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Clement et al.

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(54) **AUTOMATIC DEVICE MODE BASED ON PHYSICAL LOCATION OR USER IN A VEHICLE**

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(52) **U.S. Cl.**
USPC **701/2**; 701/36

(58) **Field of Classification Search**
USPC 701/2, 36
See application file for complete search history.

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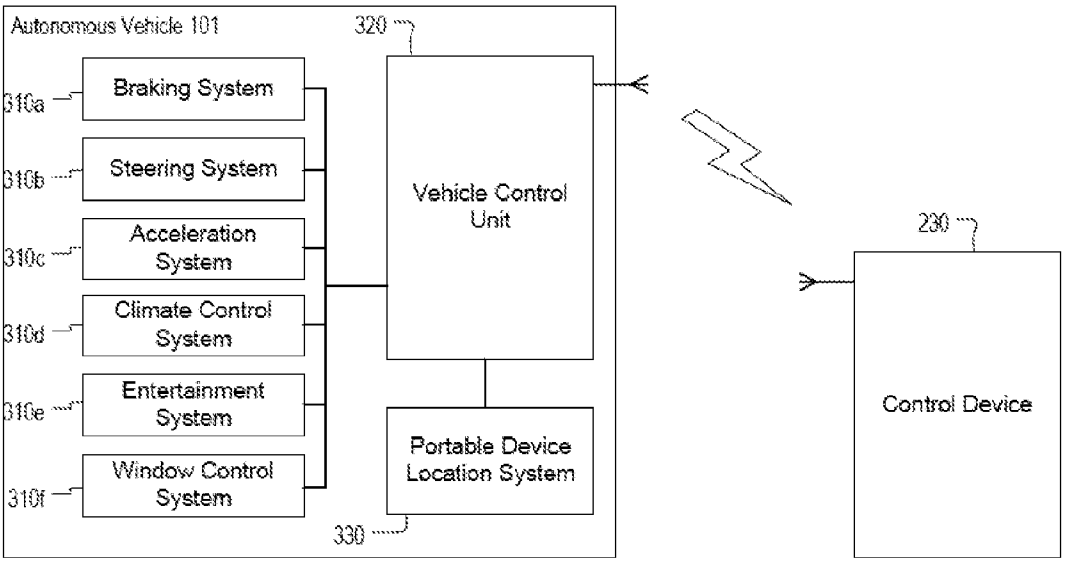
(57) **ABSTRACT**

One aspect of the disclosure provides a control device that is located inside the passenger compartment of a vehicle. The control device may include a portable computing device configured to execute software that effectively enables passengers to use a touch screen (or another input device) to perform control actions for the vehicle that would otherwise take a flip of a switch, turning of a knob, or pressing of a pedal. For example, the portable computing device may be used to steer the vehicle or apply the brakes of the vehicle. The capabilities of the portable computing device are subject to location-specific permissions. The portable computing device, for example, may be allowed to steer the vehicle only when it is located in the area of the vehicle's driver seat.

16 Claims, 9 Drawing Sheets



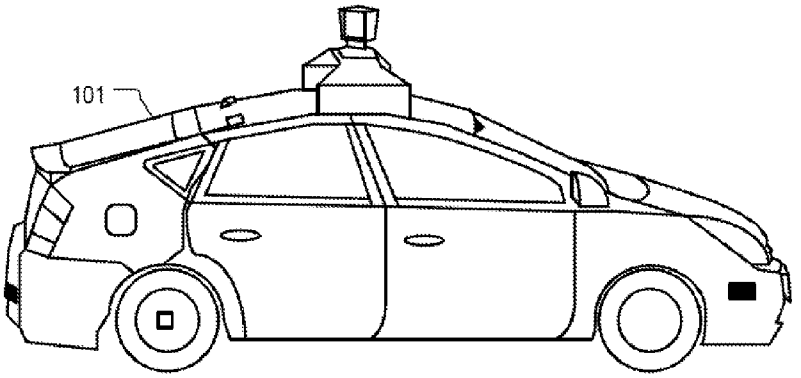


Fig. 1

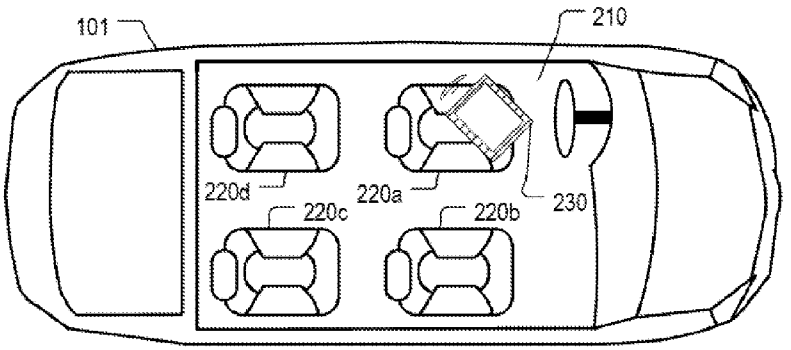


Fig. 2

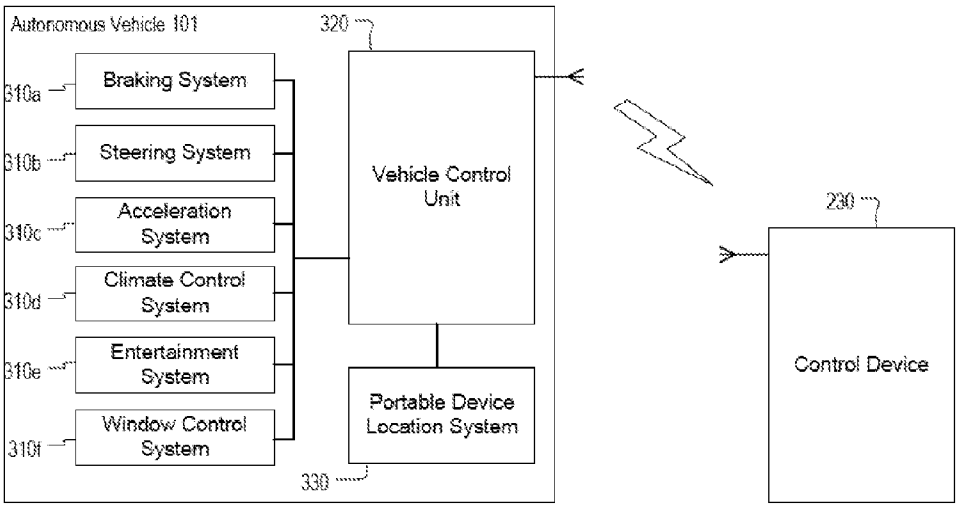

Autonomous Vehicle 101
320
310a
Braking System
310b
Steering System
310c
Acceleration System
310d
Climate Control System
310e
Entertainment System
310f
Window Control System
Vehicle Control Unit
Portable Device Location System
330
230
Control Device

Fig. 3

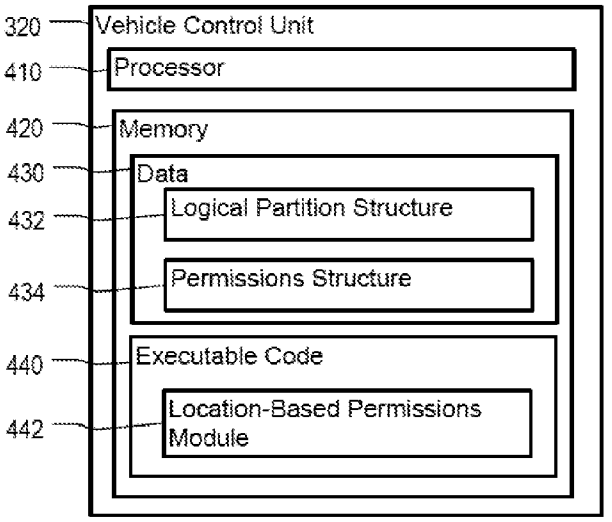

320
Vehicle Control Unit
410
Processor
420
Memory
430
Data
432
Logical Partition Structure
434
Permissions Structure
440
Executable Code
442
Location-Based Permissions Module

Fig. 4

432

	Region	Region Definiton
432a	Region #1	$[(X_1, Y_1), (X_1, Y_2), (X_2, Y_1), (X_2, Y_2)]$
432b	Region #2	$[(X_1, Y_2), (X_1, Y_3), (X_2, Y_2), (X_2, Y_3)]$
432c	Region #3	$[(X_2, Y_2), (X_2, Y_3), (X_3, Y_3), (X_3, Y_2)]$
432d	Region #4	$[(X_2, Y_1), (X_2, Y_2), (X_3, Y_2), (X_3, Y_1)]$

Fig. 5

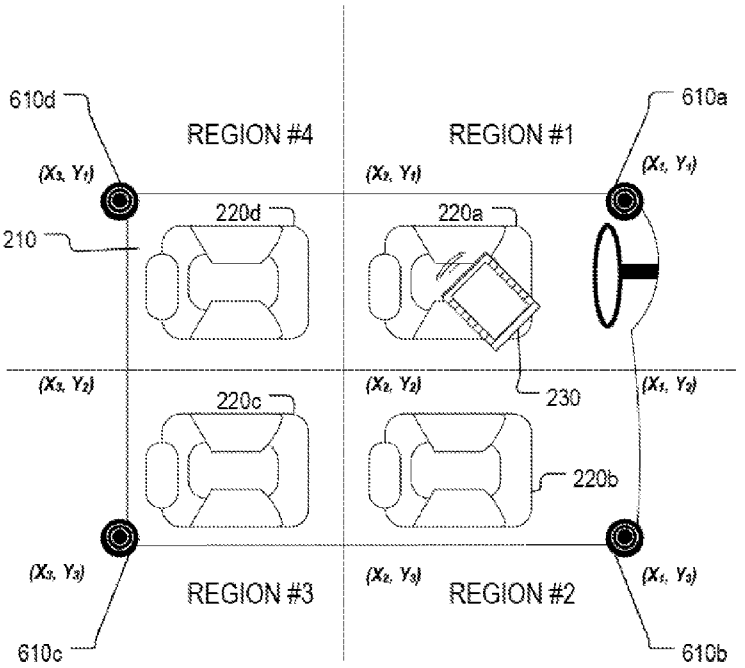


Fig. 6

434

	Instruction	Location
434a	Stop Vehicle	Region #1
434b	Accelerate	Region #1
434c	Change Volume	Regions #1-2
434d	Change Temperature	Regions #1-4
434e	Open Rear Left Window	Regions #1 and 3

Fig. 7

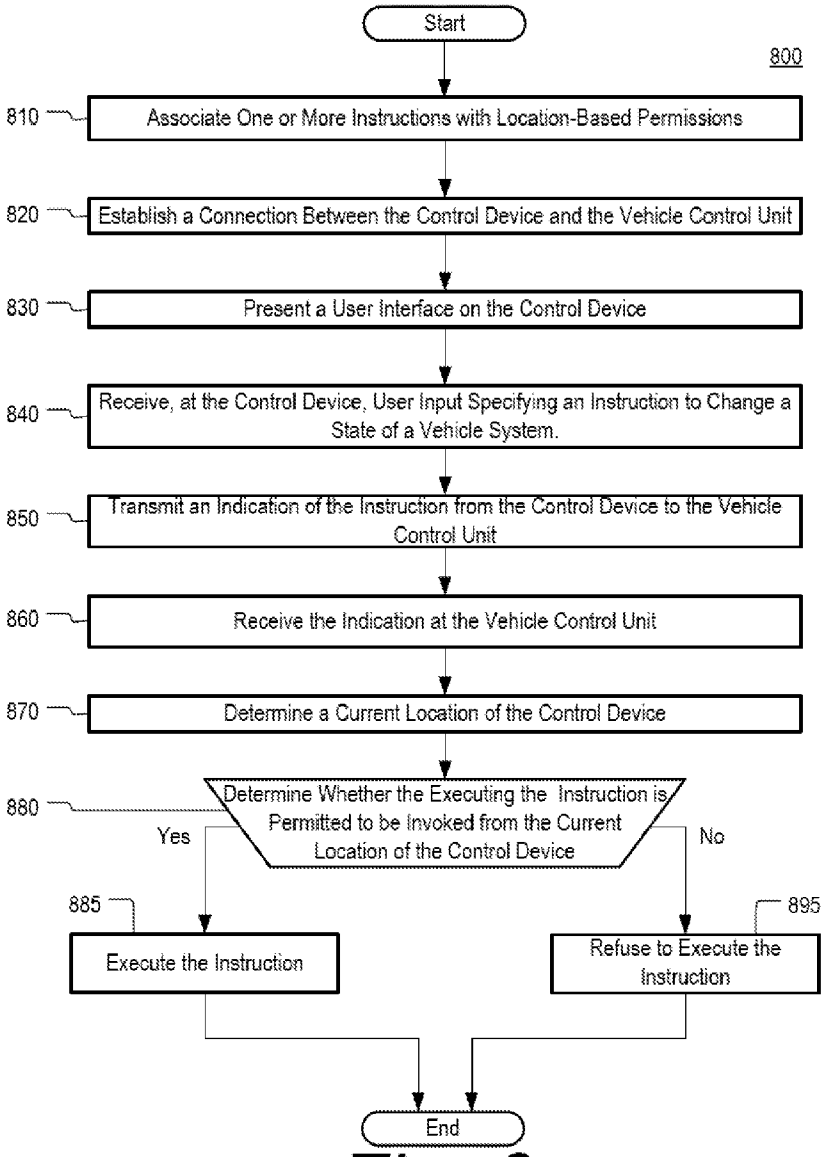

Start
800
810
Associate One or More Instructions with Location-Based Permissions
820
Establish a Connection Between the Control Device and the Vehicle Control Unit
830
Present a User Interface on the Control Device
840
Receive, at the Control Device, User Input Specifying an Instruction to Change a State of a Vehicle System.
850
Transmit an Indication of the Instruction from the Control Device to the Vehicle Control Unit
860
Receive the Indication at the Vehicle Control Unit
870
Determine a Current Location of the Control Device
880
Determine Whether the Executing the Instruction is Permitted to be Invoked from the Current Location of the Control Device
Yes
No
885
Execute the Instruction
895
Refuse to Execute the Instruction
End

Fig. 8

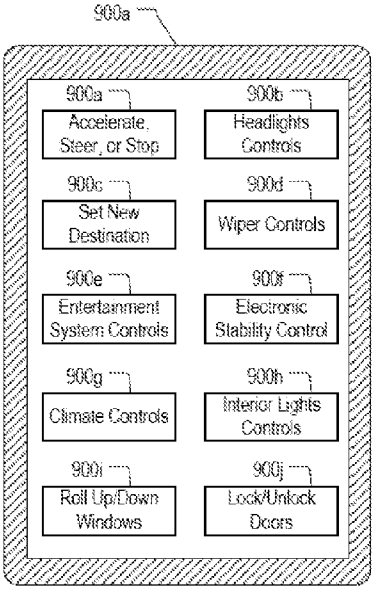

900a
900a
Accelerate, Steer, or Stop
900b
Headlights Controls
900c
Set New Destination
900d
Wiper Controls
900e
Entertainment System Controls
900f
Electronic Stability Control
900g
Climate Controls
900h
Interior Lights Controls
900i
Roll Up/Down Windows
900j
Lock/Unlock Doors

Fig. 9A

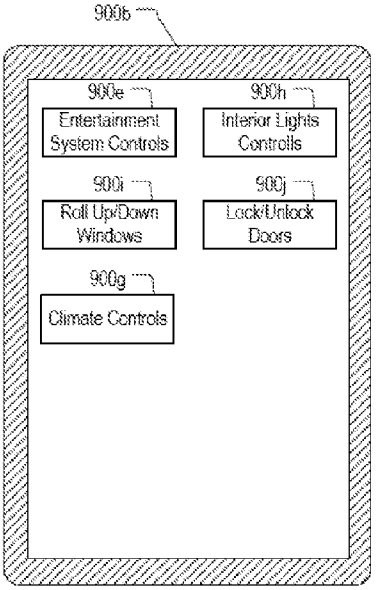

900b
900e
Entertainment System Controls
900h
Interior Lights Controls
900i
Roll Up/Down Windows
900j
Lock/Unlock Doors
900g
Climate Controls

Fig. 9B

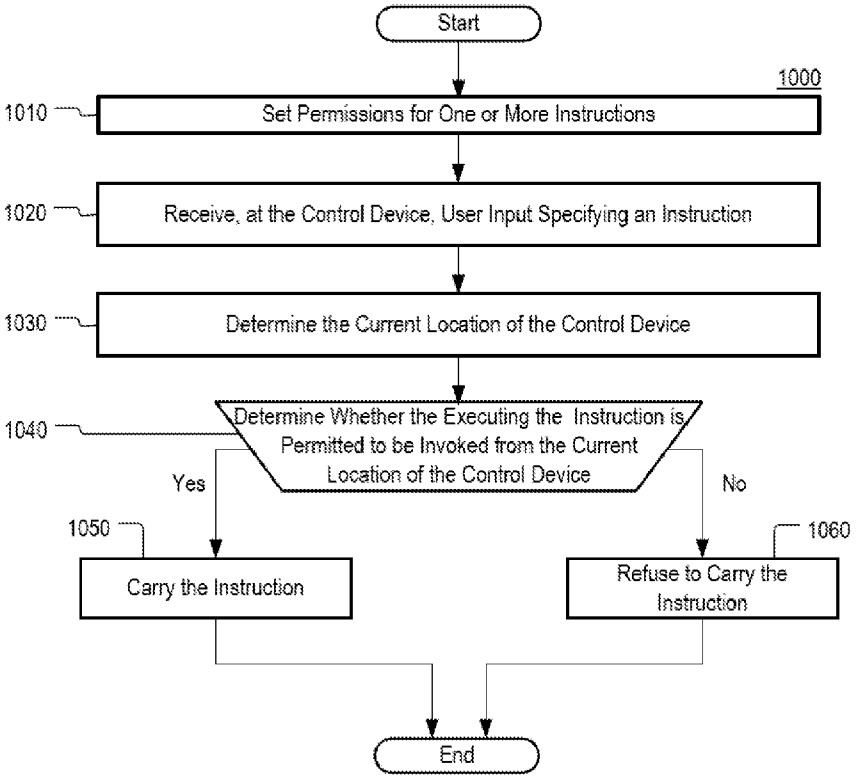

Start
1000
1010
Set Permissions for One or More Instructions
1020
Receive, at the Control Device, User Input Specifying an Instruction
1030
Determine the Current Location of the Control Device
1040
Determine Whether the Executing the Instruction is Permitted to be Invoked from the Current Location of the Control Device
Yes
No
1050
Carry the Instruction
1060
Refuse to Carry the Instruction
End

Fig. 10

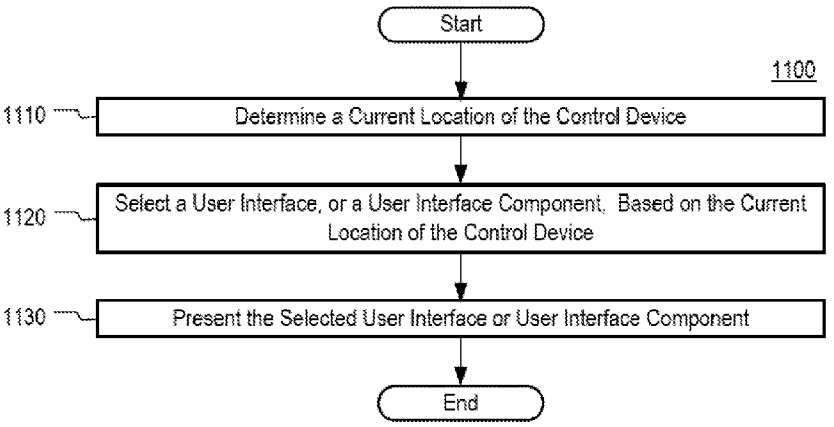

Start
1100
1110
Determine a Current Location of the Control Device
1120
Select a User Interface, or a User Interface Component, Based on the Current Location of the Control Device
1130
Present the Selected User Interface or User Interface Component
End

Fig. 11

AUTOMATIC DEVICE MODE BASED ON PHYSICAL LOCATION OR USER IN A VEHICLE

BACKGROUND

Smart vehicles rely on computing systems to aid in the transport of passengers. The computing systems may control the operation of various vehicle systems, such as braking, steering, and acceleration systems, and they may be used to guide the autonomous vehicles from one location to another. Furthermore, such computing systems may control the operation of additional vehicle systems, such as climate control systems, entertainment systems, navigation systems, automatic window systems, and windshield wiper systems. Over the course of their operation, the computing systems may receive user input for controlling the operation of their respective smart vehicles. The user input may require the vehicles to perform any action that is normally associated with the operation of vehicles.

SUMMARY

In one aspect, user instructions may be submitted to a vehicle via a portable computing device, such as a tablet or a smart phone. The instructions may specify a new travel destination, a new travel route, or an action that the user would like the vehicle to perform, such as steering, applying the brakes, accelerating, opening a window, turning up the volume on the vehicle's radio, or activating the vehicle's interior lights. Using the portable computing device to provide user input to the vehicle may increase the ease at which users interact with their vehicles.

In another aspect, a method is provided that includes receiving, over a wireless link, an instruction to change a state of a vehicle system, the vehicle system including at least one of a mechanical component that is part of a vehicle or an electronic component that is part of the vehicle. The instruction is transmitted by a portable control device and received by a vehicle control unit that is operatively connected to the vehicle system. The vehicle control unit includes a processor coupled to a memory. The method further includes identifying a current location of the portable control device within a passenger compartment of the vehicle, and depending on the current location of the portable control device, performing one of the following tasks: executing the instruction when it is determined that the portable control device is located in a first region in the passenger compartment of the vehicle, or refusing to execute the instruction when it is determined that the portable control device is located in a second region in the passenger compartment of the vehicle. In some instances, the vehicle system may further be one of a steering system, an acceleration system, or a braking system.

The method may further include determining, based on the current location of the portable control device, whether the portable control device is permitted to output a first user interface component for calling the instruction from the portable control device and outputting the first user interface component, by the portable control device, upon determining that the first user interface component is permitted to be output. The portable control device may further be one of a smart phone, a tablet, or a laptop. The portable control device may further be configured to store, in a memory, a data structure that relates the first user interface component with the first region in the passenger compartment of the vehicle, thereby indicating that the portable control device is permitted to output the first user interface component when the portable control device is located in the first region. The first input component may be part of a first user interface and the data structure may further indicate that the first user interface is permitted to be output by the portable control device when the portable control device is located in the first region.

The memory of the vehicle control unit may further store a data structure that associates the instruction with one or more regions in the passenger compartment of the vehicle from where the instruction is permitted to be executed. In some instances, the method may further include accessing the data structure and determining whether the instruction should be executed based on the current location of the portable control device. Furthermore, the method may further include transmitting to the portable control device a message indicating that the instruction will not be executed. Moreover, the method may further include a user input indicating whether the instruction is permitted to be executed when the portable control device is located in the first region.

In yet another aspect, a vehicle is provided that includes a passenger compartment, a plurality of vehicle systems, and a vehicle control unit operatively connected to each vehicle system. The passenger compartment is configured to accommodate one or more passengers. The vehicle control unit includes a processor and a memory. The memory stores (i) a first indication of a first location within the passenger compartment from where a portable device is permitted to change the state of a first vehicle system of the plurality and (ii) a second indication of a second location within the passenger compartment from where the portable device is permitted to change the state of a second vehicle system of the plurality. The processor is configured to receive a first instruction from the portable control device to change a first state of the first vehicle system, receive a second instruction from the portable control device to change a second state of the second vehicle system, and determine a current location of the portable control device in the passenger compartment. The processor is further configured to determine, based on the first indication and the current location of the portable control device, whether the first instruction is permitted to be executed, determine, based on the second indication and the current location of the portable control device, whether the second instruction is permitted to be executed, and execute the first instruction, but not the second instruction, in response to determining that only the first instruction is permitted to be executed when the portable control device is located at its current location.

The first system may further be a steering system and the first instruction may further be permitted to be executed only when the portable control device is located at a driver seat of the vehicle. Alternatively, the first system may further be an entertainment system and the first instruction may further be permitted to be executed only when the portable control device is located at a driver seat or a front passenger seat of the vehicle.

The first location may further be part of a first region of the passenger compartment and the second location is part of a second region of the passenger compartment. The portable control device may further be one of a smart phone, a tablet, or a laptop. The portable control device may further be connected to the vehicle control unit via a wireless connection.

In yet another aspect, a vehicle is provided that includes a passenger compartment, a plurality of vehicle systems, and a vehicle control unit. The vehicle control unit includes a processor and a memory. The memory stores a permissions structure having one or more entries, each entry identifying an instruction and one or more regions in the passenger compartment from where the instruction is permitted to be invoked. The processor is configured to receive, from a por-

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table control device, an instruction to change a state of first vehicle system from the plurality and determine a current location of the portable control device. The processor is further configured to determine, based on the permissions structure, whether the current location is a location from where the first instruction is permitted to be executed and execute the first instruction when and only when it is determined that the first instruction is permitted to be executed from the current location.

The portable control device may further be connected to the vehicle control unit via a wireless connection. The portable control device may further be connected to the vehicle control unit via a wired connection. The location of the portable control device may further be determined based on a radio signal transmitted by the portable control device. The plurality of vehicle systems may further include at least one of a steering system, acceleration system, braking system, a climate control system, and an entertainment system. The first instruction may further be an instruction to perform at least one of steering the vehicle, braking, activating a blinker, activating headlights of the vehicle, stopping the vehicle, changing a temperature setting of a heating or air conditioning system, or changing a volume on an audio system. The portable control device may further be one of a tablet, a laptop, or a smart phone.

In yet another aspect, an apparatus is provided that includes an output device, a memory, and a processor coupled to the output device and the memory. The memory stores a data structure that relates: (i) a first user interface component with a first region in a passenger compartment of a vehicle, thereby indicating that the apparatus is permitted to output the first user interface component on the output device when the apparatus is located in the first region, and (ii) a second user interface component with a second region in the passenger compartment of the vehicle, thereby indicating that the apparatus is permitted to output the second user interface component on the output device when the apparatus is located in the second region. The processor is configured to determine a current location of the apparatus within the vehicle, determine, based on the current location of the apparatus and the data structure stored in the memory, whether the first user interface component is permitted to be output, and determine, based on the current location of the apparatus and the data structure stored in the memory, whether the second user interface component is permitted to be output. The processor is further configured to output the first user interface component using the output device upon determining that the first user interface component is permitted to be output and output the second user interface component using the output device upon determining that the second user interface component is permitted to be output.

The output device may further be one of a display screen or a speaker and outputting the first user interface component using the output device may further include one of rendering the first user interface component on the display screen or playing a sound representing the first user input component. The vehicle may further include a first vehicle system and a second vehicle system. The first user interface component may further be for receiving user input for changing a state of the first vehicle system. The second user interface component may further be for receiving user input for changing a state of the second vehicle system.

The first vehicle system may further be a braking system and the second vehicle system may further be an entertainment system. The first user interface component may further be part of a first user interface. The second user interface component may further be part of a second user interface. The data structure may further indicate that the first user interface is permitted to be output using the output device when the apparatus is located in the first region. The data structure may further indicate that the second user interface is permitted to be output using the output device when the apparatus is located in the second region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a side view of a vehicle in accordance with aspects of the disclosure.

FIG. **2** depicts a top-down cut out view of the vehicle of FIG. **1**.

FIG. **3** depicts a schematic diagram of the vehicle of FIG. **1**.

FIG. **4** depicts a schematic diagram of a vehicle control unit of the vehicle of FIG. **1**.

FIG. **5** depicts a schematic diagram of a data structure used to define different regions within a passenger compartment of the vehicle of FIG. **1**.

FIG. **6** depicts a schematic diagram of the passenger compartment of the vehicle of FIG. **1** showing the regions defined by the data structure of FIG. **5**.

FIG. **7** depicts a schematic diagram of a data structure used to define location-based permissions for instructions that are executable by the vehicle control unit of FIG. **4**.

FIG. **8** depicts a schematic diagram of a process associated with controlling of the vehicle of FIG. **1** by the vehicle control unit of FIG. **4**

FIGS. **9**A and **9**B depict schematic diagrams of user interfaces that may be used to supply instructions to the vehicle control unit of FIG. **4**.

FIG. **10** depicts a schematic diagram of a process associated with the operation of the vehicle of FIG. **1** and/or the vehicle control unit of FIG. **4**.

FIG. **11** depicts a schematic diagram of a process associated with the operation of the vehicle of FIG. **1** and/or the vehicle control unit of FIG. **4**.

DETAILED DESCRIPTION

In one aspect, a vehicle is provided that is configured to receive user input for controlling the vehicle. The user input may be entered via a control device, such as a portable computing device. Examples of such devices may include a cell phone, a tablet, a laptop, or a portable gaming device. By way of example, the user input may specify a control action for the vehicle to perform. Examples of control actions may include steering the vehicle, braking the vehicle, accelerating the vehicle, shifting gears, changing a transmission mode, changing settings on an electronic stability control system, activating low beams, activating high beams, turning on/off of an interior light, turning on of windshield wipers, changing the settings of a climate control system, (e.g., changing temperature inside a passenger compartment of the vehicle), changing settings of an entertainment system (e.g., changing the volume, changing the radio station playing, playing a particular media file), changing settings on a navigation system (e.g., entering a new travel destination), changing cruise control settings, or any other action that may be performed over the course of the vehicle's usage by a driver and/or passengers of the vehicle.

The operation of the control device may be subject to predetermined permission settings. For example, the control device may be configured to steer the vehicle only when it is permitted to steer the vehicle. Similarly, the control device may be configured to change the music on the radio, only

when given permission to do so. As is further discussed below, the permission settings may be subject to the location of the control device within the vehicle's cab. Depending on its location, the control device may be permitted to perform different types of actions.

Having a permission management system is important with respect to ensuring the safety of the vehicle. For instance, it is unsafe for a 5-year old sitting in the rear seat of the vehicle to be allowed to steer the vehicle, via the control device, should he or she manage somehow to grab the control device and bring it in the backseat. To increase the vehicle's safety, the location of the control device inside the vehicle may be monitored and a determination may be made as to what region of the vehicle's cab the control device is located in. Possible regions may include a region where the driver's seat is located, a region where the front passenger's seat is located, and a region where the backseats are located.

In one example, the control device may be permitted to perform safety-critical actions, such as steering or applying the brakes, only if it is located in the region where the driver seat is located. In this regard, the ability to perform safety-critical actions may be denied when the control device is located elsewhere in the vehicle's cab. This ensures that only the person in the driver's seat retains control over aspects of the operation of the vehicle that are important with respect to safety. Nevertheless, the control device may be permitted to control non-safety critical aspects of the operation of the vehicle when it is located in other parts of the vehicle, like the backseat. For example, the control device may be permitted to perform actions from the backseat, such as activating an air-conditioner, rolling down a window, or changing the station playing on the vehicle's radio.

FIG. **1** is a schematic diagram of vehicle **101** in accordance with one aspect of the disclosure. Vehicle **101** may be an autonomous or semi-autonomous vehicle capable of driving form one point to another without (or with partial) user input. Although in this example vehicle **101** is an automobile, in various other examples vehicle **101** may be any type of vehicle adapted to carry one or more people, such as a truck, motorcycle, bus, boat, airplane, helicopter, lawnmower, recreational vehicle, amusement park vehicle, farm equipment, construction equipment, tram, golf cart, trains, or trolley. Furthermore, although in this example vehicle **101** is an autonomous or semi-autonomous vehicle, in other examples vehicle **101** may be a human-operated vehicle that lacks any automation.

As shown in FIG. **2**, vehicle **101** includes a passenger compartment **210** having a driver seat **220***a* and passenger seats **220***b-d*. Inside the passenger compartment **210** may be a control device **230** used by the vehicle's driver and/or passengers to control the vehicle. The control device **230** may be configured to execute software that enables the vehicle's driver and passengers to perform control actions, such as those discussed above. The software may effectively enable the vehicle's occupants to use a touch screen (or another input component/peripheral) of the control device **230** to perform actions that would otherwise take a flip of a switch, turning of a knob, or pressing of a pedal.

The operational capabilities of the control device **230** may vary with the control device's location in the passenger compartment **210**. If the control device **230**, for example, is held by the driver occupying seat **220***a* as shown in FIG. **2**, the portable device may be capable of steering or accelerating the vehicle **101**. If, however, the portable device **230** is held by a passenger occupying the seat **220***b*, the portable device may be permitted to control the vehicle's entertainment system, but not steer or apply the brakes of the vehicle. Furthermore, if the control device **230** is in possession of a passenger occupying the backseat **220***c*, the portable device may only be permitted to roll down the window adjacent to that seat, but not do anything else. Put another way, varying the operational capabilities of the control device **230** in dependence upon its location may enable the allocation of different privileges to different among the occupants of the passenger compartment **210**.

The control device **230** may be a tablet, a smart phone, a laptop, or another type of portable computing device. Moreover, in some instances, the control device **230** may be special-purpose hardware designed specifically to serve as a control interface for the vehicle **101**. Although in the example of FIG. **2** the passenger compartment **210** is a vehicle cab that includes a single space for both the driver and passengers, in other examples the passenger compartment may include a plurality of spaces separated by dividers. For example, on airplanes, the passenger compartment may include one or more of the pilots' cockpit, the passenger cabins, and even the cargo area. Similarly, in a train, the passenger compartment may include the interior of a locomotive and/or the interior of one or more of the train's cars. The passenger compartment **210**, in other words, may include one or more spaces on a vehicle that are human accessible or at least one or more spaces inside the vehicle where the control device **230** could fit.

FIG. **3** depicts a schematic diagram of the vehicle **101** in accordance with aspects of the disclosure. As illustrated, vehicle **101** includes vehicle systems **310***a-f*, a vehicle control unit **320**, and a portable device location system **330**. The vehicle systems **310***a-f* may include a braking system **310***a*, a steering system **310***b*, an acceleration system **310***c*, a climate control system **310***d*, an entertainment system **310***e*, and a navigation system **310***f*. The above systems are provided only as an example and thus the vehicle systems **310***a-f* may include any type system that is capable of performing one or more functions that are normally associated with vehicles, such as braking, steering, playing the radio, rolling down the windows, turning on an air-conditioner, etc. Although the vehicle systems **310***a-f* are depicted as separate blocks, in some instances they may share components (e.g., computer hardware, mechanical hardware, software, etc.) or they may be fully integrated with one another.

In one example, a vehicle system may include one or more of a mechanical hardware components that are part of the vehicle (e.g., rack and pinion, engine, brakes, steering motor, suspension, steering pump, etc.) and/or software that is executed by computer hardware and used to control aspects of the operation of the mechanical hardware components. In another example, a vehicle system may include one or more electronic components that are part of the vehicle **101** (e.g., light bulb, music player, radio, air conditioner, windshield wiper motor, steering pump, etc.), and/or software that is executed by computer hardware and used to control aspects of the operation of the electric or electronic components. Furthermore, in yet another example, vehicle systems may include logic implemented in hardware (e.g. an FPGA or another controller) instead of software for controlling aspects of the operation of mechanical or electric vehicle components.

The vehicle control unit **320** may include a computing system for controlling at least some aspects of the operation of the vehicle **101**. Vehicle control unit **320** may also be operatively connected to one or more of the vehicle systems **310***a-f* and it may be operable to change the state of any one of these systems. For example, the vehicle control unit **320** may interact with the braking system, steering system, and

acceleration system, to steer, slow down, or accelerate the vehicle. Furthermore, as another example, the vehicle control unit **320** may interact with: the climate control system to change the temperature inside the passenger compartment **210**, the entertainment system **310***e* to change the station playing on the radio, or the vehicle navigation system **310***f* to change a destination the vehicle is travelling to.

The vehicle control unit **320** may be coupled to the control device **230** via a wireless or wired connection and it may be operable to receive instructions from the control device **230** to change the state of one or more of the vehicle systems **310***a-f*. As discussed above, passengers and the driver of the vehicle **101** may use the control device **230** to perform actions, such as opening a window, turning on the headlights, slowing down, accelerating, or changing the station playing on the radio. In operation, once the control device **230** has received a user instruction for the vehicle to perform a given action, the control device **230** may forward an indication of the instruction to the vehicle control unit **320** for further execution. As discussed above, instructions may be executed in dependence of the location of the control device **230** within the passenger compartment **210**.

The location system **330** may include hardware and/or software for determining the location of the control device **230** within the passenger compartment **210**. In this example, the location system **330** includes receivers **610***a-d* (depicted in FIG. **6**) located in different parts of the of the passenger compartment **210**. The receivers **610***a-b* may take measurements of the strength of radio signal(s) transmitted by the control device **230** and forward those measurements to the vehicle control unit **320** where they are triangulated and used to determine the location of the control device **230**. Although in this example, the location system **330** and the vehicle control unit **320** are depicted as separate blocks, in some instances, they may be (completely or partially) integrated together. The location system **330** described herein is provided as an example and the disclosure is not limited to any method for determining the location of the control device **230**.

The vehicle control unit **320** may use the location system **330** to enforce location-based permissions on instructions received from the control device **230**. As discussed above, some instructions, such as steering the vehicle **101**, may be invoked only when the control device **230** is located in the area of the driver seat **220***a*. Thus, before executing an instruction invoked using the control device **230**, the vehicle control unit **320** may determine the current location of the control device **230** in the passenger compartment **210** and execute the instruction only if that instruction is permitted to be invoked from the control device's current location.

FIG. **4** depicts a schematic diagram of the vehicle control unit **320** in accordance with aspects of the disclosure. As illustrated, the vehicle control unit **320** may include a processor **410** and memory **420**. Memory **420** of vehicle control unit **320** may store information accessible by processor **410**, including executable code **440** that may be executed by the processor **410**. The memory also includes data **430** that may be retrieved, manipulated or stored by the processor. The memory may be of any type of tangible media capable of storing information accessible by the processor, such as a hard-drive, memory card, ROM, RAM, DVD, CD-ROM, write-capable, and read-only memories. The processor **410** may be any well-known processor, such as commercially available processors. Alternatively, the processor may be a dedicated controller such as an ASIC.

Data **430** may be retrieved, stored or modified by processor **410** in accordance with the executable code **440**. For instance, although the system and method are not limited by any particular data structure, the data may be stored in computer registers, in a relational database as a table having a plurality of different fields and records, or XML documents. The data may also be formatted in any computer-readable format such as, but not limited to, binary values, ASCII or Unicode. Moreover, the data may comprise any information sufficient to identify the relevant information, such as numbers, descriptive text, proprietary codes, pointers, references to data stored in other memories (including other network locations) or information that is used by a function to calculate the relevant data.

The executable code **440** may perform at least some of the tasks of the process **800** depicted in FIG. **8**. For example, the executable code **440** may include a location-based permissions module **442** that is configured to enforce location-based restriction policies. That is, when an instruction is received from the control device **230**, the module **432** may determine the current location of the control device **230** in the passenger compartment **210** and execute the instruction only if the control device **230** is located in a region of the passenger compartment **210** where the instruction is permitted to be invoked from. Different regions within the passenger compartment **210** may be specified in partition structure **432** and different location-based restriction policies may be specified in permission structure **434**. The structures **432** and **434** may be data structures, data files, or any other type of device (e.g. software or hardware) for storing information. Although the structures **432** and **434** are depicted as separate blocks, in other examples they may be integrated together. Furthermore, in some instances, the structures **432** and **434** may be stored on a remote device and accessed by the vehicle control unit **320** over a network connection.

FIG. **5** depicts a schematic diagram of the logical partition structure **432**. In this example, the logical partition structure **432** divides the passenger compartment **210** into four regions, numbered **1** through **4**, respectively. As illustrated in FIG. **6**, region #1 is collocated with the driver seat **220***a*, region #2 is collocated with the front passenger seat **220***b*, and regions #3 and #4 are collocated with the rear passenger seats **220***c-d*. The location of the control device **230**, as discussed, may be determined using radio receivers **610***a-d*. The radio receivers may measure the power of radio signals emitted by the control device **230** and triangulate the signals to determine the location of the control device **230**.

As illustrated in FIG. **5**, the different regions of passenger compartment **210** may be represented as sets of coordinates. In one alternative example however, each region may be presented as a single coordinate and a radius. In another alternative example, however, regions #1-4 may be represented by 4-tupples of signal strength ranges (e.g., sets of signal strength ranges that are expected to be measured by each of the receivers **610***a-d* when the control device **230** is in a given region). Stated succinctly, the indications of regions of the logical partition structure **432** may include any type of information capable of being used to distinguish from one another different portions of the passenger compartment **210**.

Although in this example the depicted passenger compartment includes a standard layout featuring two front seats and two backseats, in other examples other less conventional seating arrangements are possible. For instance, in autonomous vehicles, the driver's seat may be placed in another location, such as a location other than the front left (or right) portion of the vehicle compartment **210**. In that regard, each one of the regions #1-4 may be located anywhere in the vehicle compartment **210** and each one of the regions #1-4 may have any

shape or size. Also, there can may be any number of regions, and not just four (4) (e.g., 2, 3, 5, 7, 20, 120).

Furthermore, although in this example regions #1-4 exist in the same horizontal plane, in other examples the regions may be situated in different horizontal planes. For example, in double-deck vehicles (e.g., busses or planes), different regions may be specified on the different vehicle decks. Such regions, for example, may be located above or below one another. Accordingly, in such instances, the regions may be defined using three-dimensional coordinate systems or any other approach capable of accounting for the vertical positioning of a region within the passenger compartment **210**.

FIG. **7** depicts a schematic diagram of the permissions structure **434**. In this example, the structure includes a plurality of entries **434***a-e*. Each entry may include an indication of an instruction and an indication of one or more regions from where the instruction is permitted to be invoked. For instance, according to this example, the instructions "stop vehicle" or "accelerate" may be invoked by the control device **230** only when the control device **230** is located in region #1. Similarly, as another example, the instruction "change "radio station" may be invoked only when the control device **230** is located in regions #1-2, and the instruction "change temperature" may be invoked from anywhere in the passenger compartment **210**.

FIG. **8** depicts a flowchart of a process **800** associated with the operation of the vehicle **101** in accordance with aspects of the disclosure. At task **810**, the vehicle control unit **320** is configured to store location-based permissions for one or more instructions. In some instances, the permissions may be factory-specified and in other instances the permissions may be specified by the user. For example, a user may be presented with a user interface and allowed to enter via the user interface at least one of (1) an indication of an instruction and (2) an indication of at least one region in the passenger compartment **210** where the control device **230** is permitted to invoke the instruction from. The user interface may be presented on a display screen of the vehicle control unit **320**, or alternatively, it may be presented on a display of the control device **230**. In the latter instance, after the user input is entered, an indication of the user input may be communicated by the control device **230** to the vehicle control unit **320**. The vehicle control unit **320** may then create and store a new entry in the permissions structure **432** based on the received user input.

At task **820**, a connection between the control device **230** and the vehicle control unit **320** is established. The connection may be either wired or wireless. To establish the connection, any communications protocol may be utilized, such as TCP/IP, Bluetooth, USB, wireless USB, WiFi, or a custom communications protocol.

At task **830**, a user interface for controlling one or more aspects of the operation of vehicle **101** is presented on the control device **230**. Examples of user interfaces that may be displayed on a display screen of the control device **230** are provided in FIGS. **9**A-B, respectively. As illustrated in FIG. **9**A, the user interface **900**A may provide buttons **910***a-j* that enable control over different aspects of the operation of the vehicle **101**. For example, clicking on the button **910***a* may lead users to a menu that enables the steering, stopping, or acceleration of the vehicle **101**. Clicking on the button **910***b* may take users to a menu that enables the turning on/off of the vehicle's **101** headlights. Clicking on the button **910***c* may take users to a menu for setting a new destination for the vehicle **101** to travel to. Clicking on the button **910***d* may take users to a menu that enables the turning on/off of the vehicle's **101** windshield wipers. Clicking on the menu **910***e* may take users to a menu that enables controlling vehicle's **101** entertainment system. Clicking on the button **910***f* may take users to a menu that enables turning on/off of the vehicle's **101** electronic stability control. Clicking on the button **910***g* may take users to a menu that enables changing various climate control settings, such as turning on/off of an air conditioner or increasing the temperature in the passenger compartment **210**. Clicking on the button **910***h* may take users to a menu that enables the turning on/off of the vehicle's **101** interior lights. Clicking on the button **910***i* may take users to a menu that enables the rolling up/down of the windows of the vehicle **101**. Clicking on the button **910***j* may take users to a menu that enables the locking and unlocking of the vehicle's **101** doors. Various other buttons and controls may also be used.

In some aspects, the user interface presented by the control device **230** may be varied in dependence upon the location of the control device **230** in the vehicle cab **210**. For example, only if the control device **230** is located in region #1, the menu **900**A may be displayed. By contrast, when the control device **230** is located in regions #2-3, the menu **900**B may be displayed. As illustrated in this example, the interface **900**A may include input components (e.g., buttons, text input field, sliders, check boxes, etc.) for safety-critical aspects of the operation of the vehicle **101**, such as accelerating, steering, and braking, whereas the interface **900**B may lack such input components for controlling safety-critical aspects of the operation of the vehicle **101**.

Returning to FIG. **8**, at task **840**, user input is entered into the control device **230**. The user input may be entered using a touch screen, trackball, keyboard, microphone, or any other user input device. The user input may specify an instruction to change a state of a vehicle system, such as the vehicle systems **310***a-f*, and as such it may identify a control action that is requested to be performed by the vehicle **101**. At task **850**, an indication of the instruction is transmitted by the control device **230** to the vehicle control unit **320**. The transmitted indication is received by the vehicle control unit at task **860**.

At task **870**, the vehicle control unit **320** determines the current location of the control device **230**. Without limitation, the current location of the control device **230** may be the location where the control device is located when task **870** is executed, the location where the control device is located when task **860** is executed, or the location of the control device **230** at another time instant that is substantially cotemporaneous with the time instant when either one of task **860** or task **870** is executed.

As discussed above, the current location of the control device **230** may be determined using the radio receivers **610***a-d*. In other examples, the control device **230** may determine its location and communicate it to the vehicle control unit **230**. For example, instead of the radio receivers **610***a-d*, transmitters may be positioned at various locations in the vehicle **101** and the control device **230** may triangulate signal strength measurements from those transmitters to independently determine its location within the passenger compartment **210**.

At task **880**, the vehicle control unit **320** determines whether the instruction is permitted to be invoked from the current location of the control device **230**. The determination may be based on the permissions structure **434** or another similar data structure. The determination may involve finding out whether the current location of the vehicle **101** is within one or more regions in the passenger compartment **210** where the instruction is permitted to be invoked from. If the current location of the control device **230** is within one of the regions where the instruction is permitted to be invoked from, task **885** is executed. Otherwise, if the control device **230** is outside of any regions where the instruction is permitted to be invoked from, task **895** is performed.

At task **885**, the vehicle control unit **320** executes the instruction. By way of example, executing the instruction may involve the vehicle control unit **320** activating an actuator, closing a switch, or performing some other task necessary to accomplish the action requested by the user. At task **895**, the vehicle control unit **320** refuses to execute the instruction. Refusing to execute the instruction includes refraining from executing the instruction. Furthermore, in some instances, but not necessarily, refusing to execute the instruction may include transmitting an indication back to the control device **230** that execution of the instruction has been refused.

FIG. **10** depicts a flowchart of a process **1000** associated with the operation of the control device **230**. Unlike the process **800**, in this example, the control device **230** enforces location-based restrictions on instructions that are invoked via the control device **230**. To this end, the control device **230** may store data structures, such as the logical partition structure **432** and the permissions structure **434**, in local memory (e.g., in a volatile or non-volatile memory module that is part of the device) and use these data structures to enforce location-based permissions.

At task **1010**, the control device **230** is configured to store location-based permissions for one or more instructions. In some instances, the permissions may be factory-specified and in other instances the permissions may be specified by the user. For example, a user may be presented with a user interface and allowed to enter via the user interface at least one of (1) an indication of an instruction and (2) an indication of at least one region in the passenger compartment **210** where the control device **230** is permitted to invoke the instruction from. The instructions may be related to the operation of the vehicle **101** (e.g., steer, brake, set destination, change interior temperature, open/lock doors) or alternatively, the instructions may be un-related to the operation of the vehicle **101** (e.g., make a phone call, send a text message, play a video game, open a text editing software application, play a movie, play a particular movie title). In some aspects, the location based permissions may be entered manually into the control device **230** by using a user interface that is presented on a display screen of the control device **230**. In other aspects, the location-based permissions may be transmitted to the control device by a remote device, over a communications network connection.

At task **1020**, user input is entered into the control device **230**. The user input may be entered using a touch screen, trackball, keyboard, microphone, or any other input device. The user input may identify a control action that is requested to be performed by the vehicle **101** or the control device **230**.

At task **1030**, the control device **230** determines its current location within the passenger compartment **210**. At task **1040**, the control device **230** determines whether the instruction is permitted to be invoked from the current location of the control device **230**. In one example, the determination may be based on a permissions structure, such as the permissions structure **434**. The determination may involve determining whether the current location of the vehicle **101** is within one or more regions from where the instruction is permitted to be invoked. If the current location of the control device **230** is within one of the regions from where the instruction is permitted to be invoked, the control device **230** carries the instruction at task **1050**. In one aspect, carrying the instruction may include transmitting an indication of the instruction to the vehicle control unit **230** for further execution. In another aspect, carrying the instruction may include executing the instruction by the control device **230**. That is, in instances where the control device **230** is a smart phone, the control device **230** may initiate phone call, start a software application, or transmit the instruction to another computing device in the vehicle **101** that is not involved in controlling the operation of the vehicle (e.g., a computer terminal used by a stewardess).

Returning to task **1040**, if the current location of the control device **230** is outside of the any of the regions from where the instruction is permitted to be invoked, the control device **230** refuses to carry the instruction at task **1060**. Refusing to carry the instruction includes refraining from carrying the instruction. In some instances, but not necessarily, refusing to execute the instruction may include outputting, by the control device **230**, of an indication that the instruction has been refused.

FIG. **11** depicts a flowchart of a process **1100** that is associated with the operation of the control device **230**. Tasks in the process **1100** may be performed by the control device **230** or by both the control device **230** and the vehicle control unit **320**. At task **1110**, the current location of the control device **230** within the passenger compartment **230** is determined. As noted, the control device **230** may determine the current location by itself, or alternatively, it may receive an indication of the current location from the vehicle control unit **230**. At task **1120**, one of a plurality of user interfaces (or user interface components) is selected based on the location of the control device **230**.

For example, returning to FIG. **9**A, the interface **900***a* may be selected when the control device **230** is located in region #1 and the interface **900***b* may be presented when the control device is located in regions #2-4. The selection of user interfaces, or components thereof, may be implemented using a table, or another similar data structure, that relates one or more indications of regions in the passenger compartment **210** with identifiers of user interfaces or user interface components (e.g., menus, buttons, sliders, checkboxes) that may be displayed by the control device **230** when the control device **230** is located in those regions. For instance, the data structure may associate the interface **900***a* with region #1 and the interface **900***b* with regions #2-4. At task **1130**, the control device **1230** presents the interface on a display screen. In other instances, where audio user interfaces are used, such as Interactive Voice Response interfaces, those interfaces may be presented using a speaker. The disclosure is not limited to any type of user interface or output device for presenting the user interface.

FIGS. **1-11** are provided as examples only. At least some of the tasks may be performed in a different order than represented, performed concurrently, or altogether omitted. In addition, other tasks may also be included. Although in the above examples, the location-based permissions module **442** is implemented using software, in other examples it may be implemented using hardware (e.g., implemented using an FPGA) or a combination of hardware and software. Furthermore, although the above examples discuss withholding presentation of user interface components based on the location of the control device **230**, in other examples user components may be only disabled. That is, the user interface components may remain visible to the user, but they may be rendered inactive when the control device **230** is not located in a region in the passenger compartment **210** where it is permitted to invoke instructions associated with the user interface components.

As discussed above, varying the operational capabilities of the control device **230** in dependence upon its location may enable the allocation of different privileges to different occupants of a vehicle. This concept may be applied particularly in mass transit applications. In such applications, the control device **230** may be used to provide different electronic ser-

vices (e.g., playing movies, playing music, electronically requesting a drink or another amenity from wait staff) in dependence upon its location. For example, control devices that are located towards the front of an air plane (first class) may be permitted to play a greater selection of movies than devices located in the economy class portions of the plane. Similarly, control devices located only in the first-class section of the airplane, may be enabled to display a menu that allows their users to electronically order a drink. Accordingly, in instances where the control device **230** is used to render electronic services to mass transit passengers, the decision of whether a particular electronic service (e.g., playing movies at all, playing a particular movie, requesting a drink, or requesting another amenity) may be rendered by the control device **230** to a user may depend, at least in part, on the device's location. In such instances, the process **800** may be performed by a media server, a computing device used by wait staff to receive orders, or another similar device.

As these and other variations and combinations of the features discussed above can be utilized without departing from the subject matter as defined by the claims, the foregoing description of exemplary aspects should be taken by way of illustration rather than by way of limitation of the subject matter as defined by the claims. It will also be understood that the provision of the examples described herein (as well as clauses phrased as "such as," "e.g.", "including" and the like) should not be interpreted as limiting the claimed subject matter to the specific examples; rather, the examples are intended to illustrate only some of many possible aspects.

The invention claimed is:

1. A method comprising:

receiving by one or more processors, over a wireless link, an instruction to change a state of a vehicle system, the vehicle system including at least one of a mechanical component that is part of a vehicle or an electronic component that is part of the vehicle, the instruction being transmitted by a portable control device and received by a vehicle control unit that is operatively connected to the vehicle system, wherein the vehicle control unit includes a processor coupled to a memory;

identifying a current location of the portable control device within a passenger compartment of the vehicle; and

depending on the current location of the portable control device, performing, by the one or more processors, one of the following tasks:

executing the instruction upon determination that the portable control device is located in a first region in the passenger compartment of the vehicle; or

refusing to execute the instruction upon determination that the portable control device is located in a second region in the passenger compartment of the vehicle;

wherein the vehicle system is one of a steering system, an acceleration system, or a braking system.

2. The method of claim **1**, further comprising:

determining, based on the current location of the portable control device, whether the portable control device is permitted to output a first user interface component for calling the instruction from the portable control device; and

outputting the first user interface component, by the portable control device, upon determining that the first user interface component is permitted to be output.

3. The method of claim **2**, wherein the portable control device is configured to store, in a memory, a data structure that relates the first user interface component with the first region in the passenger compartment of the vehicle, thereby indicating that the portable control device is permitted to output the first user interface component when the portable control device is located in the first region.

4. The method of claim **3**, wherein:

the first input component is part of a first user interface; and

the data structure indicates that the first user interface is permitted to be output by the portable control device when the portable control device is located in the first region.

5. The method of claim **1**, wherein the memory of the vehicle control unit stores a data structure that associates the instruction with one or more regions in the passenger compartment of the vehicle from where the instruction is permitted to be executed.

6. The method of claim **5**, further comprising accessing the data structure and determining whether the instruction should be executed based on the current location of the portable control device.

7. The method of claim **1**, wherein the portable control device is one of a smart phone, a tablet, or a laptop.

8. The method of claim **1**, wherein refusing to execute the instruction further includes transmitting to the portable control device a message indicating that the instruction will not be executed.

9. The method of claim **1**, further comprising receiving a user input indicating whether the instruction is permitted to be executed when the portable control device is located in the first region.

10. A vehicle comprising:

a passenger compartment;

a plurality of vehicle systems;

a vehicle control unit including a processor and a memory, the memory storing a permissions structure having one or more entries, each entry identifying an instruction and one or more regions in the passenger compartment from where the instruction is permitted to be invoked;

the processor being configured to:

receive, from a portable control device, an instruction to change a state of a first one of the plurality of vehicle systems;

determine a current location of the portable control device;

determine, based on the permissions structure, whether the current location is a location from where the first instruction is permitted to be executed; and

execute the first instruction when and only when it is determined that the first instruction is permitted to be executed from the current location;

wherein the plurality of vehicle systems includes at least one of a steering system, an acceleration system or a braking system.

11. The vehicle of claim **10**, wherein the portable control device is connected to the vehicle control unit via a wireless connection.

12. The vehicle of claim **10**, wherein the portable control device is connected to the vehicle control unit via a wired connection.

13. The vehicle of claim **10**, wherein the location of the portable control device is determined based on a radio signal transmitted by the portable control device.

14. The vehicle of claim **10**, wherein the plurality of vehicle systems further includes at least one of a climate control system and an entertainment system.

15. The vehicle of claim **10**, wherein the first instruction is an instruction to perform at least one of steering the vehicle, braking, activating a blinker, activating headlights of the vehicle, stopping the vehicle, changing a temperature setting of a heating or air conditioning system, or changing a volume on an audio system.

16. The vehicle of claim **10**, wherein the portable control device is one of a tablet, a laptop, or a smart phone.

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