of the plurality of speakers of the vehicle audio system. This may occur when the driver is suspected to be in distressed state. Thereafter, the in-vehicle electronic device **114** may be configured to activate an emergency response (ERS) mode in the vehicle **102**. The in-vehicle electronic device **114** may be configured to communicate a health emergency alert signal to the medical emergency center **106** if no response is received from the driver within a user specified or pre-defined time period. The health emergency alert signal may be referred to as emergency call systems, or simply eCall. eCall is an emergency response system known in the art. Typically, when vehicle crash sensors are triggered, the eCall system detects that the occupants are in distress and automatically calls emergency services to alert of possible injuries. The eCall system also transmits vehicle location (e.g., GPS coordinates) to the medical emergency center **106** (e.g., an emergency response team).

**[0034]** In accordance with an embodiment, when the ERS mode is activated and no response is received from the driver (e.g., the first user **116A**) within the user specified or pre-defined time period, the in-vehicle electronic device **114** may be configured to communicate a self-diagnostic test start signal to an on-board diagnostics (OBD) system of the vehicle **102**. The self-diagnostic test is done to determine whether the vehicle **102** is damaged or okay-to-drive in an autonomous mode or auto pilot (AP) mode. In cases where the vehicle **102** is damaged, the vehicle **102** remains parked, a health emergency alert signal is communicated to the

medical emergency center 106. In cases where the vehicle 102 is diagnosed as okay-to-drive but the driver is unresponsive to the audio alert, the in-vehicle electronic device 114 may communicate an autonomous mode start signal to an engine control module (ECM) of the vehicle 102. This may cause the vehicle 102 to automatically drive itself to a nearest hospital or an emergency service provider, such as the medical emergency center 106. In certain scenarios, the driver profile may include user preferences related to handling of emergency response. For example, the driver, such as the first user 116A may feed information related to one or more hospitals of choice in an order of preference, a preferred health insurance network, contact numbers of friends and family, and the like, via a user interface rendered on the display (such as the display 210 of FIG. 2). In cases where such user preferences related to handling of emergency response is present, and the emergency response AP-mode is activated, the in-vehicle electronic device 114 may dynamically set a destination location in a navigation unit of the vehicle 102 to one of the preferred hospitals. The selection of the preferred hospital from the listed hospitals may be done based on a shortest distance between each location of the listed hospitals from a current location of the vehicle 102 and the order of preference. Thereafter, the in-vehicle electronic device 114 may communicate the autonomous mode start signal to the ECM of the vehicle 102 to cause the vehicle 102 to automatically drive itself to the set destination location of the selected hospital. The in-vehicle electronic device 114 may also communicate a route information from the current location of the vehicle 102 to the set destination location of the selected hospital, to the contact numbers of friends and family, as provided in the driver profile. The route information may be communicated via the wireless communication network 110, by use of a wireless communication system of the vehicle 102.

[0035] FIG. 2 is a block diagram that illustrates various exemplary components or systems of a vehicle, in accordance with an embodiment of the disclosure. FIG. 2 is explained in conjunction with elements from FIG. 1. With reference to FIG. 2, there is shown the vehicle 102. The vehicle 102 may comprise the in-vehicle electronic device 114. The in-vehicle electronic device 114 may be implemented as a part of the IVI system or as an ECU. The in-vehicle electronic device 114 may include circuitry 202, which may comprise at least a microprocessor. The in-vehicle electronic device 114 may also include a memory 204. The vehicle 102 may comprise an audio interface 206, an outside rear view mirror (ORVM) 208, and a display 210 communicatively coupled to the in-vehicle electronic device 114. In some embodiments, the display 210 may be part of the in-vehicle electronic device 114 (e.g., display of an infotainment head unit, where the in-vehicle electronic device 114 is implemented as a part of the IVI system). One or more user interfaces (UIs), such as the UI 210a, may be rendered on the display 210.

[0036] The vehicle 102 may further comprise a powertrain control system 212, a sensing system 214, and other systems, such as a plurality of in-vehicle systems 216. The powertrain control system 212 may include a steering system 218 and a braking system 220. The sensing system 214 may include a plurality of vehicle sensors 222, a plurality of external cameras, such as a plurality of external image-capture devices 224C, and an inner camera, such as the image-capture device 112 of FIG. 1. The plurality of in-

vehicle systems 216 may include an HVAC system 226 and a vehicle audio system 228. The HVAC system 226 may include one or more servo motors, such as the servo-motor 230. The vehicle audio system 228 may include a plurality of speakers 232. The vehicle 102 may further comprise a vehicle power system 234, a battery 236, a wireless communication system 238, and an in-vehicle network 240.

[0037] The various components or systems may be communicatively coupled via the in-vehicle network 240, such as a vehicle area network (VAN), and/or an in-vehicle data bus. The circuitry 202, such as a microprocessor, may be communicatively coupled to the audio interface 206, the ORVM 208, the display 210, the sensing system 214, the plurality of in-vehicle systems 216, and the wireless communication system 238. The circuitry 202 may also be operatively connected with the powertrain control system 212, the steering system 218, and the braking system 220. The wireless communication system 238 may be configured to communicate with one or more external devices, such as the RSU 108 and the server 104 under the control of the circuitry 202. A person of ordinary skill in the art will understand that the vehicle 102 may also include other suitable components or systems, in addition to the components or systems which are illustrated herein to describe and explain the function and operation of the present disclosure.

[0038] The circuitry 202 may comprise suitable logic, circuits, interfaces, and/or code that may be configured to execute a set of instructions stored in the memory 204. The circuitry 202 may refer to a microprocessor. In accordance with an embodiment, the circuitry 202 may be configured to automatically control one or more components or systems, such as the powertrain control system 212, the steering system 218, the braking system 220, the sensing system 214, and/or the plurality of in-vehicle systems 216 of the vehicle 102, when the vehicle 102 is in an autonomous mode. Examples of the circuitry 202 may include, but are not limited to a microcontroller, a Reduced Instruction Set Computing (RISC) processor, an Application-Specific Integrated Circuit (ASIC) processor, a Complex Instruction Set Computing (CISC) processor, a microcontroller, a central processing unit (CPU), a graphics processing unit (GPU), a state machine, and/or other processors or circuits.

[0039] The memory 204 may comprise suitable logic, circuitry, and/or interfaces that may be configured to store a set of instructions executable by the circuitry 202. The memory 204 may store various types of information related to the vehicle 102. Various types of information may include Z-height information of a plurality of body portions of each occupant of the vehicle 102, and associative relationship between the Z-height information and corresponding in-vehicle system of the plurality of in-vehicle systems 216. Examples of implementation of the memory 204 may include, but are not limited to, Electrically Erasable Programmable Read-Only Memory (EEPROM), Random Access Memory (RAM), Read Only Memory (ROM), Hard Disk Drive (HDD), Flash memory, Solid-State Drive (SSD), and/or CPU cache memory.

[0040] The audio interface 206 may be connected to the vehicle audio system 228 or other device that may be configured to generate a sound. The audio interface 206 may also be connected to the microphone 224B or other device to receive a voice input from an occupant, such as the first user 116A and the second user 116B, of the vehicle 102. The audio interface 206 may also be communicatively coupled to

the circuitry **202**. The audio interface **206** may be a part of the IVI system or the infotainment head unit of the vehicle **102**. The IVI system, for example, may include a combination of hardware devices and software that provides audio or video entertainment to occupants of a vehicle, such as the vehicle **102**. In accordance with an embodiment, display **210** may also be communicatively coupled to the IVI system.

[0041] The display **210** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to render various types of information and/or entertainment content via the UI **210a**. The UI **210a** may be a customized graphical user interface (GUI) configured to display the various types of information, driver profiles, and/or the entertainment content to occupants of the vehicle **102**. The display **210** may be a touch screen configured to receive an input from the one or more occupants of the vehicle **102**. Examples of the display **210** may include, but are not limited to a display of the infotainment head unit, a projection-based display, a see-through display, and/or an electro-chromic display.

[0042] The powertrain control system **212** may refer to an onboard computer of the vehicle **102** that controls operations of an engine and a transmission system of the vehicle **102**. In some embodiments, the powertrain control system **212** may control ignition, fuel injection (in case of hybrid or non-electric vehicle), emission systems, and/or operations of a transmission system (when provided) and the braking system **220**.

[0043] The sensing system **214** may comprise the image-capture device **112** and the plurality of vehicle sensors **222**. The plurality of vehicle sensors **222** may include a seat occupancy sensor **224A**, a microphone **224B**, and a plurality of external image-capture devices **224C**. The sensing system **214** may be communicatively coupled to the circuitry **202** to provide input signals to the circuitry **202**. For example, the sensing system **214** may be used to sense or detect the sensor data by use of the plurality of vehicle sensors **222** and the selfie camera, such as the image-capture device **112**. Other examples of the plurality of vehicle sensors **222**, may include, but are not limited to a yaw rate sensor, a vehicle speed sensor, odometric sensors, a steering angle sensor, a vehicle travel direction detection sensor, a magnetometer, an image sensor, a touch sensor, an infrared (IR) sensor, Lidar, and a depth sensor.

[0044] The plurality of in-vehicle systems **216** may include at least the HVAC system **226** and the vehicle audio system **228**. One or more vents may be connected to the HVAC system **226** so that hot, cold, and/or dehumidified air may be introduced in the interior of the vehicle **102** as per needs or as desired. The one or more vents may be servo-controlled vents that are controlled by one or more servo motors, such as the servo-motor **230**. In some embodiments, a first vent may be coupled to the HVAC system **226** to generate a first plane of air (e.g., a horizontal plane) in the interior of the vehicle **102**. A second vent may be coupled to the HVAC system **226** to generate a second plane of air (e.g., a vertical plane). The vehicle audio system **228** may include the plurality of speakers **232**.

[0045] The steering system **218** may be configured to receive one or more control command from the circuitry **202**. The steering system **218** may include a steering wheel and/or an electric motor (provided for a power-assisted steering) that may be used by the first user **116A** to control movement of the vehicle **102** in manual mode or a semi-

autonomous mode. In accordance with an embodiment, the movement or steering of the vehicle **102** may be automatically controlled when the vehicle **102** is in autonomous mode. Examples of the steering system **218** may include, but are not limited to, an autonomous steering control, a power-assisted steering system, a vacuum/hydraulic-based steering system, an electro-hydraulic power-assisted system (EH-PAS), or a “steer-by-wire” system, or an autonomous steering system, known in the art.

[0046] The braking system **220** may be used to stop or slow down the vehicle **102** by application of resistive forces such as electromagnetic and/or frictional forces. The braking system **220** may be configured to receive a command from the powertrain control system **212** under the control of the circuitry **202**, when the vehicle **102** is in an autonomous mode or a semi-autonomous mode. In accordance with an embodiment, the braking system **220** may be configured to receive a command from the circuitry **202** when the circuitry **202** preemptively detects a steep curvature based on the set current travel route of the vehicle **102**, an obstacle, or other road hazards.

[0047] The vehicle power system **234** may regulate the charging and the power output of the battery **236** to various electric circuits and the loads of the vehicle **102**. When the vehicle **102** is a hybrid vehicle or an autonomous vehicle, the vehicle power system **234** may provide the required voltage for certain components and enable the vehicle **102** to utilize the battery **236** power for a sufficient amount of time. In accordance with an embodiment, the vehicle power system **234** may correspond to power electronics, and may include a microcontroller that may be communicatively coupled (shown by dotted lines) to the in-vehicle network **240**. In such an embodiment, the microcontroller may receive one or more commands from the powertrain control system **212** under the control of the circuitry **202**.

[0048] The battery **236** may be a source of electric power for one or more electric circuits or loads (not shown). For example, the loads may include, but are not limited to various lights or lighting systems, such as headlights and interior cabin lights, electrically powered adjustable components, such as vehicle seats, mirrors, windows or the like, and/or other in-vehicle infotainment system, such as radio, speakers, electronic navigation system, electrically controlled, powered and/or assisted steering, such as the steering system **218**. The battery **236** may be a rechargeable battery. The battery **236** may be a source of electrical power to the in-vehicle electronic device **114** (shown by dashed lines), the plurality of vehicle sensors **222**, the image-capture device **112**, and other hardware units, such as display **210**. The battery **236** may be a source of electrical power to start an engine of the vehicle **102**.

[0049] The wireless communication system **238** may comprise suitable logic, circuitry, interfaces, and/or code that may be configured to communicate with other vehicles (a V2V communication) and one or more external devices (such as the RSU **108**), and one or more cloud servers, such as the server **104**, via the wireless communication network **110**. The wireless communication system **238** may include, but is not limited to, an antenna, a telematics unit, a radio frequency (RF) transceiver, one or more amplifiers, one or more oscillators, a digital signal processor, a coder-decoder (CODEC) chipset, and/or a subscriber identity module (SIM) card. The wireless communication system **238** may wirelessly communicate by use of various communication

protocols of the short or medium range communication channel and wireless communication network **110** (as described in FIG. 1).

[0050] The in-vehicle network **240** may include a medium through which the various control units, components, and/or systems of the vehicle **102** (such as the in-vehicle electronic device **114**, the audio interface **206**, display **210**, the powertrain control system **212**, the sensing system **214**, the plurality of in-vehicle systems **216**, and the wireless communication system **238**) may communicate with each other. In accordance with an embodiment, in-vehicle communication of audio/video data for multimedia components may occur by use of Media Oriented Systems Transport (MOST) multimedia network protocol of the in-vehicle network **240** or other suitable networks for audio/video data communication. The MOST-based network may be a separate network from the controller area network (CAN). The MOST-based network may use a plastic optical fiber (POF) medium. In accordance with an embodiment, the MOST-based network, the CAN, and other in-vehicle networks may co-exist in a vehicle, such as the vehicle **102**. The in-vehicle network **240** may facilitate access control and/or communication between the circuitry **202** and other ECUs, such as ECM or a telematics control unit (TCU) of the vehicle **102**. Various devices or components in the vehicle **102** may be configured to connect to the in-vehicle network **240**, in accordance with various wired and wireless communication protocols. Examples of the wired and wireless communication protocols for the in-vehicle network **240** may include, but are not limited to, a vehicle area network (VAN), a CAN bus, Domestic Digital Bus (D2B), Time-Triggered Protocol (TTP), FlexRay, IEEE 1394, Carrier Sense Multiple Access With Collision Detection (CSMA/CD) based data communication protocol, Inter-Integrated Circuit (FC), Inter Equipment Bus (IEBus), Society of Automotive Engineers (SAE) J1708, SAE J1939, International Organization for Standardization (ISO) 11992, ISO 11783, Media Oriented Systems Transport (MOST), MOST25, MOST50, MOST150, Plastic optical fiber (POF), Power-line communication (PLC), Serial Peripheral Interface (SPI) bus, and/or Local Interconnect Network (LIN).

[0051] The functions and/or operations performed by the in-vehicle electronic device **114**, as described in FIG. 1A, may be performed by the circuitry **202**, such as a microprocessor. Other operations performed by the circuitry **202**, are further described, for example, in FIGS. 3A to 3F.

[0052] FIGS. 3A to 3F illustrate exemplary scenarios for implementation of the disclosed personalization system and method for a vehicle based on spatial locations of body portions of occupants in the vehicle, in accordance with an embodiment of the disclosure. FIGS. 3A to 3F are explained in conjunction with elements from FIGS. 1 and 2.

[0053] With reference to FIG. 3A, there is shown an exemplary scenario **300A**. The exemplary scenario **300A** illustrates a portion **302** of the interior of the vehicle **102** to depict the location of mounting of the image-capture device **112** in the vicinity of a front mirror **304**. There is also shown the display **210** of an infotainment head unit **306**. The image-capture device **112** may be a wide-angle camera having a field-of-view **308** that is suited to capture a plurality of images of all the occupants of the vehicle **102** when the occupants are in a seated position.

[0054] With reference to FIG. 3B, there is shown an exemplary scenario **300B**. FIG. 3B is explained in conjunc-

tion with elements from FIGS. 1, 2, and 3A. The exemplary scenario **300B** includes a portion of the interior of the vehicle **102** to depict identification of a first occupant **310A** in the vehicle **102** and tracking of a first facial portion **312A** by the image-capture device **112**. The first occupant **310A** may correspond to the first user **116A** (FIG. 1).

[0055] The image-capture device **112** may be configured to capture one or more images or a video of the first occupant **310A**. The circuitry **202** may be communicatively coupled to the image-capture device **112**. The circuitry **202** may be configured to identify a driver profile associated with the first occupant **310A** based on facial recognition of the first occupant **310A**. The circuitry **202** may be configured to match facial features of the first occupant **310A** with stored images or facial features of different users for the identification of the first occupant **310A**. In certain scenarios, for example, in low lighting conditions or at night, one or more other sensors, such as IR sensor, may be employed to aid in identification based on a comparison of an object boundary of the first occupant **310A** and pre-stored boundary data of different users. In some embodiments, the image-capture device **112** may include night-vision functionalities to execute facial recognition at night or in low lighting conditions.

[0056] In cases where the driver profile of the first occupant **310A** is identified based on facial recognition, the circuitry **202** may be configured to communicate an audio signal to the vehicle audio system **228** to output a customized audio greeting specific to the first occupant **310A**. For example, the first occupant **310A** may be notified of recognition confirmation with custom audio greeting, "Good morning, Fredrick; How are you doing today?" via at least one of the audio speakers of the plurality of speakers **232**. Based on learned information received from the machine learning system in the memory **204**, the circuitry **202** may be configured to predict that first occupant **310A** intends to drive to the office address of the first occupant **310A**. The learned information is generated by the machine learning system based on analysis of historical data related to a schedule of daily activities, user behavior, and a current time of day. In some embodiments, the circuitry **202** may be configured to automatically set the destination location in the navigation unit of the vehicle **102** and seek confirmation from the first occupant **310A** for an autonomous ride. For example, the destination location automatically set to the office address when it is detected that the first occupant **310A** usually takes an autonomous ride to office in the morning time between 8 AM and 9 AM, based on the analysis of the historical data.

[0057] In some embodiments, the circuitry **202** may be configured to execute a first level of customization in the vehicle **102** based on the defined user preferences in the identified driver profile of the first occupant **310A**. For example, the electrically powered adjustable components, such as the driver seat, vehicle mirrors (e.g., the ORVM **208**), front mirror, radio, music preferences, and driving mode preferences, may be adjusted in accordance with the user preferences in the driver profile of the first occupant **310A**. The circuitry **202** may be configured to communicate a plurality of control signals to one or more other ECUs to initiate the adjustments in accordance with the user preferences in the driver profile of the first occupant **310A**.

[0058] With reference to FIG. 3C, there is shown an exemplary scenario **300C**. FIG. 3C is explained in conjunc-

tion with elements from FIGS. 1, 2, 3A, and 3B. The exemplary scenario 300B illustrates a portion of the interior of the vehicle 102 to depict determination of a plurality of Z-heights of a plurality of body portions of the first occupant 310A and a second occupant 310B in the vehicle 102.

[0059] In FIG. 3C, there is shown a first body portion, such as the first facial portion 312A of the first occupant 310A and a second facial portion 312B of the second occupant 310B. There is further shown a reference position 314, a second body portion, such as a first facial middle portion 318A and a second facial middle portion 318B, and face rectangles 316A and 316B.

[0060] In accordance with an embodiment, the circuitry 202 may be configured to estimate a first Z-height 320A (also represented by “X1” cm”) of the first facial portion 312A of the first occupant 310A from the reference position 314 in the vehicle, as shown. The circuitry 202 may be configured to continuously track the first facial portion 312A as represented by the face rectangle 316A. The first Z-height 320A of “X1” cm, may refer to a vertical height from the reference position 314 in the vehicle 102 to one side (e.g., the lower side) of the face rectangle 316A of the detected first facial portion 312A of the first occupant 310A. The reference position 314 corresponds a horizontal plane in the vehicle 102 from a seated position of the first occupant 310A, as shown, for example. A second Z-height 322A (also represented by “Y1” cm”) of a second body portion, such as the first facial middle portion 318A, from the reference position 314 may also be estimated, as shown. Similar to the first Z-height 320A and the second Z-height 322A for different body portions of the first occupant 310A, the circuitry 202 may be further configured to estimate a third Z-height 320B of the second facial portion 312B of the second occupant 310B from the reference position 314. Accordingly, a fourth Z-height 322B of the second facial middle portion 318B from the reference position 314 may also be estimated.

[0061] In accordance with an embodiment, the plurality of Z-heights of the plurality of body portions may be estimated concurrently by face tracking based on the plurality of images captured by the image-capture device 112. It is to be understood by a person of ordinary skill in the art that only two body portions and two occupants are described above for exemplary and illustrative purposes only, and therefore, shall not be construed to limit the scope of the disclosure.

[0062] The circuitry 202 may be further configured to determine an associative relationship between the estimated plurality of Z-heights and the plurality of in-vehicle systems 216 of the vehicle 102. An example of the associative relationship between the estimated plurality of Z-heights and the plurality of in-vehicle systems 216 of the vehicle 102, is given in TABLE 1.

identification number of driver profile “DOI”. The column “Occupant\_name” denotes name of the occupant as identified based on face recognition. In case an occupant is unidentified, the cell may be left blank or “0”. The column “First\_Z-height\_B1” includes the first Z-height 320A (also represented by “X1” cm”) of the first facial portion 312A of the first occupant 310A (e.g., having driver profile “DO I”). The column “First\_Z-height\_B1” also includes the third Z-height 320B (also represented by “X2” cm”) of the second facial portion 312B of the second occupant 310B (e.g., having a new passenger profile “POI”). The first body portion, such as both the facial portions 312A and 312B, are associated with the HVAC system 226 (an in-vehicle system of the plurality of in-vehicle systems 216 represented under column “Vehicle\_system\_1”) in the TABLE 1, as shown. Similarly, the second Z-height 322A (also represented by “Y1” cm”) of a second body portion, such as the first facial middle portion 318A and the fourth Z-height 322B (also represented by “Y2” cm”) of the second facial middle portion 318B are associated with the vehicle audio system 228.

[0064] With reference to FIG. 3D, there is shown an exemplary scenario 300D. FIG. 3D is explained in conjunction with elements from FIGS. 1, 2, 3A, 3B, and 3C. The exemplary scenario 300D illustrates a portion of the interior of the vehicle 102 to depict a precise personalization of in-vehicle systems based on Z-heights of body portions of vehicle occupants. There is further shown a HVAC unit 324 with a first set of vents 324A and a second set of vents 324B. There is also shown a custom output from the HVAC unit 324, such as a direction of a first airflow 326A to the first facial portion 312A of the first occupant 310A and a direction of a second airflow 326B to the second facial portion 312B of the second occupant 310B. A custom output from the vehicle audio system 228 to the first facial middle portion 318A and the second facial middle portion 318B, is also shown.

[0065] In accordance with an embodiment, the circuitry 202 may be configured to control the plurality of in-vehicle systems 216 to direct an output from a corresponding in-vehicle system of the plurality of in-vehicle systems 216 to a specific body portion of the plurality of body portions of each of the one or more occupants in the vehicle 102. The output from a corresponding in-vehicle system, such as the HVAC system 226, may be directed to the specific body portion, such as the face portions, based on the estimated plurality of Z-heights and the determined associative relationship, as shown in TABLE 1, for example. In some embodiments, the plurality of in-vehicle systems 216 may be controlled concurrently to direct a plurality of output from the plurality of in-vehicle systems 216 such that output

TABLE 1

Associative relationship between a Z-height of a body portion and corresponding mapped in-vehicle system						
Occupants	Occupant_name	First_Z-height_B1	Vehicle_system_1	Second_Z-height_B2	Vehicle_system_2	...
D01	Fredrick	X1	HVAC	Y1	Audio	...
P01	Samantha	X2	HVAC	Y2	Audio	...
...	...	...	...	...	...	...

[0063] With reference to TABLE 1, the column “Occupants” denotes type of occupants (such as a driver) and an

from one in-vehicle system, such as the HVAC system 226, do not interfere (and instead complement) with output of

another in-vehicle system, such as the vehicle audio system **228**, of the plurality of in-vehicle systems **216**.

[0066] The circuitry **202**, such as the microprocessor, may be configured to control an angle of the first set of vents **324A** of the HVAC unit **324** to direct an airflow (such as the first airflow **326A**) toward the first facial portion **312A** of the first occupant **310A**. The airflow (such as the first airflow **326A**) may be directed toward the first facial portion **312A** based on the estimated first Z-height **320A** (e.g., “X1” cm) and the determined associative relationship that the first Z-height **320A** (e.g., “X1” cm) is meant for the HVAC system **226** of the vehicle **102**. The circuitry **202** may be configured to communicate a position control signal to the first set of vents **324A** to automatically control positioning and/or angle of first set of vents **324A** such that an airflow output from the first set of vents **324A** is directed toward the first facial portion **312A**. Similarly, the circuitry **202** may be configured to control an angle of the second set of vents **324B** of the HVAC unit **324** to direct an airflow (such as the second airflow **326B**) toward the second facial portion **312B** of the second occupant **310B** in accordance with the estimated third Z-height **320B** (also represented by “X2” cm”). The positioning and/or angle of the servo-motor **230** controlled first set of vents **324A** and the second set of vents **324B** are vertically adjusted and updated continuously to control airflow in real time or near-real time based on face tracking and change in estimation of corresponding Z-heights of the facial portions **312A** and **312B**.

[0067] The control the plurality of in-vehicle systems **216** further includes control of the vehicle audio system **228** to direct an audio output from the plurality of speakers **232** of the vehicle audio system **228** toward the mid facial portions **318A** and **318B** of first occupant **310A** and the second occupant **310B** respectively. The directivity of the audio output may be based on the second Z-height **322A** (also represented by “Y1” cm”) and the fourth Z-height **322B** (also represented by “Y2” cm”) and the determined associative relationship that the “Y1” and “Y2” are associated with the vehicle audio system **228** for optimum audio experience. Thus, the vehicle audio system **228** may be tuned in real time or near-real time for optimum audio performance and enhanced listening experience for the first occupant **310A** and the second occupant **310B** in the vehicle **102**.

[0068] With reference to FIG. 3E, there is shown an exemplary scenario **300E**. FIG. 3E is explained in conjunction with elements from FIGS. 1, 2, and 3A to 3D. The exemplary scenario **300E** illustrates a top view of the interior of the vehicle **102** to depict a precise and a real time personalization of in-vehicle systems based on Z-heights of body portions of vehicle occupants, occupants positioning, and the number of occupants. There is further shown a first center of audio focus **330A**, a second center of audio focus **330B** and different directions of airflows **332A**, **332B**, **332C**, and **332D** based on positioning and the detected number of occupants, such as the first occupant **310A**, the second occupant **310B**, a third occupant **310C**, and a fourth occupant **310D**.

[0069] In accordance with an embodiment, in addition to the vertical Z-height based personalization, a horizontal (X, Y coordinates) occupant’s position based personalization may also occur in the vehicle **102**. For example, the circuitry **202** may be configured to determine and update an optimal location in real time or near-real time for a center of audio

focus in the interior of the vehicle **102** based on a track of current positioning of one or more occupants in the vehicle **102**. For example, when a single occupant, such as the first occupant **310A** is present in the vehicle **102**, the circuitry **202** may communicate a first control signal to the vehicle audio system **228** to focus the output from the plurality of speakers **232** to the first center of audio focus **330A**. The circuitry **202** may also communicate a second control signal to the HVAC system **226** to selectively direct the airflow **332A** from a front HVAC unit of the HVAC system **226** to the first facial portion **312A** of the first occupant **310A**. In some embodiments, both the first control signal and the second control signal may be communicated concurrently to respective in-vehicle systems.

[0070] In accordance with an embodiment, when the number of occupants or seating position of the occupants changes (an increase in this case) in the vehicle **102**, the circuitry **202** may be configured to shift the first center of audio focus **330A** to the second center of audio focus **330B**, as shown in FIG. 3E. In some embodiments, a combination of seat occupancy sensors (such as the seat occupancy sensor **224A**) and the face tracking feature of the image-capture device **112** may be utilized for an accurate occupant (s) position estimation.

[0071] Further, the output from different servo-controlled vents in the front or rear of the vehicle **102** may be controlled such that each of the first occupant **310A**, the second occupant **310B**, the third occupant **310C**, and the fourth occupant **310D** receive a personalized directed airflow (e.g., the different directions of airflows **332A**, **332B**, **332C**, and **332D**, as shown). The personalized directed airflow towards their facial portions may be outputted in accordance to estimated Z-heights of the facial portions, as discussed in FIGS. 3C and 3D, for example.

[0072] In accordance with an embodiment, Right-left (R-L) balance, Front-back (F-B) fade, and other audio settings may be adjusted for optimal listening experience for current positioning of the one or more occupants. Further, when the vehicle **102** stops and one passenger exits the vehicle **102**, the image-capture device **112** may be configured to detect change in an occupant seating scenario. The circuitry **202**, based on the detected change in the occupant seating scenario, may automatically update audio settings of the vehicle audio system **228** for the remaining occupants (i.e. new occupant seating scenario).

[0073] With reference to FIG. 3F, there is shown an exemplary scenario **300F**. FIG. 3F is explained in conjunction with elements from FIGS. 1, 2, and 3A to 3E. The exemplary scenario **300F** illustrates a portion of the interior of the vehicle **102** to depict monitoring of a driver state. There is shown the first occupant **310A** in a distressed state in the vehicle **102**.

[0074] In accordance with an embodiment, the circuitry **202** may be configured to monitor, by use of the image-capture device **112**, a plurality of defined metrics related to the driver, such as the first occupant **310A**, of the vehicle **102**. The plurality of defined metrics related to the driver of the vehicle **102** may include, but are not limited to a facial position, body language, a seating position, eye movement, body movement, health parameters, and a tone, or pitch of driver’s voice. In accordance to the exemplary scenario **300F**, the driver, such as the first occupant **310A**, is detected in a distressed state during after a crash. The circuitry **202** activates an emergency response (ERS) mode in the vehicle

**102** and seeks response from the driver (e.g., the first occupant **310A**) within the user specified or pre-defined time period. In other embodiments, a driver dozing off is identified through recognition of closing eyes or a bobbing head. In such a situation, an alert may be sounded, cabin temperature may be reduced, cold air may be blown on the driver, and the vehicle **102** may be brought to a stop in a safe manner, or another action may be taken.

[0075] Thereafter, the circuitry **202** may be configured to communicate a self-diagnostic test start signal to an on-board diagnostics (OBD) system of the vehicle **102**. The self-diagnostic test is done to determine whether the vehicle **102** is damaged or okay-to-drive in an autonomous mode or auto pilot (AP) mode. In cases where the vehicle **102** is damaged, the vehicle **102** remains parked, and a health emergency alert signal is communicated to the medical emergency center **106**, by the wireless communication system **238**. In cases where the vehicle **102** is diagnosed as okay-to-drive but the first occupant **310A** is unresponsive, the circuitry **202** may communicate an autonomous mode start signal to an engine control module (ECM) of the vehicle **102**. This may cause the vehicle **102** to automatically drive itself to a preferred hospital based on the identified driver profile “DOP”.

[0076] FIGS. 4A, 4B, 4C, and 4D collectively, depict a flow chart that illustrates exemplary operations for personalization of a vehicle based on spatial locations of body portions of occupants in the vehicle, in accordance with an embodiment of the disclosure. With reference to FIGS. 4A, 4B, 4C, and 4D there is shown a flow chart **400**. The flow chart **400** is described in conjunction with FIGS. 1, 2, and 3A to 3F. The operations, implemented at the in-vehicle electronic device **114** in association with the image-capture device **112**, for personalization of a vehicle, begin at **402** and proceed to **404**.

[0077] At **404**, a plurality of images or a video of one or more occupants in the vehicle **102** may be captured. The image-capture device **112** may be configured to capture the plurality of images or the video of the one or more occupants in the vehicle **102**. At **406**, facial portion(s) of one or more occupants in the vehicle **102** may be detected based on the plurality of images or the video captured by the image-capture device **112**.

[0078] At **408**, at least a driver profile or a passenger profile (each could also be referred to as an occupant profile) associated with each occupant (who may be seated at a driver seat or one of the passenger seats) may be searched based on a comparison of facial features of the occupant with stored facial features of users related to a plurality of driver profiles and a plurality of passenger profiles. The circuitry **202**, such as a microprocessor, may be configured to search for the driver profile and/or the passenger profile of each occupant based on the comparison of the facial features of the occupant, such as the first occupant **310A**, with stored facial features of users related to the plurality of driver profiles stored in the memory **204**. At **410**, facial recognition is performed on the acquired data, such as the plurality of images or the video of the one or more occupants, to identify a driver profile and/or a passenger profile. The circuitry **202** may be configured to check whether the driver profile is identified based on facial recognition from the stored plurality of driver profiles in the memory **204**. Similarly, the circuitry **202** may be further configured to check whether the passenger profile is identified based on

facial recognition from the stored plurality of passenger profiles in the memory **204**. A match of the facial features of an occupant, such as the first occupant **310A**, with stored facial features of one user may result in the facial recognition. In cases where the driver profile and/or the passenger profile is identified, the control passes to **412** else to **416**.

[0079] At **412**, an audio signal may be communicated to the vehicle audio system **228** to output customized audio greeting to at least the first occupant **310A**. The circuitry **202** may be configured to communicate the audio signal to the vehicle audio system **228** to output the customized audio greeting, for example, “Hello, Fredrick” to the first occupant **310A**. At **414**, a first level of customization may be executed in the vehicle **102** based on defined user-preferences in the identified driver profile or passenger profile of the one or more occupants, such as the first occupant **310A**. For example, the electrically powered adjustable components, such as the driver seat, vehicle mirrors (e.g., the ORVM **208**), front mirror, radio, music preferences, and driving mode preferences, may be adjusted in accordance with the user preferences in the driver profile of the first user **116A**. The circuitry **202** may be configured to communicate a plurality of control signals to one or more other ECUs to initiate the adjustments in accordance with the user preferences in the driver profile of the first occupant **310A**. In some embodiments, if there are more than one occupants in the vehicle **102**, similar to the first occupant **310A**, audio signal may be communicated to the vehicle audio system **228** to output customized audio greeting to each occupant. For example, in addition to custom audio greeting to the first occupant **310A**, the second occupant **310B** may also be greeted as, “Hello Samantha, how are you doing today?”, via an audio speaker that is in vicinity of the second occupant **310B**.

[0080] At **416**, an unrecognized occupant (e.g., a first occupant, a second occupant, or a new occupant) may be marked (or tagged) as a new user and a request to set a new profile may be generated on the display **210** of an infotainment head unit (e.g., the in-vehicle electronic device **114**). In cases where there are multiple occupants, and one or more occupants are not identified, for example, a passenger seated at the front seat, the passenger may be tagged as new user and requested to set the new profile similar to the first occupant **310A**, such as the driver. At **418**, a plurality of Z-heights of a plurality of body portions of each of the one or more occupants in the vehicle **102** may be estimated. An example of the estimation of the plurality of Z-heights, has been shown and described in details in the FIG. 3C.

[0081] At **420**, an associative relationship may be determined between the estimated plurality of Z-heights of the plurality of body portions of each of the one or more occupants and the plurality of in-vehicle systems **216** of the vehicle **102**. An example of the associative relationship is depicted in TABLE 1 in the FIG. 3C. At **422**, the plurality of in-vehicle systems **216** may be controlled to direct an output from a corresponding in-vehicle system of the plurality of in-vehicle systems **216** to a specific body portion of the plurality of body portions of each of the one or more occupants in the vehicle **102**. An example of the control of the plurality of in-vehicle systems **216**, such as the HVAC system **226** and the vehicle audio system **228**, has been shown and described in the FIGS. 3D and 3E.

[0082] At **424**, an optimal location to direct the audio in the interior of the vehicle **102** is determined, based on

positioning of the one or more occupants in the vehicle **102**. An example of the determination of the optimal location for the center of audio (or music) focus has been shown and described in FIG. 3E. In some embodiments, as the vehicle **102** includes the plurality of speakers **232**, audio from all of the plurality of speakers **232** may be directed towards one location (or position). Alternatively, a same audio or different audio from the plurality of speakers **232** may be directed toward different locations in the interior of the vehicle **102** based on positioning of the one or more occupants in the vehicle **102**. In cases where audio output from the plurality of speakers **232** are directed toward different locations, each speaker or a group of speakers of the plurality of speakers **232** may output different audio to different locations suited to individual occupant in the vehicle **102**. Audio beam forming techniques may be used for providing directed audio toward each occupant. For example, certain speakers of the plurality of speakers **232** may be in close proximity to an occupant. For instance, the vehicle door near driver may comprise multiple speakers to allow for beam forming. In some scenarios, the selection of different audio may be based on individual user-preferences in accordance with identified driver and passenger profiles of each occupant.

[0083] At **426**, an angle of the one or more vents of the HVAC system **226** may be controlled to direct an airflow toward a first body portion, such as the first facial portion **312A**, of the first occupant **310A** of the one or more occupants. The airflow may be directed toward the first body portion based on a first Z-height (e.g., the first Z-height **320A**) of the first body portion of the first occupant **310A** in the determined associative relationship. An example of control of angle to direct an airflow toward a specific body portion, has been shown and described in FIGS. 3D and 3E.

[0084] At **428**, the vehicle audio system **228** may be controlled to direct an audio output from the plurality of speakers **232** of the vehicle audio system **228** to a second body portion of plurality of body portions of the first occupant **310A**. The audio output, for example, an audio beam, may be directed based on a second Z-height (e.g., the second Z-height **322A**) of the second body portion of the first occupant **310A** in the determined associative relationship. An example of the control of vehicle audio system **228** angle to direct an audio output toward a specific body portion, has been shown and described in the FIG. 3D. At **430**, a change in occupant(s) seating positions and a number of current occupants in the vehicle **102** may be detected. The circuitry **202** may be configured to detect the change in occupant(s) seating positions and the number of current occupants in the vehicle **102** based on face tracking of the one or more occupants. In some embodiments, a combination of seat occupancy sensors (such as the seat occupancy sensor **224A**) and the face tracking feature of the image-capture device **112** may be utilized for an accurate occupant (s) position estimation. In some embodiments, where there are multiple occupants, for example, the driver, a front passenger and a back passenger seated in a rear seat, the front passenger might have similar setting for air flow, audio, and the like, as that of the driver. However, the back passenger seated in the rear seat, may be a child (or a user of different age-group) and may be associated with different settings (e.g. a preference of reduced audio level as compared to front occupants, a different choice for audio, airflow settings, and the like). Accordingly, different audio may be played for the back passenger based on identified passenger

profile for the rear seat passenger, or a specific audio may be directed to ears of the passenger (e.g., the child) based on the estimated Z-height. In some embodiments, settings for air flow, audio, and the like, may be specific for each occupant, such as the driver and each passenger, based on estimated Z-heights and user-preferences in their respective profiles (e.g., the identified passenger and driver profiles).

[0085] At **432**, an optimal location for a center of audio focus and an angle of the one or more vents of the HVAC system may be dynamically updated. The update may be done for a specific body portion for new occupants. An example of the shift in the center of audio focus based on an increase in the number of occupants and a concurrent update in the angle of the one or more vents, has been described in FIG. 3E. At **434**, a plurality of defined metrics related to a driver, such as the first occupant **310A**, of vehicle **102**, may be monitored. An example of the monitoring of the plurality of defined metrics has been described in FIGS. 1 and 3F.

[0086] At **436**, a state of the driver of the vehicle **102** may be detected, based on an analysis of the plurality of defined metrics. An example of a distressed state is shown and described in FIG. 3F. At **438**, it may be checked whether the driver is in normal state. In cases where the driver is detected in the normal state, the control returns to **434**, as shown. In cases where the driver is detected in the distressed state, the control passes to **440**.

[0087] At **440**, a driver emergency alert signal may be generated and then communicated to the vehicle audio system **228** for output, such as an audio alert. The circuitry **202** may be configured to generate and then communicate the driver emergency alert signal to the vehicle audio system **228** for output via one of the plurality of speakers **232**. At **442**, it may be checked whether the driver is responsive to the generated output, such as the generated audio alert. In cases where the driver is responsive, the control may pass to **444**. In cases where the driver is unresponsive to the audio alert, the control may pass to **446**.

[0088] At **444**, it may be determined whether the driver have requested for emergency services, such as to call the medical emergency center **106**. In cases where the driver has requested for emergency services, the control may pass to **446**, else the control may return to **434**. At **446**, an emergency response (ERS) mode may be activated in the vehicle **102**. The circuitry **202** may be configured to activate the ERS mode in the vehicle **102**.

[0089] At **448**, a health emergency alert signal may be communicated to the medical emergency center **106**. The circuitry **202** may be configured to communicate the health emergency alert signal to the medical emergency center **106** if no response is received from the driver (e.g., the first occupant **310A**) within a user specified or pre-defined time period. The health emergency alert signal may be referred to as emergency call systems, or simply eCall. At **450**, it may be checked whether the vehicle **102** is damaged based on a self-diagnostic test of the vehicle **102**. In cases where the vehicle is damaged, the control may pass to **448** to call for emergency services. In cases where the vehicle is not damaged and diagnosed as okay-to-drive, the control may pass to **452**.

[0090] At **452**, an autonomous mode start signal may be communicated to the engine control module of the vehicle **102**. In cases where the vehicle **102** is diagnosed as okay-to-drive but the driver is unresponsive to the audio alert, the circuitry **202** may communicate the autonomous mode start



signal to the ECM. At **454**, the vehicle **102** may be automatically driven to the medical emergency center **106**. The control may pass to the end. The receipt of the autonomous mode start signal at the ECM may cause the vehicle **102** to automatically drive itself to a nearest hospital, such as the medical emergency center **106** or a preferred hospital, if provided in the identified driver profile.

**[0091]** The present disclosure may be realized in hardware, or a combination of hardware and software. The present disclosure may be realized in a centralized fashion, in at least one computer system, or in a distributed fashion, where different elements may be spread across several interconnected computer systems. A computer system or other apparatus adapted for carrying out the methods described herein may be suited. A combination of hardware and software may be a general-purpose computer system with a computer program that, when loaded and executed, may control the computer system such that it carries out the methods described herein. The present disclosure may be realized in hardware that comprises a portion of an integrated circuit that also performs other functions. It may be understood that, depending on the embodiment, some of the steps described above may be eliminated, while other additional steps may be added, and the sequence of steps may be changed.

**[0092]** The present disclosure may also be embedded in a computer program product, which comprises all the features that enable the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program, in the present context, means any expression, in any language, code or notation, of a set of instructions intended to cause a system with an information processing capability to perform a particular function either directly, or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

**[0093]** While the present disclosure has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from its scope. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed, but that the present disclosure will include all embodiments that fall within the scope of the appended claims. Equivalent elements, materials, processes or steps may be substituted for those representatively illustrated and described herein. Moreover, certain features of the disclosure may be utilized independently of the use of other features, all as would be apparent to one skilled in the art after having the benefit of this description of the disclosure.

**[0094]** As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any contextual variants thereof, are intended to cover a non-exclusive inclusion. For example, a process, product, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements, but may include other elements not expressly listed or inherent to such process, product, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive or and not to an exclusive or. For example, a condition “A or B” is satisfied by any one of the following: A is true (or present)

and Bis false (or not present), A is false (or not present) and Bis true (or present), and both A and Bis true (or present).

**[0095]** Although the steps, operations, or computations may be presented in a specific order, this order may be changed in different embodiments. In some embodiments, to the extent multiple steps are shown as sequential in this specification, some combination of such steps in alternative embodiments may be performed at the same time. The sequence of operations described herein can be interrupted, suspended, reversed, or otherwise controlled by another process.

**[0096]** It will also be appreciated that one or more of the elements depicted in the drawings/figures can also be implemented in a more separated or integrated manner, or even removed or rendered as inoperable in certain cases, as is useful in accordance with a particular application.

**1.-20.** (canceled)

**21.** A method implemented by one or more processors included in a vehicle, the method comprising:

capturing, by an image-capture device in the vehicle, one or more images of a driver in the vehicle, wherein the driver is associated with a respective profile;

estimating, by circuitry in the vehicle, a plurality of Z-heights of a plurality of body portions of the driver from a reference position in the vehicle, based on the plurality of images captured from the image-capture device;

determining, by the circuitry, an associative relationship between the plurality of Z-heights of the plurality of body portions of the driver and a plurality of in-vehicle systems, wherein a first of the in-vehicle systems is automatically associated with a first body portion of the driver, wherein the circuitry identifies respective Z-heights of the first body portions for the driver, wherein a second of the in-vehicle systems is automatically associated with a second body portion of the driver, and wherein the circuitry is configured to identify respective Z-heights of the second body portions of the driver;

accessing a profile associated with the driver, the profile defining user-preferences for the driver comprising, at least, settings for the plurality of in-vehicle systems;

detecting that the driver is in a distressed state based on an analysis of a plurality of defined metrics associated with the driver; and

communicating an autonomous mode start signal to an engine control module of the vehicle to cause the vehicle to be automatically driven to a medical emergency center, wherein the medical emergency center is selected based on the profile associated with the driver.

**22.** The method of claim **21**, wherein the plurality of defined metrics associated with the driver are first user in the vehicle, facial position, body language, seating position, eye movement, body movement, health parameters, and tone or pitch of the driver’s voice.

**23.** The method of claim **21**, wherein detecting the driver is in a distressed state comprises detecting a sudden deviation in the plurality of defined metrics.

**24.** The method of claim **23**, wherein the plurality of defined metrics are established as a regular baseline and defined as normal.

**25.** The method of claim **21**, further comprising detecting the driver is unresponsive to an audio alert generated in the vehicle, wherein the audio alert generated in the vehicle asks the driver if they are okay.

**26.** The method of claim **21**, further comprising communicating a health emergency alert signal to the medical emergency center based on a lack of response received from the driver within a user specified time period.

**27.** The method of claim **26**, wherein the health emergency alert signal comprises an indication that the driver is in distress and a vehicle location.

**28.** The method of claim **21**, wherein the vehicle is diagnosed as okay-to-drive based on a determination that the vehicle is undamaged.

**29.** The method of claim **21**, wherein the driver is identified based on facial recognition.

**30.** The method of claim **21**, wherein the medical emergency center is chosen based on a closest medical emergency center list listed in the profile associated with the driver.

**31.** A system comprising one or more processors and non-transitory computer storage media storing instructions that when executed by the one or more processors, cause the one or more processors in a vehicle to:

capture, by an image-capture device in the vehicle, one or more images of a driver in the vehicle, wherein the driver is associated with a respective profile;

estimate, by circuitry in the vehicle, a plurality of Z-heights of a plurality of body portions of the driver from a reference position in the vehicle, based on the plurality of images captured from the image-capture device;

determine, by the circuitry, an associative relationship between the plurality of Z-heights of the plurality of body portions of the driver and a plurality of in-vehicle systems, wherein a first of the in-vehicle systems is automatically associated with a first body portion of the driver, wherein the circuitry identifies respective Z-heights of the first body portions for the driver, wherein a second of the in-vehicle systems is automatically associated with a second body portion of the driver, and wherein the circuitry is configured to identify respective Z-heights of the second body portions of the driver;

access a profile associated with the driver, the profile defining user-preferences for the driver comprising, at least, settings for the plurality of in-vehicle systems;

detect that the driver is in a distressed state, based on an analysis of a plurality of defined metrics associated with the driver; and

communicate an autonomous mode start signal to an engine control module of the vehicle to cause the vehicle to be automatically driven to a medical emergency center, wherein the medical emergency center is selected based on the profile associated with the driver.

**32.** The system of claim **31**, wherein the plurality of defined metrics associated with the driver are first user in the vehicle, facial position, body language, seating position, eye movement, body movement, health parameters, and tone or pitch of the driver's voice.

**33.** The system of claim **31**, wherein detecting the driver is in a distressed state comprises detecting a sudden deviation in the plurality of defined metrics.

**34.** The system of claim **33**, wherein the plurality of defined metrics are established as a regular baseline and defined as normal.

**35.** The system of claim **31**, further comprising detecting the driver is unresponsive to an audio alert generated in the vehicle, wherein the audio alert generated in the vehicle asks the driver if they are okay.

**36.** The system of claim **31**, further comprising communicating a health emergency alert signal to the medical emergency center based on a lack of response received from the driver within a user specified time period.

**37.** The system of claim **36**, wherein the health emergency alert signal comprises an indication that the driver is in distress and a vehicle location.

**38.** The system of claim **31**, wherein the vehicle is diagnosed as okay-to-drive based on a determination that the vehicle is undamaged.

**39.** The system of claim **31**, wherein the medical emergency center is chosen based on a closest medical emergency center list listed in the profile associated with the driver.

**40.** Non-transitory computer storage media storing instructions that when executed by a system of one or more processors, cause the one or more processors in a vehicle to:

capture, by an image-capture device in the vehicle, one or more images of a driver in the vehicle, wherein the driver is associated with a respective profile;

estimate, by circuitry in the vehicle, a plurality of Z-heights of a plurality of body portions of the driver from a reference position in the vehicle, based on the plurality of images captured from the image-capture device;

determine, by the circuitry, an associative relationship between the plurality of Z-heights of the plurality of body portions of the driver and a plurality of in-vehicle systems, wherein a first of the in-vehicle systems is automatically associated with a first body portion of the driver, wherein the circuitry identifies respective Z-heights of the first body portions for the driver, wherein a second of the in-vehicle systems is automatically associated with a second body portion of the driver, and wherein the circuitry is configured to identify respective Z-heights of the second body portions of the driver;

access a profile associated with the driver, the profile defining user-preferences for the driver comprising, at least, settings for the plurality of in-vehicle systems;

detect that the driver is in a distressed state, based on an analysis of a plurality of defined metrics associated with the driver; and

communicate an autonomous mode start signal to an engine control module of the vehicle to cause the vehicle to be automatically driven to a medical emergency center, wherein the medical emergency center is selected based on the profile associated with the driver.