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(54) **LOW-SPEED VEHICLE CONTROL**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

6,385,527 B1   5/2002 Zumberge et al.
7,117,077 B2   10/2006 Michi et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN   109070918 A   12/2018
CN   112297861 B   7/2022
(Continued)

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(57)   **ABSTRACT**

A computer includes a processor and a memory, and the
memory stores instructions executable by the processor to,
in response to one of a vehicle feature of a vehicle being
active or the vehicle being in a preset geographic area,
control acceleration and braking of the vehicle based on
input from an input device of the vehicle according to a
low-speed mode; and in response to the low-speed mode
being inactive, control acceleration and braking of the
vehicle not according to the low-speed mode. In the low-
speed mode, acceleration occurs upon receiving input from
the input device. In the low-speed mode, braking occurs
upon not receiving input from the input device.
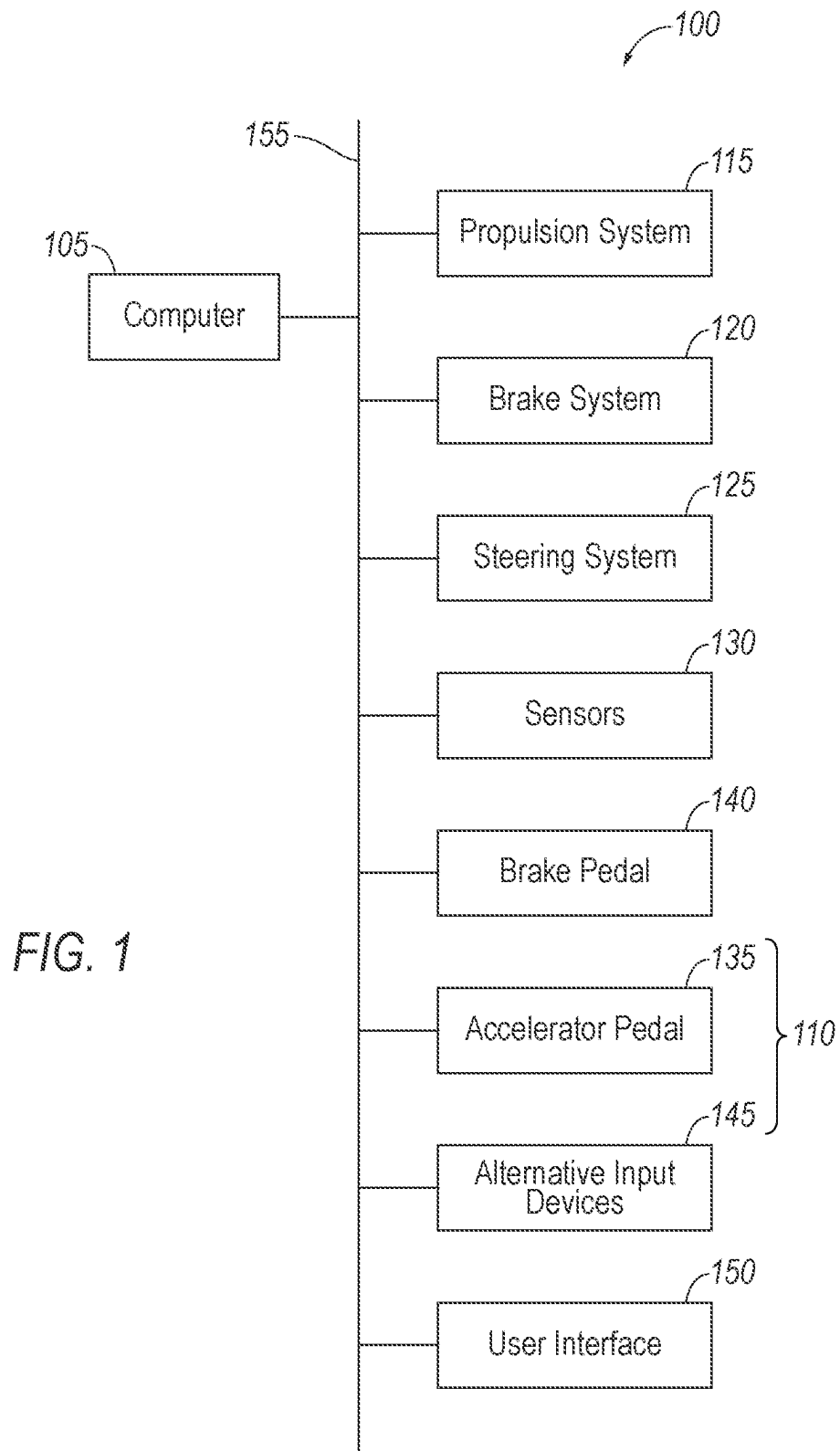
20 Claims, 4 Drawing Sheets
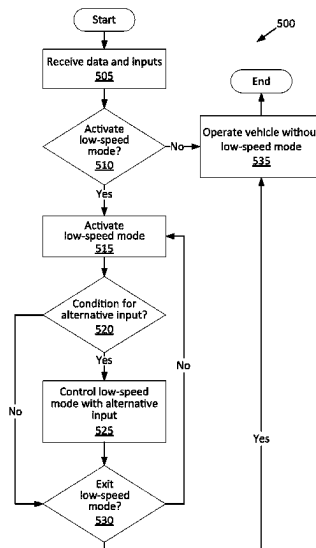
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(58) **Field of Classification Search**
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 See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,214,124 B2	7/2012	Kumabe et al.	
9,187,067 B2	11/2015	Breu	
10,137,872 B2	11/2018	Goto	
11,603,092 B2 *	3/2023	Ding	B60W 30/143
2006/0229771 A1	10/2006	Messner et al.	
2018/0141556 A1	5/2018	Goh	
2018/0154876 A1	6/2018	Kim	
2019/0161082 A1 *	5/2019	Fairgrieve	B60W 30/143
2020/0130452 A1 *	4/2020	Rothwell	B60T 8/175
2020/0298855 A1 *	9/2020	Demerly	B60W 30/143
2020/0317194 A1 *	10/2020	Yan	B60W 30/12
2021/0101596 A1	4/2021	Yan et al.	
2021/0403033 A1 *	12/2021	Cohen	B60W 60/0013
2022/0032929 A1 *	2/2022	Wang	B60W 60/0015
2022/0332312 A1 *	10/2022	Lee	B60W 30/16
2023/0021615 A1 *	1/2023	Inaba	F16D 61/00

FOREIGN PATENT DOCUMENTS

EP	1695859	A1	8/2006
EP	1702786	A1	9/2006
EP	3858696	A1	8/2021
WO	2018085324	A1	5/2018
WO	2021139710	A1	7/2021

* cited by examiner

FIG. 1

215 — Two-Pedal Drive

205 — Low-Speed Mode

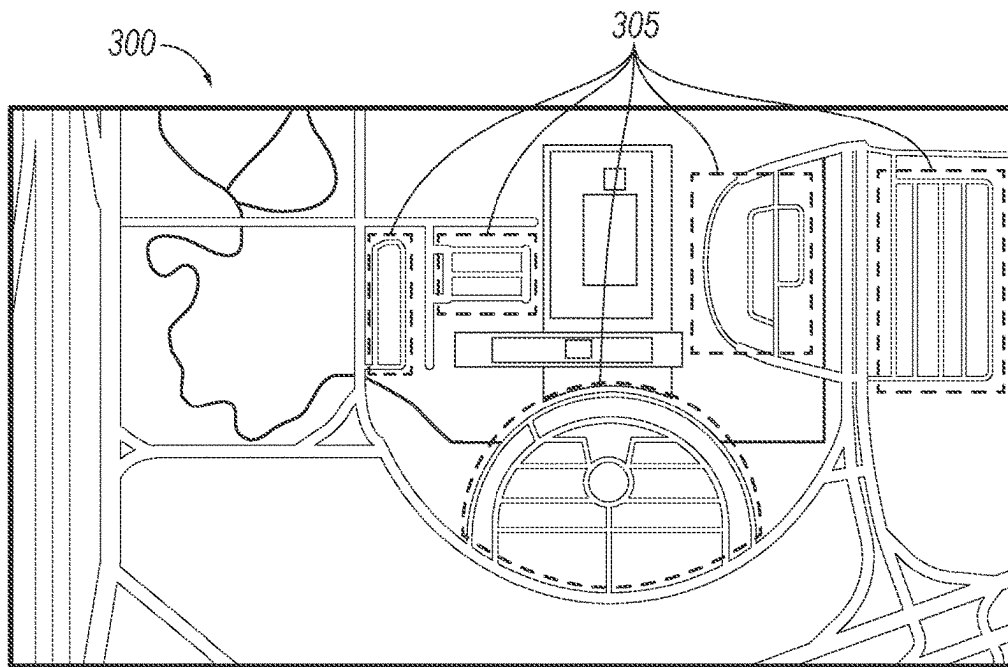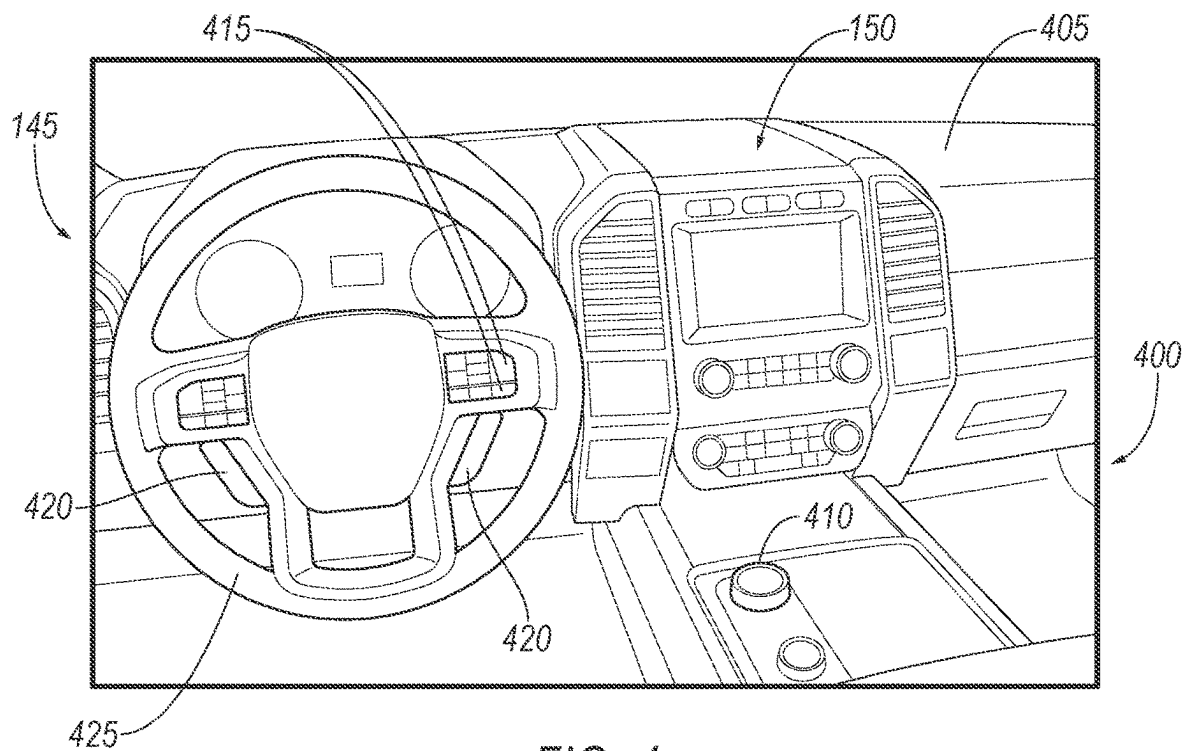210 — Low-Speed Mode with Alternative Input Devices

FIG. 2
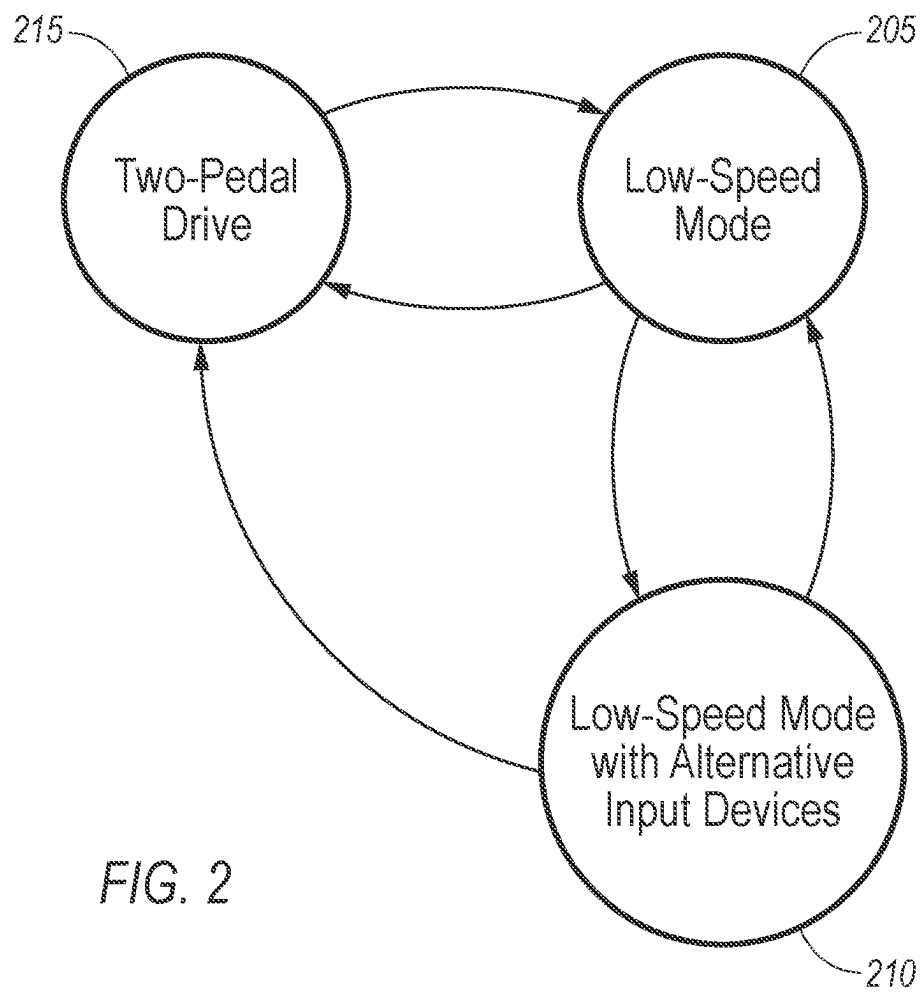
FIG. 3

FIG. 4
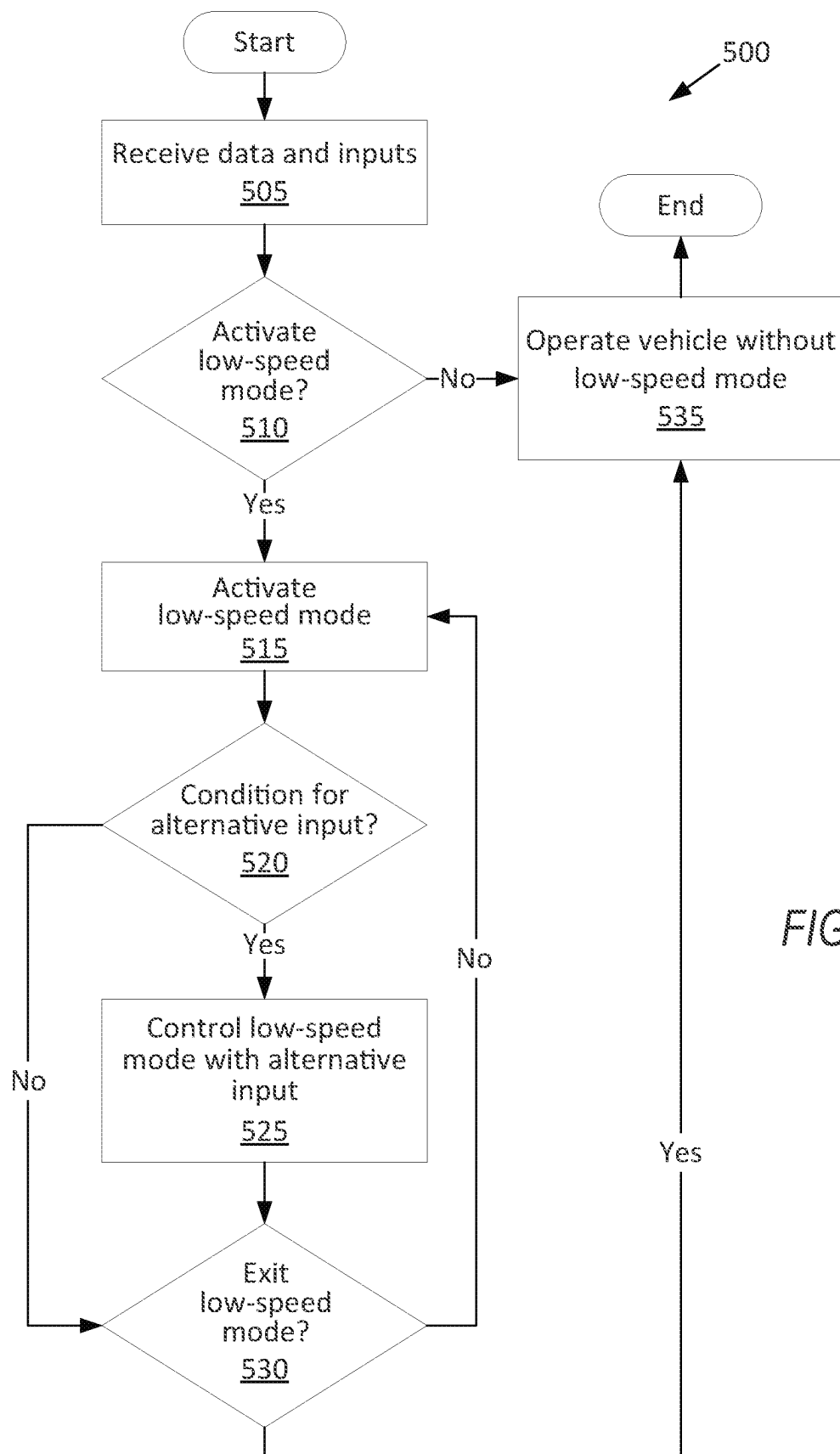
FIG. 5

LOW-SPEED VEHICLE CONTROL

BACKGROUND

Some electric vehicles are equipped with one-pedal drive. When the one-pedal drive is disengaged (or when a vehicle is not equipped with one-pedal drive), the vehicle will drive at a slow speed when no pressure is applied to the accelerator pedal or to the brake pedal. This is called creep torque. When an operator engages one-pedal drive, the vehicle will accelerate when pressure is applied to the accelerator pedal, and the vehicle will brake when no pressure is applied to the accelerator pedal, even if no pressure is applied to the brake pedal. In other words, the vehicle does not use creep torque when one-pedal drive is engaged.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an example vehicle.

FIG. **2** is a network graph of example modes of the vehicle.

FIG. **3** is a diagram of an example preset geographic area.

FIG. **4** is a plan view of an example instrument panel of the vehicle.

FIG. **5** is a flowchart of an example process for controlling the vehicle with a low-speed mode.

DETAILED DESCRIPTION

This disclosure describes techniques for controlling a vehicle using a low-speed mode. A computer of the vehicle is programmed to, under certain conditions, control acceleration and braking of the vehicle based on input from an input device of the vehicle according to the low-speed mode. In the low-speed mode, acceleration occurs upon receiving input from the input device, and braking occurs upon not receiving input from the input device. If the low-speed mode is inactive, the computer controls acceleration and braking of the vehicle not according to the low-speed mode, e.g., according to a two-pedal-drive mode in which creep torque is exhibited. The input device may be an accelerator pedal of the vehicle or may be an alternative input device such as a knob, button, or paddle. The conditions being satisfied may prompt activation of the low-speed mode, i.e., accepting inputs from the accelerator pedal according to the low-speed mode. Alternatively or additionally, when the low-speed mode is already active, the conditions being satisfied may prompt acceptance of inputs from one or more of the alternative input devices.

The conditions include one of a vehicle feature of the vehicle being active or the vehicle being in a preset geographic area. Examples of vehicle features include adaptive cruise control and automatic vehicle hold. The preset geographic area may be, e.g., a parking lot or other environment in which low-speed movement of the vehicle is expected. Use of these conditions may provide a smoother transition for the operator to providing input for the low-speed mode. For example, if the low-speed mode is activated in response to the adaptive cruise control being active while the vehicle is stopped (e.g., as occurs in stop-and-go traffic), the operator may be able to move the vehicle closer to a leading vehicle without needing to quickly press the accelerator pedal and then the brake pedal. Instead, braking occurs upon release of the accelerator pedal. For another example, if the use of an alternative input device is activated to control the vehicle in the low-speed mode while the vehicle is in a parking lot, the operator may be able to quickly transition

from using the accelerator pedal to using the alternative input device in order to more finely control the position of the vehicle when parking.

A computer includes a processor and a memory, and the memory stores instructions executable by the processor to, in response to one of a vehicle feature of a vehicle being active or the vehicle being in a preset geographic area, control acceleration and braking of the vehicle based on input from an input device of the vehicle according to a low-speed mode; and in response to the low-speed mode being inactive, control acceleration and braking of the vehicle not according to the low-speed mode. In the low-speed mode, acceleration occurs upon receiving input from the input device. In the low-speed mode, braking occurs upon not receiving input from the input device.

In an example, the instructions may further include instructions to, in response to (1) a speed at which the vehicle is traveling being below a threshold and (2) one of the vehicle feature being active or the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode.

In an example, the input device may include an accelerator pedal. In a further example, the instructions may further include instructions to, in response to the accelerator pedal being pressed by at least a preset amount, deactivate the low-speed mode.

In an example, the instructions may further include instructions to, in response to the vehicle feature being active, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode. In a further example, the vehicle feature may include adaptive cruise control.

In another further example, the vehicle feature may include automatic vehicle hold, and the instructions may further include instructions to, in response to the automatic vehicle hold being active, brake the vehicle in response to a brake pedal of the vehicle being released while the vehicle is stopped.

In an example, the instructions may further include instructions to, in response to the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode. In a further example, the preset geographic area may include areas designated in map data as parking areas.

In another further example, the preset geographic area may include a user-inputted geographic area.

In another further example, the instructions may further include instructions to, in response to the vehicle being in the preset geographic area, control acceleration and braking of the vehicle to prevent the vehicle from exceeding a preset speed.

In an example, the instructions may further include instructions to, in response to the low-speed mode being active and the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode. In a further example, the input device may include an alternative input device other than an accelerator pedal.

In an example, the input device may include an alternative input device other than an accelerator pedal. In a further example, the alternative input device may include a knob.

In another further example, the alternative input device may include a button.

In another further example, the alternative input device may include a paddle.

In another further example, the instructions may further include instructions to control acceleration and braking of the vehicle to travel a distance and then stop, the distance being a function of an input from the alternative input device.

In another further example, an input from the alternative input device may include a direction of the input, and the instructions may further include instructions to control acceleration and braking of the vehicle to travel forward in response to the direction of the input being a first direction and to travel in reverse in response to the direction of the input being a second direction.

A method includes, in response to one of a vehicle feature of a vehicle being active or the vehicle being in a preset geographic area, controlling acceleration and braking of the vehicle based on input from an input device of the vehicle according to a low-speed mode; and in response to the low-speed mode being inactive, controlling acceleration and braking of the vehicle not according to the low-speed mode. In the low-speed mode, acceleration occurs upon receiving input from the input device. In the low-speed mode, braking occurs upon not receiving input from the input device.

With reference to the Figures, wherein like numerals indicate like parts throughout the several views, a computer **105** includes a processor and a memory, and the memory stores instructions executable by the processor to, in response to one of a vehicle feature of a vehicle **100** being active or the vehicle **100** being in a preset geographic area **305**, control acceleration and braking of the vehicle **100** based on input from an input device **110** of the vehicle **100** according to a low-speed mode **205, 210**; and in response to the low-speed mode **205, 210** being inactive, control acceleration and braking of the vehicle **100** not according to the low-speed mode **205, 210**. In the low-speed mode **205, 210**, acceleration occurs upon receiving input from the input device **110**. In the low-speed mode **205, 210**, braking occurs upon not receiving input from the input device **110**.

With reference to FIG. **1**, the vehicle **100** may be any passenger or commercial automobile such as a car, a truck, a sport utility vehicle, a crossover, a van, a minivan, a taxi, a bus, etc.

The computer **105** is a microprocessor-based computing device, e.g., a generic computing device including a processor and a memory, an electronic controller or the like, a field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC), a combination of the foregoing, etc. Typically, a hardware description language such as VHDL (VHSIC (Very High Speed Integrated Circuit) Hardware Description Language) is used in electronic design automation to describe digital and mixed-signal systems such as FPGA and ASIC. For example, an ASIC is manufactured based on VHDL programming provided pre-manufacturing, whereas logical components inside an FPGA may be configured based on VHDL programming, e.g., stored in a memory electrically connected to the FPGA circuit. The computer **105** can thus include a processor, a memory, etc. The memory of the computer **105** can include media for storing instructions executable by the processor as well as for electronically storing data and/or databases, and/or the computer **105** can include structures such as the foregoing by which programming is provided. The computer **105** can be multiple computers coupled together.

The computer **105** may transmit and receive data through a communications network **155** such as a controller area network (CAN) bus, Ethernet, WiFi, Local Interconnect Network (LIN), onboard diagnostics connector (OBD-II), and/or by any other wired or wireless communications network. The computer **105** may be communicatively coupled to a propulsion system **115**, a brake system **120**, a steering system **125**, sensors **130**, an accelerator pedal **135**, a brake pedal **140**, alternative input devices **145**, a user interface **150**, and other components via the communications network **155**.

The propulsion system **115** of the vehicle **100** generates energy and translates the energy into motion of the vehicle **100**. The propulsion system **115** may be a conventional vehicle propulsion subsystem, for example, a conventional powertrain including an internal-combustion engine coupled to a transmission that transfers rotational motion to wheels; an electric powertrain including batteries, an electric motor, and a transmission that transfers rotational motion to the wheels; a hybrid powertrain including elements of the conventional powertrain and the electric powertrain; or any other type of propulsion. The propulsion system **115** can include an electronic control unit (ECU) or the like that is in communication with and receives input from the computer **105** and/or a human operator. The human operator may control the propulsion system **115** via, e.g., the accelerator pedal **135** and/or a gear-shift lever, as well as with the alternative input devices **145** as described below.

The brake system **120** is typically a conventional vehicle braking subsystem and resists the motion of the vehicle **100** to thereby slow and/or stop the vehicle **100**. The brake system **120** may include friction brakes such as disc brakes, drum brakes, band brakes, etc.; regenerative brakes; any other suitable type of brakes; or a combination. The brake system **120** can include an electronic control unit (ECU) or the like that is in communication with and receives input from the computer **105** and/or a human operator. The human operator may control the brake system **120** via, e.g., the brake pedal **140**, as well as with the alternative input devices **145** as described below.

The steering system **125** is typically a conventional vehicle steering subsystem and controls the turning of the wheels. The steering system **125** may be a rack-and-pinion system with electric power-assisted steering, a steer-by-wire system, as both are known, or any other suitable system. The steering system **125** can include an electronic control unit (ECU) or the like that is in communication with and receives input from the computer **105** and/or a human operator. The human operator may control the steering system **125** via, e.g., a steering wheel **425**.

The sensors **130** may provide data about operation of the vehicle **100**, for example, vehicle speed, wheel speed, wheel orientation, and engine and transmission data (e.g., temperature, fuel consumption, etc.). The sensors **130** may detect the location and/or orientation of the vehicle **100**. For example, the sensors **130** may include global positioning system (GPS) sensors; accelerometers such as piezo-electric or microelectromechanical systems (MEMS); gyroscopes such as rate, ring laser, or fiber-optic gyroscopes; inertial measurements units (IMU); and magnetometers. The sensors **130** may detect the external world, e.g., objects and/or characteristics of surroundings of the vehicle **100**, such as other vehicles, road lane markings, traffic lights and/or signs, pedestrians, etc. For example, the sensors **130** may include radar sensors, ultrasonic sensors, scanning laser range finders, light detection and ranging (lidar) devices, and image processing sensors such as cameras.

The accelerator pedal **135** provides input to the computer **105** indicating a position of the accelerator pedal **135** for use in controlling the propulsion system **115** and/or the brake system **120**. The accelerator pedal **135** is positioned to be pressable by an operator of the vehicle **100**. The accelerator

pedal 135 is movable relative to the body of the vehicle 100, e.g., is coupled by a hinge to the body of the vehicle 100. The accelerator has a range of motion, e.g., an angular range of motion around the hinge. The position of the accelerator pedal 135 within the range of motion is reported to the computer 105.

The brake pedal 140 provides input to the computer 105 indicating a position of the brake pedal 140 for use in controlling the brake system 120. The brake pedal 140 is positioned to be pressable by an operator of the vehicle 100. The brake pedal 140 is movable relative to the body of the vehicle 100, e.g., is coupled by a hinge to the body of the vehicle 100. The brake has a range of motion, e.g., an angular range of motion around the hinge. The position of the brake pedal 140 within the range of motion is reported to the computer 105.

The input device 110 may include the accelerator pedal 135 and one or more alternative input devices 145. An alternative input device 145 is a component other than the accelerator pedal 135 that is manipulable by an operator of the vehicle 100 for controlling the propulsion system 115 under at least some circumstances. The alternative input devices 145 provide input to the computer 105 for use in controlling the propulsion system 115 and the brake system 120 when the vehicle 100 is in a specific mode, as described below with respect to FIG. 2. Examples of the alternative input devices 145 are described below with respect to FIG. 4.

The user interface 150 presents information to and receives information from an occupant of the vehicle 100. The user interface 150 may be located, e.g., on an instrument panel 405 in a passenger cabin 400 of the vehicle 100, or wherever may be readily seen by the occupant. The user interface 150 may include dials, digital readouts, screens, speakers, and so on for providing information to the occupant, e.g., human-machine interface (HMI) elements such as are known. The user interface 150 may include buttons, knobs, keypads, microphone, and so on for receiving information from the occupant. The user interface 150 may include the alternative input devices 145.

The vehicle 100 may have a plurality of vehicle features. For the purposes of this disclosure, a "vehicle feature" is defined as an activatable functionality or set of functionalities of the vehicle 100. For example, the vehicle features may be advanced driver assistance systems (ADAS). The vehicle features may affect the operation of the acceleration and/or braking of the vehicle 100, i.e., the propulsion system 115 and/or the brake system 120. For example, the vehicle features may include adaptive cruise control, automatic vehicle hold, etc.

The vehicle features may include adaptive cruise control. When adaptive cruise control is engaged, the computer 105 accelerates the vehicle 100 to maintain the vehicle speed at an operator-selected speed when data from the sensors 130 indicate no objects within a threshold distance in front of the vehicle 100, and the computer 105 brakes the vehicle 100 and/or reduces acceleration to maintain at least the threshold distance with a nearest object detected by the sensors 130 in front of the vehicle 100.

The vehicle 100 feature may include automatic vehicle hold. In response to the automatic vehicle hold being active, the computer 105 brakes the vehicle 100 in response to a brake pedal 140 of the vehicle 100 being released while the vehicle 100 is stopped. In other words, when the vehicle 100 is stopped, the vehicle 100 remains stopped until the computer 105 receives an input to accelerate. Thus, the vehicle 100 does not exhibit creep torque when stopped.

With reference to FIG. 2, when the vehicle 100 is in the low-speed mode 205, 210, the computer 105 is programmed to control acceleration and braking of the vehicle 100 based on input from the input devices 110 of the vehicle 100 according to the low-speed mode 205, 210. In the low-speed mode 205, 210, acceleration occurs upon receiving input from one of the input devices 110. In other words, the computer 105 actuates the propulsion system 115 to accelerate the vehicle 100 upon receiving input from one of the input devices 110. The acceleration may be capped at a maximum torque or maximum speed. The maximum torque or maximum speed may be chosen to keep the vehicle 100 within speeds appropriate for parking or similar maneuvers. In the low-speed mode 205, 210, braking occurs upon not receiving input from the input device 110, e.g., from the accelerator pedal 135 or from any of the alternative input devices 145. In other words, the computer 105 actuates the brake system 120 to slow or stop the vehicle 100 upon not receiving input from any of the input devices 110 that are currently designated to provide input controlling acceleration, even if the brake pedal 140 is not being pressed. The braking force applied by the brake system 120 may depend on circumstances such as how the low-speed mode 205, 210 was engaged. For example, the braking force may be applied by regenerative brakes of the brake system 120 and may slow the vehicle 100 more gradually (sometimes called one-pedal drive), or the braking force may be applied by the disc brakes of the brake system 120 at a typical braking force used when the brake pedal 140 is engaged. In the low-speed mode 205, 210, braking also occurs upon receiving an input from the brake pedal 140, in the same manner as occurs in a two-pedal-drive mode 215.

The low-speed mode 205, 210 may include a first low-speed mode 205 and a second low-speed mode 210. In the first low-speed mode 205, the accelerator pedal 135 is designated to provide input controlling acceleration, and the alternative input devices 145 are not designated to provide input controlling acceleration. In other words, in the first low-speed mode 205, the computer 105 is programmed to control acceleration based on input from the accelerator pedal 135 and ignore inputs from the alternative input devices 145. In the first low-speed mode 205, braking occurs upon not receiving input from the accelerator pedal 135, regardless of input from the alternative input devices 145. In the second low-speed mode 210, the accelerator pedal 135 and the alternative input devices 145 are designated to provide input controlling acceleration. In other words, in the second low-speed mode 210, the computer 105 is programmed to control acceleration based on input from any of the input devices 110. In the second low-speed mode 210, braking occurs upon not receiving input from any of the input devices 110, i.e., from the accelerator pedal 135 or any of the alternative input devices 145.

The computer 105 is programmed to, in response to the low-speed mode 205, 210 being inactive, control acceleration and braking of the vehicle 100 not according to the low-speed mode 205, 210. For example, the vehicle 100 may be in the two-pedal-drive mode 215. In the two-pedal-drive mode 215, acceleration occurs upon receiving input from the accelerator pedal 135, and braking occurs upon receiving input from the brake pedal 140. If neither the accelerator pedal 135 nor the brake pedal 140 are providing input (i.e., are pressed by the operator), then friction will slow the vehicle 100, and the vehicle 100 will exhibit creep torque at low speeds.

The computer 105 is programmed to switch the vehicle 100 between the modes 205, 210, 215 under various con-

ditions, as will be described below. The computer **105** may switch from the two-pedal-drive mode **215** to the low-speed mode **205**, **210**, specifically the first low-speed mode **205**. The computer **105** may switch from the low-speed mode **205**, **210**, either the first low-speed mode **205** or the second low-speed mode **210**, to the two-pedal-drive mode **215**. The computer **105** may be able to switch from the first low-speed mode **205** to the second low-speed mode **210** but not from the two-pedal-drive mode **215** to the second low-speed mode **210**. In other words, the second low-speed mode **210** may only be entered from the first low-speed mode **205**.

The computer **105** is programmed to switch the vehicle **100** from the two-pedal-drive mode **215** to the low-speed mode **205**, **210**, specifically the first low-speed mode **205**, in response to one or a combination of (1) a speed at which the vehicle **100** is traveling (i.e., the vehicle speed) being below a threshold, (2) one of the vehicle features being active, and (3) receiving an input from an operator indicating to switch the vehicle **100** to the first low-speed mode **205**. For example, the computer **105** may switch the vehicle **100** from the two-pedal-drive mode **215** to the first low-speed mode **205** in response to both (1) the vehicle speed being below the threshold and (2) one of the vehicle features being active. For another example, the computer **105** may switch the vehicle **100** from the two-pedal-drive mode **215** to the first low-speed mode **205** in response to receiving the input from the operator indicating to switch the vehicle **100** to the first low-speed mode **205**.

The condition for switching the vehicle **100** to the first low-speed mode **205** may include the vehicle speed being below the threshold. The computer **105** may receive the vehicle speed from the sensors **130** over the communications network **155**. The threshold may be a preset value stored in the memory of the computer **105**. The threshold may be chosen to be a typical speed used for parking the vehicle **100**, e.g., 2 miles per hour.

The condition for switching the vehicle **100** to the first low-speed mode **205** may include one of the vehicle features being active. For example, the condition may include that one of adaptive cruise control or automatic vehicle hold are active.

The condition for switching the vehicle **100** to the first low-speed mode **205** may include receiving the input from the operator indicating to switch the vehicle **100** to the first low-speed mode **205**. For example, the operator may provide the input via the user interface **150**, e.g., using a button or touchscreen.

One or more characteristics of the first low-speed mode **205** may be dependent on the manner of switching to the first low-speed mode **205**. For example, the braking force may be dependent on the manner of switching. When the first low-speed mode **205** was activated by the vehicle feature being active, the computer **105** may use the disc brakes when actuating the brake system **120**. When the first low-speed mode **205** was activated by the input from the operator, the computer **105** may use the regenerative brakes when actuating the brake system **120** as a result of a lack of input from the input device **110** and may use the disc brakes when actuating the brake system **120** as a result of an input from the brake pedal **140**.

The computer **105** may be programmed to deactivate the low-speed mode **205**, **210**, e.g., switch the vehicle **100** from either the first low-speed mode **205** or the second low-speed mode **210** to the two-pedal-drive mode **215**, in response to one of (1) the accelerator pedal **135** being pressed by at least a preset amount or (2) receiving an input from an operator indicating to deactivate the low-speed mode **205**, **210**.

The condition for deactivating the low-speed mode **205**, **210** may include the accelerator pedal **135** being pressed by at least a preset amount. The computer **105** may receive the position of the accelerator pedal **135** via the communications network **155**. The computer **105** may compare the position of the accelerator pedal **135** within the range of motion with the position of the preset amount within the range of motion. The preset amount may be chosen to indicate a desired speed greater than a typical speed used for parking, e.g., 10 miles per hour.

The condition for deactivating the low-speed mode **205**, **210**, e.g., switching the vehicle **100** from the first low-speed mode **205** or second low-speed mode **210** to the two-pedal-drive mode **215**, may include receiving the input from the operator indicating to deactivate the low-speed mode **205**, **210**. For example, the operator may provide the input via the user interface **150**, e.g., using a button or touchscreen.

The computer **105** may be programmed to switch the vehicle **100** to the second low-speed mode **210**, i.e., control acceleration and braking of the vehicle **100** based on input from the alternative input devices **145**, in response to one or a combination of (1) the first low-speed mode **205** being active, (2) the vehicle **100** being in a preset geographic area **305**, (3) receiving an input from an operator indicating to switch the vehicle **100** to the second low-speed mode **210**, and (4) the vehicle speed being below a threshold. For example, the computer **105** may switch the vehicle **100** to the second low-speed mode **210** in response to (1) the first low-speed mode **205** being active and (2) the vehicle **100** being in the preset geographic area **305**. For another example, the computer **105** may switch the vehicle **100** to the second low-speed mode **210** in response to (1) the first low-speed mode **205** being active and (2) receiving an input from an operator indicating to switch the vehicle **100** to the second low-speed mode **210**. For another example, the computer **105** may switch the vehicle **100** to the second low-speed mode **210** in response to the vehicle speed being below the threshold.

The condition for switching the vehicle **100** to the second low-speed mode **210** may include the first low-speed mode **205** being active.

With reference to FIG. **3**, the condition for switching the vehicle **100** to the second low-speed mode **210** may include the vehicle **100** being in the preset geographic area **305**. The preset geographic area **305** may be a geofenced area, i.e., a geographical area enclosed by preset virtual boundaries. The preset geographic area **305** may be stored in map data **300** in the memory of the computer **105**. The computer **105** may receive a location of the vehicle **100** from a GPS sensor of the sensors **130** and compare the location with the map data **300** indicating the preset geographic area **305** to determine whether the vehicle **100** is inside or outside the preset geographic area **305**.

The preset geographic area **305** may include areas designated with a specific categorization in map data **300**. For example, the preset geographic area **305** may include areas designated as parking areas, e.g., parking lots, parking garages, etc. The preset geographic area **305** may be limited to areas designated as parking areas or may include, e.g., all nonroad areas, thereby including parking areas. The preset geographic area **305** may be chosen to correspond to areas in which low-speed travel is likely.

The preset geographic area **305** may include a user-inputted geographic area. An operator of the vehicle **100** may provide inputs selecting the preset geographic area **305**, e.g., by selecting landmarks or locations in the map data **300**, via the user interface **150**. The operator may be able to select

geographic areas at which the operator knows that the vehicle **100** will be traveling at low speeds.

The condition for switching the vehicle **100** to the second low-speed mode **210** may include receiving the input from the operator indicating to switch the vehicle **100** to the second low-speed mode **210**. For example, the operator may provide the input via the user interface **150**, e.g., using a button or touchscreen.

The condition for switching the vehicle **100** to the second low-speed mode **210** may include the vehicle speed being below the threshold. The computer **105** may receive the vehicle speed from the sensors **130** over the communications network **155**. The threshold may be a preset value stored in the memory of the computer **105**. The threshold may be the same or different than the threshold for switching from the two-pedal-drive mode **215** to the first low-speed mode **205**. The threshold may be chosen to be a typical speed used for parking the vehicle **100**, e.g., 2 miles per hour.

With reference to FIG. **4**, the input devices **110** may include one or more alternative input devices **145** other than the accelerator pedal **135**. For example, the alternative input devices **145** may include a knob **410**, at least one button **415**, and/or at least one paddle **420**.

The knob **410** may be disposed on the instrument panel **405**. The knob **410** may be circular and rotatable by the operator. The knob **410** may return an angle of rotation that the operator has turned the knob **410**. The knob **410** may freely rotate and may remain in a same position when released by the operator, that position being the point from which further rotation is measured. Alternatively, the knob **410** may be, e.g., spring-loaded to return to a default position when released.

The at least one button **415** may be disposed on the instrument panel **405** or on the steering wheel **425**. The at least one button **415** may include, e.g., two buttons **415**, e.g., an "up" button **415** and a "down" button **415**. Each button **415** may be movable from an unpressed position to a pressed position by the operator pressing the button **415** and movable from the pressed position to the unpressed position by, e.g., a spring mechanism when released by the operator.

The at least one paddle **420** may be coupled to the steering wheel **425** and movable with the steering wheel **425** as the steering wheel **425** is rotated. The at least one paddle **420** may include, e.g., two paddles **420**, e.g., a left paddle **420** and a right paddle **420**. Each paddle **420** may be tiltable relative to the steering wheel **425** from an untilted position to a tilted position by the operator pressing the paddle **420** and movable from the tilted position to the untilted position by, e.g., a spring mechanism when released by the operator.

The input provided through the alternative input devices **145** provides instructions for actuating the propulsion system **115** and/or the brake system **120**. The input may map onto torque, distance, speed of the vehicle **100**, and/or direction of travel; i.e., the torque, distance, speed of the vehicle **100**, or direction of travel may be a function of the input.

The input from the alternative input devices **145** may map onto a torque outputted by the propulsion system **115**, i.e., $t=f(I)$, in which t is the torque outputted by the propulsion system **115** and I is the input. For example, if the alternative input device **145** is a button **415** or paddle **420**, the input I may be binary, corresponding to the button **415** or paddle **420** being pressed or not pressed, so the torque t is a constant positive value when the button **415** or paddle **420** is pressed and zero when the button **415** or paddle **420** is not pressed. The constant positive value of the torque t may be chosen to correspond to low-speed driving.

The input from the alternative input devices **145** may map onto a distance traveled by the vehicle **100** before stopping, i.e., $d=f(I)$, in which d is the distance traveled by the vehicle **100** and I is the input. The computer **105** may control acceleration and braking of the vehicle **100** to travel the distance d and then stop. To travel the distance d, the computer **105** may actuate the propulsion system **115** to apply a constant, low torque until the vehicle **100** has traveled the distance d and actuate the brake system **120** to brake the vehicle **100** to a stop upon the vehicle **100** traveling the distance d. For example, if the alternative input device **145** is a knob **410**, the input I may be an angle that the knob **410** is rotated, and the distance d may have positive relationship with the input I, i.e., the farther the knob **410** is rotated, the farther the vehicle **100** travels before stopping. The relationship may be linear, i.e., $d=kI$, in which k is a constant chosen to correspond to a small movement of the vehicle **100**. For another example, if the alternative input device **145** is a button **415** or paddle **420**, the input I may be binary, corresponding to the button **415** or paddle **420** being pressed or not pressed, so the distance d may be a preset positive value that the vehicle **100** travels before stopping upon the button **415** or paddle **420** being pressed, and the vehicle **100** may remain stationary when the button **415** or paddle **420** is not pressed. Mapping the input I onto the distance d rather than onto the torque t may provide a finer degree of control to an operator of the vehicle **100** while performing low-speed maneuvers like parking.

The input from the alternative input devices **145** may map onto a speed at which the vehicle **100** travels, i.e., $v=f(I)$, in which v is the vehicle speed and I is the input. For example, if the alternative input device **145** is a knob **410**, the input I may be an angle that the knob **410** is rotated from a default position, and the speed v may have positive relationship with the input I, i.e., the farther the knob **410** is rotated, the faster the vehicle **100** travels (up to a maximum speed, as described below). The relationship may be linear, i.e., $v=kI$, in which k is a constant chosen to correspond to a gradual increase in the speed v as the input I is increased. For example, if the alternative input device **145** is a button **415** or paddle **420**, the input I may be binary, corresponding to the button **415** or paddle **420** being pressed or not pressed, so the speed v is a constant positive value when the button **415** or paddle **420** is pressed and zero when the button **415** or paddle **420** is not pressed. The constant positive value of the speed v may be chosen to correspond to low-speed driving. Mapping the input I onto the speed v rather than onto the torque t may provide a finer degree of control to an operator of the vehicle **100** while performing low-speed maneuvers like parking.

In addition to one or more of these examples, the input from the alternative input devices **145** may map onto a direction of travel of the vehicle **100**, i.e., traveling in forward or reverse. The input from the alternative input device **145** may include a direction of the input. For a knob **410**, the direction of the input may correspond to a direction of rotation of the knob **410**, i.e., clockwise or counterclockwise. For another example, the alternative input device **145** may include two buttons **415**, e.g., labeled "up" and "down," or two paddles **420**, e.g., a left paddle **420** and a right paddle **420**. The direction may be indicated by which of the two buttons **415** or which of the two paddles **420** is pressed by the operator. The computer **105** may actuate the propulsion system **115** for the vehicle **100** to travel forward in response to the direction of input being a first direction, e.g., clockwise rotation of the knob **410**, the "up" button **415**, or the right paddle **420**, and to travel in reverse in response to the

direction of the input being a second direction, e.g., counterclockwise rotation of the knob 410, the "down" button 415, or the left paddle 420. Using the direction of input may permit the operator to more conveniently perform maneuvers that would normally require shifting between forward and reverse such as parallel parking or a three-point turn.

The computer 105 may be programmed to control acceleration and braking of the vehicle 100 to prevent the vehicle 100 from exceeding a preset speed. For example, the computer 105 may decrease a torque outputted from the propulsion system 115 from the torque that would otherwise have been outputted in response to the vehicle 100 reaching the preset speed. The preset speed may be chosen to keep the vehicle 100 within a typical range of speeds for parking or similar maneuvers, e.g., 5 miles per hour. Using the preset speed may prevent larger movements by the vehicle 100 than an operator would normally desire in low-speed situations.

FIG. 5 is a process flow diagram illustrating an example process 500 for controlling the vehicle 100 with the low-speed modes 205, 210. The memory of the computer 105 stores executable instructions for performing the steps of the process 500 and/or programming can be implemented in structures such as mentioned above. As a general overview of the process 500, the computer 105 switches the vehicle 100 into the first low-speed mode 205 in response to one of the conditions being satisfied for switching to the first low-speed mode 205, switches the vehicle 100 from the first low-speed mode 205 to the second low-speed mode 210 in response to one of the conditions being satisfied for switching to the second low-speed mode 210, and switches the vehicle 100 to the two-pedal-drive mode 215 in response to one of the conditions being satisfied for switching to the two-pedal-drive mode 215. The computer 105 may put the vehicle 100 into the two-pedal-drive mode 215 by default and in response to the conditions for switching to the first low-speed mode 205 not being satisfied.

The process 500 begins in a block 505, in which the computer 105 receives data and inputs via the communications network 155, as described above. When the process 500 begins, the vehicle 100 is in the two-pedal-drive mode 215.

Next, in a decision block 510, the computer 105 determines whether to switch the vehicle 100 from the two-pedal-drive mode 215 to the first low-speed mode 205, as described above. In response to one of the conditions being satisfied for switching the vehicle 100 to the first low-speed mode 205, the process 500 proceeds to a block 515. In response to the conditions not being satisfied, the process 500 proceeds to a block 535.

In the block 515, the computer 105 controls acceleration and braking of the vehicle 100 based on input from the accelerator pedal 135 according to the first low-speed mode 205, as described above.

Next, in a decision block 520, the computer 105 determines whether to switch the vehicle 100 from the first low-speed mode 205 to the second low-speed mode 210, as described above. In response to one of the conditions being satisfied for switching the vehicle 100 to the second low-speed mode 210, the process 500 proceeds to a block 525. In response to the conditions not being satisfied, the process 500 proceeds to a decision block 530.

In the block 525, the computer 105 controls acceleration and braking of the vehicle 100 based on input from the alternative input devices 145 according to the second low-speed mode 210, as described above. After the block 525, the process 500 proceeds to the decision block 530.

In the decision block 530, the computer 105 determines whether to switch the vehicle 100 from the low-speed mode 205, 210 to the two-pedal-drive mode 215, as described above. In response to one of the conditions being satisfied for switching the vehicle 100 from the low-speed mode 205, 210 to the two-pedal-drive mode 215, the process 500 proceeds to the block 535. In response to the conditions not being satisfied, the process 500 returns to the block 515 to remain in the low-speed mode 205, 210.

In the block 535, the computer 105 controls acceleration and braking of the vehicle 100 according to the two-pedal-drive mode 215, as described above. After the block 535, the process 500 ends.

In general, the computing systems and/or devices described may employ any of a number of computer operating systems, including, but by no means limited to, versions and/or varieties of the Ford Sync® application, App-Link/Smart Device Link middleware, the Microsoft Automotive® operating system, the Microsoft Windows® operating system, the Unix operating system (e.g., the Solaris® operating system distributed by Oracle Corporation of Redwood Shores, California), the AIX UNIX operating system distributed by International Business Machines of Armonk, New York, the Linux operating system, the Mac OSX and iOS operating systems distributed by Apple Inc. of Cupertino, California, the BlackBerry OS distributed by Blackberry, Ltd. of Waterloo, Canada, and the Android operating system developed by Google, Inc. and the Open Handset Alliance, or the QNX® CAR Platform for Infotainment offered by QNX Software Systems. Examples of computing devices include, without limitation, an on-board vehicle computer, a computer workstation, a server, a desktop, notebook, laptop, or handheld computer, or some other computing system and/or device.

Computing devices generally include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above. Computer executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, Matlab, Simulink, Stateflow, Visual Basic, Java Script, Python, Perl, HTML, etc. Some of these applications may be compiled and executed on a virtual machine, such as the Java Virtual Machine, the Dalvik virtual machine, or the like. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer readable media. A file in a computing device is generally a collection of data stored on a computer readable medium, such as a storage medium, a random access memory, etc.

A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory (e.g., tangible) medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media and volatile media. Instructions may be transmitted by one or more transmission media, including fiber optics, wires, wireless communication, including the internals that comprise a system bus coupled to a processor of a computer. Common forms of computer-readable media include, for example, RAM, a PROM, an EPROM, a FLASH-EEPROM,

any other memory chip or cartridge, or any other medium from which a computer can read.

Databases, data repositories or other data stores described herein may include various kinds of mechanisms for storing, accessing, and retrieving various kinds of data, including a hierarchical database, a set of files in a file system, an application database in a proprietary format, a relational database management system (RDBMS), a nonrelational database (NoSQL), a graph database (GDB), etc. Each such data store is generally included within a computing device employing a computer operating system such as one of those mentioned above, and are accessed via a network in any one or more of a variety of manners. A file system may be accessible from a computer operating system, and may include files stored in various formats. An RDBMS generally employs the Structured Query Language (SQL) in addition to a language for creating, storing, editing, and executing stored procedures, such as the PL/SQL language mentioned above.

In some examples, system elements may be implemented as computer-readable instructions (e.g., software) on one or more computing devices (e.g., servers, personal computers, etc.), stored on computer readable media associated therewith (e.g., disks, memories, etc.). A computer program product may comprise such instructions stored on computer readable media for carrying out the functions described herein.

In the drawings, the same reference numbers indicate the same elements. Further, some or all of these elements could be changed. With regard to the media, processes, systems, methods, heuristics, etc. described herein, it should be understood that, although the steps of such processes, etc. have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted.

All terms used in the claims are intended to be given their plain and ordinary meanings as understood by those skilled in the art unless an explicit indication to the contrary in made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary. The adjectives "first" and "second" are used throughout this document as identifiers and are not intended to signify importance, order, or quantity. Use of "in response to" and "upon determining" indicates a causal relationship, not merely a temporal relationship.

The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

What is claimed is:

1. A computer comprising a processor and a memory, the memory storing instructions executable by the processor to:
    in response to one of a vehicle feature of a vehicle being active or the vehicle being in a preset geographic area, control acceleration and braking of the vehicle based on input from an input device of the vehicle according to a low-speed mode; and

    in response to the low-speed mode being inactive, control acceleration and braking of the vehicle not according to the low-speed mode;
    wherein, in the low-speed mode, acceleration is caused by input from the input device and occurs as the input is received; and
    in the low-speed mode, braking is caused by a lack of the input from the input device and occurs as the input is not received.

2. The computer of claim 1, wherein the instructions further include instructions to, in response to (1) a speed at which the vehicle is traveling being below a threshold and (2) one of the vehicle feature being active or the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode.

3. The computer of claim 1, wherein the input device includes an accelerator pedal.

4. The computer of claim 3, wherein the instructions further include instructions to, in response to the accelerator pedal being pressed by at least a preset amount, deactivate the low-speed mode.

5. The computer of claim 1, wherein the instructions further include instructions to, in response to the vehicle feature being active, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode.

6. The computer of claim 5, wherein the vehicle feature includes adaptive cruise control.

7. The computer of claim 5, wherein the vehicle feature includes automatic vehicle hold, and the instructions further include instructions to, in response to the automatic vehicle hold being active, brake the vehicle in response to a brake pedal of the vehicle being released while the vehicle is stopped and in gear.

8. The computer of claim 1, wherein the instructions further include instructions to, in response to the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode.

9. The computer of claim 8, wherein the preset geographic area includes areas designated in map data as parking areas.

10. The computer of claim 8, wherein the preset geographic area includes a user-inputted geographic area.

11. The computer of claim 8, wherein the instructions further include instructions to, in response to the vehicle being in the preset geographic area, control acceleration and braking of the vehicle to prevent the vehicle from exceeding a preset speed.

12. The computer of claim 1, wherein the instructions further include instructions to, in response to the low-speed mode being active and the vehicle being in the preset geographic area, control acceleration and braking of the vehicle based on input from the input device according to the low-speed mode.

13. The computer of claim 12, wherein the input device includes an alternative input device other than an accelerator pedal.

14. The computer of claim 1, wherein the input device includes an alternative input device other than an accelerator pedal.

15. The computer of claim 14, wherein the alternative input device includes a knob.

16. The computer of claim 14, wherein the alternative input device includes a button.

17. The computer of claim 14, wherein the alternative input device includes a paddle.

18. The computer of claim **14**, wherein the instructions further include instructions to control acceleration and braking of the vehicle to travel a distance and then stop, the distance being a function of an input from the alternative input device.

19. The computer of claim **14**, wherein an input from the alternative input device includes a direction of the input, and the instructions further include instructions to control acceleration and braking of the vehicle to travel forward in response to the direction of the input being a first direction and to travel in reverse in response to the direction of the input being a second direction.

20. A method comprising:

in response to one of a vehicle feature of a vehicle being active or the vehicle being in a preset geographic area, controlling acceleration and braking of the vehicle based on input from an input device of the vehicle according to a low-speed mode; and

in response to the low-speed mode being inactive, controlling acceleration and braking of the vehicle not according to the low-speed mode;

wherein, in the low-speed mode, acceleration is caused by input from the input device and occurs as the input is received; and

in the low-speed mode, braking is caused by a lack of the input from the input device and occurs as the input is not received.

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