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(54) Title: METHOD AND SYSTEM OF BRAKING AND OVERTAKING IN AN ELECTRICALLY POWERED VEHICLE

(57) Abstract: A method and system of braking and overtaking in an electrically powered vehicle is disclosed. The system includes a controller that detects objects around the electrically powered vehicle based on signals received from one or more sensors. Upon detecting an object in front, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system is received by the controller. An intent of a driver to overtake the object or brake the vehicle based on the user input is detected. Based on the detection of the intent of the driver, activate an assist mode for the electrically powered vehicle. The controller determines a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

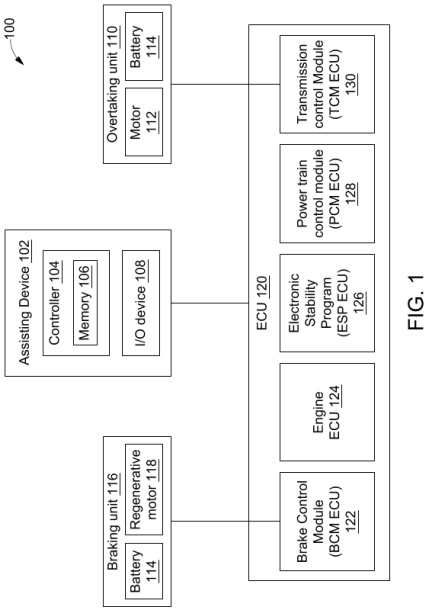

FIG. 1

FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification
(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

METHOD AND SYSTEM OF BRAKING AND OVERTAKING IN AN ELECTRICALLY POWERED VEHICLE

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

TECHNICAL FIELD

[001] This disclosure relates generally to control systems of a vehicle, and more particularly to overtaking and braking systems in an electrically powered vehicle.

BACKGROUND

[002] Electrically powered vehicles are becoming increasingly popular due to their lower environmental impact, improved efficiency, and reduced operating costs. The electrically powered vehicles have a high-voltage battery that power the traction load of the vehicle, i.e., moving the vehicle forward or backward. Electrically powered vehicles may also have driving modes i.e., economy mode, city mode, or sports mode. Electrically powered vehicles may also have regeneration modes for braking and regenerative braking i.e., level 1 or level 2, etc.

[003] One of the challenges faced by electrically powered vehicles is not providing adequate acceleration performance to meet the needs of drivers in a variety of driving conditions. Generally, electrically powered vehicles have smaller engines compared to their conventional counterparts. Overtaking other vehicles on the road needs faster acceleration to overtake the vehicle faster and safely. Accordingly, while driving the electrically powered vehicle in economy mode or city mode, enough acceleration to overtake may not be provided.

[004] Another challenge faced by electrically powered vehicles is braking the vehicle while using regenerative braking to charge the battery. The regenerative braking may not work efficiently i.e., the motor may not provide enough negative torque to stop the vehicle in time due to the mode of the regenerative braking. Thus, the desired negative torque from the motor may not be provided for braking.

[005] Thus, there is a requirement for an optimum overtaking and braking assist system which may be utilized for efficient and safe overtaking and braking in various types of electrically powered vehicles.

SUMMARY

[006] In one embodiment, a method of braking and overtaking in an electrically powered vehicle is disclosed. The method may include detecting one or more objects around the electrically powered vehicle based on signals received from one or more sensors associated with the electrically powered. In an embodiment, at least a part of traction power may be provided by an electric motor in the electrically powered vehicle. The method may further

include receiving, upon detecting an object in front of the electrically powered vehicle, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system. The method may further include detecting an intent of a driver to overtake the object or brake the electrically powered vehicle based on the user input. The method may further include activating an assist mode for the electrically powered vehicle based on the intent of the driver. It may be noted that, the assist mode may be an overtake assist mode or a braking assist mode. In an embodiment, activation of the assist mode may deactivate a current driving mode of the electrically powered vehicle. Further, the method may include determining a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

[007] In another embodiment, a system of braking and overtaking in an electrically powered vehicle is disclosed. The system may include a controller and a memory coupled to the controller. In an embodiment, the memory stores controller-executable instructions, which, on execution, causes the controller to detect one or more objects around the electrically powered vehicle based on signals received from one or more sensors associated with the electrically powered vehicle. It must be noted that at least a part of traction power may be provided by an electric motor in the electrically powered vehicle. The controller may be further be configured to receive, upon detecting an object in front of the electrically powered vehicle, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system. Further, the controller may be configured to detect an intent of a driver to overtake the object or brake the electrically powered vehicle based on the user input. The controller may be further configured to activate an assist mode for the electrically powered vehicle based on the intent of the driver. In an embodiment, the assist mode may be an overtake assist mode or a braking assist mode. In an embodiment, activation of the assist mode may deactivate a current driving mode of the electrically powered vehicle. The controller may be configured to determine a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

[008] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[009] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[010] **FIG. 1** is a block diagram of overtaking and braking assist system for electrically powered vehicles, in accordance with an embodiment of the present disclosure.

[011] **FIG. 2** is a block diagram of the assisting device of system of overtaking and braking of an electrically powered vehicle, in accordance with some embodiment of the present disclosure.

[012] **FIG. 3** illustrates a flowchart of the overtaking and braking of an electrically powered vehicle, in accordance with an embodiment of the present disclosure.

[013] **FIG. 4** illustrates a flowchart of a method of overtaking and braking of an electrically powered vehicle, in accordance with some embodiment of the present disclosure.

DETAILED DESCRIPTION

[014] The following description is presented to enable a person of ordinary skill in the art to make and use the invention and is provided in the context of particular applications and their requirements. Various modifications to the embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Moreover, in the following description, numerous details are set forth for the purpose of explanation. However, one of ordinary skill in the art will realize that the invention might be practiced without the use of these specific details. In other instances, well-known structures and devices are shown in block diagram form in order not to obscure the description of the invention with unnecessary detail. Thus, the invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[015] While the invention is described in terms of particular examples and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the examples or figures described. Those skilled in the art will recognize that the operations of the various embodiments may be implemented using hardware, software, firmware, or combinations thereof, as appropriate. For example, some processes can be carried out using processors or other digital circuitry under the control of software, firmware, or hard-wired logic. (The term "logic" herein refers to fixed hardware, programmable logic and/or an

appropriate combination thereof, as would be recognized by one skilled in the art to carry out the recited functions.) Software and firmware can be stored on computer-readable storage media. Some other processes can be implemented using analog circuitry, as is well known to one of ordinary skill in the art. Additionally, memory or other storage, as well as communication components, may be employed in embodiments of the invention

[016] Referring now to **FIG. 1**, a block diagram of an overtaking and braking assist system 100 for electrically powered vehicles is illustrated, in accordance with an embodiment of the present disclosure. The overtaking and braking assist system 100 may include an assisting device 102 to enable an assist mode to provide assistance during overtaking or braking the electrically powered vehicle. In an embodiment, the assist mode may include an overtake assist mode which may determine the maximum torque required by the motor in order to increase acceleration while overtaking one or more vehicles or an object in front of the vehicle on the road. In an embodiment, the assist mode may include a braking assist mode which may assist by determining a maximum negative torque to be provided the regenerative braking while braking, upon detection of a vehicle or an object in front of the vehicle. In an embodiment, the assisting device 102 may disable the driving mode of the electrically powered vehicle when the assist mode may be enabled. In an embodiment, the assisting device 102 may enable the assist mode by determining an intent of a user to either overtake or brake the vehicle. As will be appreciated, the assisting device 102 may not only assist in overtaking and braking of the electrically powered vehicle but may also be capable of sending real time updates to users in case the assisting device 102 is enabled or disabled via the user interface of the vehicle. In an embodiment, the overtaking and braking assist system 100 may further include an overtaking unit 110, a braking unit 116, and an ECU 120. The assistance device 102, the overtaking unit 110 and the braking unit 116 may be communicably connected to the ECU 124 via a wired or a wireless connection.

[017] Further, the assisting device 102 may include a controller 104, a memory 106 and one or more input/output (I/O) devices 108. The memory 106 may store instructions that, when executed by the controller 104, cause the controller 104 to activate an assist mode for the vehicle based on detection of an intent of the driver to either overtake or brake as discussed in greater detail below. In an embodiment, the memory 106 may be a non-volatile memory or a volatile memory. Examples of non-volatile memory may include, but are not limited to a flash memory, a Read Only Memory (ROM), a Programmable ROM (PROM), Erasable PROM (EPROM), and Electrically EPROM (EEPROM) memory. Examples of volatile memory may include but are not limited to Dynamic Random Access Memory (DRAM), and Static Random-

Access memory (SRAM). The memory 106 may also store various operational parameters of the vehicle.

[018] Further, the assisting device 102 may include one or more I/O devices 108 that may be electrically connected with the assisting device 102. In an embodiment, the I/O device 108 sends or receives data from the assisting device 102 to the ECU 120. The I/O device 108 may include one or more sensors associated with various vehicle parts such as steering, an accelerator pedal, a braking pedal, etc. One or more sensors may further include, RADAR/LIDAR sensors, ultrasonic sensors, etc. The I/O device 108 may include, but not limited to, in-vehicle system such as an infotainment system, a camera, a mic, a speaker, a handheld device i.e., phone, tablet, etc., Human Machine Interface (HMI), etc. The I/O device 108 may be configured to receive an input from a driver. In an embodiment, the I/O device 108 may detect activation of an indicator light or turn of the steering, depression of the brake pedal, or the accelerator pedal based on one or more signals from the one or more sensors. In an embodiment, the assisting device 102 may determine an intent of the driver based on the input received from the I/O device 108. In an embodiment, the and then transmit one or more outputs to the ECU 120.

[019] By a way of an example, the one or more sensors may transmit a signal based on detection of an object or a vehicle in front of the vehicle to the assisting device 102. Further, the I/O device 108 may detect one or more user inputs corresponding to an acceleration input via the accelerator pedal (not shown) or a braking input via the brake pedal (not shown) or activation of an indicator light using an indicator switch (not shown)or a steering input from a steering wheel (not shown) or an image processing device or a camera. In case there is an object or another vehicle detected in front of the electrically powered vehicle, the controller 104 of the assisting device 102 may determine an intent of the driver to overtake the object or the vehicle in front of the vehicle based on the indicator light status, steering input, one or more signals from the in-vehicle system.

[020] In an embodiment, the controller 104 may execute one or more control algorithms to facilitate monitoring and control of the components such as, but not limited to, one or more sensors for determining the obstacles, etc. According to the current disclosure, the controller 104 may generate one or more control signals for enabling or disabling the assisting device 102 based on one or more parameters determined associated to the vehicle and the determined intent of the driver. In an embodiment, the controller 104 may include software executable controller which may be implemented on hardware platform or a hybrid device that combines controller functionality and other functions such as visualization. The control

software or algorithms executed by automobile controller may include coding or algorithm to process input signal read from the vehicle components or industrial devices or sensors, etc.

[021] In an embodiment, the controller 104 may be configured to determine one or more parameters of the vehicle and an intent of the driver to enable the overtake assist mode or the braking assist mode. In an exemplary embodiment, the controller 104 may be operated with hardwired inputs and outputs that communicate with the vehicle to monitor the associated one or more vehicle parameters in order to enable or disable the assist modes. The controller 104 I/O can include digital I/O that may be transmitted and received as discrete voltage signals to and from the devices such as a vehicle component or a machinery, or analog I/O that transmits and receives analog voltage or current signals to and from the devices. The controller I/O can be received by the assisting device 102 which may then be processed to covert from analog to digital or digital to analog signals in order to be read into and controlled by the control programs or the components using one or more analog to digital convertors or digital signal processing algorithms. In an embodiment, the I/O devices 108 may transmit the signals to the controller 104, which in turn may be saved as data in a memory 106.

[022] In an embodiment, the one or more parameters determined associated to the vehicle may be based on one or more inputs received from the I/O devices 108 and may include, but not limited to, detection of an object or a vehicle in front of the electrically powered vehicle, the intent of the driver to stop the vehicle or to overtake the vehicle, speed of the object or the vehicle in front of the electrically powered vehicle, the status of the indicator lights, steering input, etc. Based on the detected parameters the overtaking unit 110 or the braking unit 116 may be enabled, either manually or automatically, by the controller 104. In an embodiment, the controller 104 may utilize a predefined control logic or algorithm saved in the memory 106 in order to determine the enabling or disabling of the overtake assist mode and the braking mode automatically. In an embodiment, the controller 104 may display a notification to the driver with respect to the assist mode being available based on which the driver may provide an input using a button or an interface to enable the overtake assist mode or the braking assist mode.

[023] In an embodiment, the system 100 may include an ECU 120 configured to determine the in-vehicle system parameters of the vehicle. The ECU 120 may further include various types of ECU i.e., a Brake Control Module (BCM ECU) 122, an engine ECU 120, an Electronic Stability Program (ESP ECU) 126, a Power-train Control Module (PCM ECU) 128, a Transmission Control Module (TCM ECU) 130, etc. In an embodiment, the various types of ECUs 122-130 may be implemented as a separate ECUs or may be implemented in the ECU

120. The BCM ECU 122 of the ECU 120 may receive a signal from the assisting device 102 to engage the regenerative braking of the electrically powered vehicle. Further, the BCM ECU 122 may enable the braking unit 116 of the system 100. The engine ECU 124 of the ECU 120 may be configured to ensure the optimal engine performance of the electrically powered vehicle. The engine ECU 124 may also ensure an optimal combination of power from the conventional combustion engine and the HV battery in a hybrid vehicle. Further, the ESP ECU 126 may be configured to support driver in dangerous driving environment i.e., skidding and loss of traction of the vehicle. The ESP ECU 126 may detect the skidding of the vehicle and can counteract skidding in real time to maintain the traction of the vehicle. The PCM ECU 128 may control a plurality of operational factors in the vehicle i.e., the transmission, braking, etc. It should be noted that the PCM ECU 128 may be implemented as a separate ECU or may be a combination of the engine ECU 124 and the TCM ECU 130. The TCM ECU 130 of the ECU 120 may be a gearbox control unit (GCU) that may be configured to control automatic transmissions. The TCM ECU 130 may also enable the overtaking unit 110 based on the received user inputs, intent of the user, and operational parameters of the electrically powered vehicle.

[024] In an embodiment, the system 100 may include the overtaking unit 110 that may implement the overtake assist mode in the electrically powered vehicle. The overtaking unit 110 may include, but not limited to, a motor 112, and a battery 114. The motor 112 of the overtaking unit 110 may draw enough power to overtake an object or a vehicle in front of the electrically powered vehicle based on the determined parameters of the vehicle and the user input. In another embodiment, the system 100 may include the braking unit 116 that may implement the braking assist mode in the electrically powered vehicle. The braking unit 116 may include a regenerative motor 118 and a battery 114. The regenerative motor 118 may charge the battery 114 when the braking unit 116 is activated by the controller 104. It should be noted that the motor 112 of the overtaking unit 110 and the regenerative motor 118 of the braking unit 116 may be analogous i.e., the motor 112 and the regenerative motor 118 may be a single motor that may be implemented in both the overtaking unit 110 and the braking unit 116 as a single motor.

[025] In an exemplary scenario, driver, in order to overtake an object or a vehicle ahead, may switch on an indicator light in order to indicate driver's intent to switch lane to either side. In an embodiment, the driver may check a status of vehicles approaching from behind or either of the side lanes, by checking a rear-view mirror and either of the side view mirrors. Further, in an embodiment, the assisting device 102 may also determine the intent by

determining a depression of the brake pedal or an acceleration pedal by the driver. In an embodiment, the assisting device 102 may determine an intent to brake or an intent to overtake based on a determination of the object or another vehicle in front. In an embodiment, the intention to overtake may be detected based on detection of a depression of an accelerator pedal and/or detection of switching of an indicator light and/or determining a gaze of the driver towards the side view mirrors and/or a steering input. In an embodiment, the intention of braking may be detected based on detection of a depression of the brake pedal. Accordingly, the controller 104 of the assisting device 102 may determine one or more operational parameters of the electrically powered vehicle in order to provide a notification regarding the availability of either the overtake assist mode or the braking assist mode by enabling the overtaking unit 110 or the braking unit 116 respectively.

[026] In an embodiment, the I/O device 108 may display a visual notification and/or output an audio notification to indicate to the driver that the assist mode is available and may activated by providing the required input. In an embodiment, the I/O device 108 may display a visual notification and/or output an audio notification to indicate to the driver that the driving mode has been deactivated once the user input regarding the activation of either the overtake assist mode or the braking assist mode has been received.

[027] In an embodiment, the ECU 120 may determine the one or more operational parameters of the electrically powered vehicle and transmit the same to the controller 104 which may enable the overtake assist mode. The one or more operational parameters determined by the ECU 120 may include, but not limited to, a state of charge of the battery 112, a torque delivered by the motor 114, a torque available from the motor 112, thermal limitations of the motor 112. The controller 104 may calculate a maximum output torque required by the motor 112 based on the intent of the driver and the one or more operational parameters. It should be noted that if the state of charge of the battery 114 is below a predefined charge level, then the controller 104 may not enable overtake assist mode. In an embodiment, in case there is a detection of a vehicle in the overtaking lane by the controller 104 based on the inputs from the I/O device 108 then the controller 104 may not activate the overtaking assist mode. Further, the controller 104 may not activate the overtake assist mode in case the depression of the accelerator pedal is for less than a predefined time period. Further, in case the controller determines no intention of overtaking based on the one or more user inputs in a pre-defined period of depression of the accelerator pedal the assist mode may not be activated.

[028] In another embodiment, the ECU 120 may determine the one or more braking operational parameters of the electrically powered vehicle and transmit the same to the

controller 104 which may enable the braking assist mode may. The one or more braking operational parameters may include the thermal limitations of the motor 114, the state of charge of the battery 114. The controller 104 may override the driving modes and provide the maximum negative torque possible for regenerative braking based on the determined operational parameters. It should be noted that if the state of the charge of the battery 114 is maximum or above a predefined charge level then the braking assist mode may not be enabled. In an embodiment, the driver may manually enable or disable the assist mode by providing one or more inputs via the I/O devices 108. Further, the braking assist mode may be deactivated in case the brake pedal is relaxed by the driver for a predefined period after the activation of the braking assist mode. Table 1 provided below provides parameters determined in order to enable the overtaking assist mode or brake assist mode.

Vehicle/object detected ahead	**Indicator Status**	**Battery state**	**Motor state**	**Driver intent**	**Accelerator pedal state**	**Brake pedal state**	**Mode status**
Yes	On	Adequate to discharge	Can provide more +ve torque	To overtake	ON	OFF	Overtake assist enabled
Yes	Off	Battery can be charged	Can provide more -ve torque	To brake	OFF	ON	Brake assist enabled

TABLE 1

[029] In an embodiment, the communication between various components of the system 100 may be based on a wired or a wireless network connection or a combination thereof. The communication may be implemented as one of the different types of networks, such as Common Industrial Protocol (CIP) network, Automotive Ethernet DeviceNet network, ethernetIP network, intranet, local area network (LAN), wide area network (WAN), the internet, Wi-Fi, LTE network, CDMA network, and the like. Further, the can either be a dedicated network or a shared network. The shared network represents an association of the

different types of networks that use a variety of protocols, for example, CAN, CAN FD, PSI5, LIN, FlexRay, Common Industrial Protocol (CIP), Open Platform Communication (OPC) protocols, Transmission Control Protocol/Internet Protocol (TCP/IP), Wireless Application Protocol (WAP), and the like, to communicate with one another. Further the communication may be implemented through a variety of network devices, including routers, bridges, servers, computing devices, storage devices, cables, and the like.

[030] Referring now to **FIG. 2**, a block diagram of the assisting device 102 of the system 100 of overtaking and braking of an electrically powered vehicle, in accordance with some embodiment of the present disclosure. In an embodiment, the system 200 is analogous to the assisting device 102 of the system 100. The assisting device 102 of the system 100 may include a plurality of modules i.e., an object detection module 202, an intent detection module 204, an overtaking assist module 206, a braking assist module 208, a notification module 210 or other module.

[031] In an embodiment, the object detection module 202 may detect an object in front and in the side lanes of the vehicle. The object may be a vehicle in the same lane or in the side overtaking lane. The object detection may be done by one or more sensors provided on the front, back and sides of the electrically powered vehicle. In an embodiment, the one or more sensors may be, but not limited to, a RADAR/LIDAR, or an ultrasonic sensor, a proximity sensor, etc. The detection of the object may be communicated to the driver through an HMI of the I/O devices 108.

[032] Further, upon detecting the object in front or in the side lanes of the vehicle, the intent detection module 204 may detect the intention of the driver i.e., whether the driver intends to overtake the vehicle or reduce the speed of the vehicle by braking. The intent of the driver to overtake or brake may be detected based on detection of one or more parameters such as, but not limited to, the status of accelerator pedal, the status of brake pedal, the status of the indicator, the direction change of the steering wheel, an image processing device which may determine the gaze of the driver to determine the intent of the driver. In an embodiment, the driver’s gaze may be on the rear view mirror in order to check if any vehicle may be approaching from behind or the driver’s gaze may be towards either of the side view mirrors in order to check if there is any vehicle approaching in a corresponding overtaking lane. The intent detection module 204 may also detect the intent of driver to stop the vehicle in case an object or a vehicle suddenly came in front of the vehicle. The intent of the driver to stop the vehicle may be detected based on the engaging of the brake pedal by the driver.

[033] In an embodiment, upon detecting the intent of the driver to overtake, the overtaking assist module 206 of the assisting device 102 may determine one or more vehicle parameters in order to activate the overtake assist mode to assist the driver in overtaking the vehicle based on user input. Based on detection of a user input to activate the overtake assist mode, the overtaking assist module 206 may calculate a maximum output torque required or an additional torque required to provide the necessary acceleration in order for the electrically powered vehicle to overtake the object or the vehicle detected in front. The overtaking assist module 206 may calculate the torque based on the vehicle parameters as defined in conjunction with FIG. 1. The overtaking assist module 206 may override the current mode of the vehicle based on the activating the overtake assist mode. Further, the overtake assist module 206 may be disabled as soon as the accelerator pedal is released for a predefined period after the vehicle may have overtaken the object or another vehicle detected in front. Accordingly, it may be noted that when the overtake assist mode is activated, motor 112 of the vehicle may generate torque at its maximum capacity.

[034] In another embodiment, upon detection of an object or another vehicle in front, and before activation of the overtake assist mode, the object detection module 202 may determine based on the detection of the steering wheel direction or the indicator light input, if there is a vehicle present in the overtaking lane to which the driver intends to switch while overtaking. In an embodiment, in case a vehicle or an object is detected in the overtaking lane corresponding to the direction of the steering wheel or the indicator light input, the overtaking assist mode may not be activated. In another embodiment, in case the driver engages the brake pedal to deaccelerate the vehicle when the overtake assist mode is activated for a pre-defined period, the overtake assist mode may be disabled. Accordingly, the braking assist module 208 of the assisting device 102 in order to assist the driver to stop the vehicle and provide by providing maximum negative torque of required negative torque regenerative braking of the vehicle to charge the battery. The braking assist module 208 may calculate the maximum negative torque required to stop the vehicle in minimum time and charge the battery with maximum regenerative power generated due to the regenerative braking. The braking assist mode 208 calculates the maximum negative torque based on the vehicle parameters in conjunction with FIG. 1. The braking assist module 208 may override the current regeneration mode or driving mode of the vehicle with braking assist mode. Further, the braking assist module 208 may be disabled as soon as the vehicle is stopped, or the driver disengages the brake pedal.

[035] The notification module 210 of the assisting device 102 may notify the driver regarding the activation or deactivation of the overtake assist mode or the braking assist mode. The notification module 210 may transmit the notification in form of an audio and/or visual notification via the HMI of the I/O device 108. Further, the driver may listen, read or visualize the transmitted notification through HMI of the I/O device 108. The HMI may include, but not limited to, the infotainment system, an in-car touch screen, buttons, rotary switches, indicators etc. The notification module 210 may also enable the driver to provide a manual input to activate or disable the overtake assist mode or braking assist mode through the HMI of the I/O device 108.

[036] It should be noted that all such aforementioned modules 202 – 210 may be represented as a single module or a combination of different modules. Further, as will be appreciated by those skilled in the art, each of the modules 202 – 210 may reside, in whole or in parts, on one device or multiple devices in communication with each other. In some embodiments, each of the modules 202 – 210 may be implemented as a dedicated hardware circuit comprising custom application-specific integrated circuit (ASIC) or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. Each of the modules 202 – 210 may also be implemented in a programmable hardware device such as a field programmable gate array (FPGA), programmable array logic, programmable logic device, and so forth. Alternatively, each of the modules 202 – 210 may be implemented in software for execution by various types of controllers (e.g., controller 104). An identified module of executable code may, for instance, include one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, function, or other construct. Nevertheless, the executables of an identified module or component need not be physically located together but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose of the module. Indeed, a module of executable code could be a single instruction, or many instructions, and may even be distributed over several different code segments, among different applications, and across several memory devices.

[037] As will be appreciated by one skilled in the art, a variety of processes may be employed for overtaking and braking of the electrically powered vehicle. For example, the exemplary system 100 and the associated assisting device 102 may assist the electrically powered vehicle in overtaking and braking by the processes discussed herein. In particular, as will be appreciated by those of ordinary skill in the art, control logic and/or automated routines for performing the techniques and steps described herein may be implemented by the system

100 and the assisting device 102 either by hardware, software, or combinations of hardware and software. For example, suitable code may be accessed and executed by the one or more controllers on the system 100 to perform some or all of the techniques described herein. Similarly, application specific integrated circuits (ASICs) configured to perform some, or all of the processes described herein may be included in the one or more controllers on the system 100.

[038] Referring now to **FIG. 3**, a flowchart of the overtaking and braking of an electrically powered vehicle is illustrated, in accordance with some embodiments of the present disclosure. It should be noted that the steps mentioned 302-326 may be implemented by the controller 104 of the assisting device 102 of the system 100. At step 302, the controller 104 may determine if there is a vehicle in front of the electrically powered vehicle based on one or more signals detected by the I/O device 108 such as, but not limited to, front facing sensors, etc. Further, at step 304, the controller 104 may check the intention of the driver based on one or more user inputs corresponding to, but not limited to, the status of the indicator lights, engagement of the brake pedal, direction of steering, engagement of acceleration pedal, etc. based on detection of a vehicle in front at step 302.

[039] By way of an example, at step 306, upon detection of an object or another vehicle in front and the intention of the driver the controller may check if there is an increased acceleration based on engagement or depression of the accelerator pedal. Further, if the accelerator pedal depression is determined at step 306, the controller 104 may check whether there is a vehicle approaching from behind in an overtaking lane corresponding to an indicator input or a steering input depicting the intention of the driver to overtake in the corresponding overtaking lane. If no vehicle is detected in the overtaking lane, then at step 310, the controller 104 may determine overtaking operational parameters such as, but not limited to, state of charge of the battery 112, a torque delivered by the motor 114, a torque available from the motor 112, thermal limitations of the motor 112, etc. In case the overtaking operational parameters are determined to be within predefined threshold limits, the controller 104 may check whether the motor 112 can generate the torque required to overtake the vehicle, at step 312. If at step 312, the motor 112 is determined to be capable of generating the required torque to overtake the vehicle, the controller 104 may then activate the overtake assist mode and may display a notification indicating the activation of the overtake assist mode on the HMI of the electrically powered vehicle, at step 314.

[040] In some embodiments, if at step 308, another vehicle is detected in the overtaking lane approaching the electrically powered vehicle the overtake assist mode may be

aborted or disabled, at step 326. Further, if at step 312, the motor 112 is determined to be not capable of generating the required torque to overtake, the controller 104 may disable the overtake assist mode, at step 326. If the accelerator pedal input is not provided at step 306, then the controller 104 may disable the overtake assist mode, at step 326.

[041] In an embodiment, if at step 304, in case the intention of the driver may be determined to brake the vehicle speed, the controller 104 may check for a depression of a brake pedal, at step 316. In an embodiment, the intention of the driver may be determined to brake the speed of the vehicle in case a depression of the brake pedal is detected. At step 320, the controller 104 may then check whether there is another vehicle or an object present in front of the electrically powered vehicle. If an object or another vehicle is detected in the front of the vehicle, then at step 320, the controller 104 may determine the braking operational parameters of the electrically powered vehicle. In an embodiment, the braking operational parameters may include, but not limited to, thermal limitations of the motor 114, the state of charge of the battery 114, etc. In case the braking operational parameters are determined to be within predefined threshold limits, then at step 322, the controller 104 may check whether the regenerative motor 118 can generate the negative torque while stopping the electrically powered vehicle. If the regenerative motor 118 can generate the required negative torque while stopping the electrically powered vehicle, the controller may enable the braking assist mode and may provide a visual and/or audio indication for the activation of the braking assist mode on the HMI of the electrically powered vehicle, at step 324.

[042] In some embodiments, if no object or another vehicle is detected in front of the electrically powered vehicle, at step 318, the braking assist mode may be disabled, at step 326. Further, if the regenerative motor 118 is determined to be incapable of generating the required negative torque to stop the electrically powered vehicle, at step 322 the controller 104 may disable the braking assist mode, at step 326. If the brake pedal input is not provided at step 316, then the controller 104 may disable the braking assist mode, at step 326.

[043] Referring now to **FIG. 4**, a flowchart of a method of overtaking and braking of an electrically powered vehicle is illustrated, by some embodiments of the present disclosure. It should be noted that the steps 402-410 of the method 400 may be performed by the controller 104 of the system 100. At step 402, one or more object may be detected around the electrically powered vehicle based on signals received from one or more sensors associated with the electrically powered vehicle. In an embodiment, the electrically powered vehicle may be provided at least a part of traction power by an electric motor.

[044] Further, at step 404, upon detecting an object in front of the electrically powered vehicle, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system may be received. Further, at step 406, an intent of a driver to overtake the object or brake the electrically powered vehicle may be detected based on the user input.

[045] Further, at step 408, an assist mode may be activated for the electrically powered vehicle based on the intent of the driver. In an embodiment, the assist mode may include an overtake assist mode or a braking assist mode. Further, at step 408, based on the activation of the assist mode a current driving mode of the electrically powered vehicle may be deactivated. Further, at step 410, a maximum output torque may be determined for the electric motor in the overtake assist mode or a maximum negative torque may be determined for the electric motor in the braking assist mode.

[046] Thus, the disclosed method and system try to overcome the technical problem of overtaking and braking of the electrically powered vehicle and manually changing the modes of the transmission to generate desired torque to overtake or brake the vehicle. Hereby, the disclosed method and system may solve this technical problem while offering a variety of advantages, such as, the disclosed overtaking and braking assist system and method may be designed in such a way that it may be implement in almost every type of electrically powered vehicle. Further, the disclosed overtaking and braking assist system and method may ensure that the vehicle may overtake the other vehicles on the road safely and the vehicle may stop safely in time while charging the battery. In addition, the disclosed overtaking and braking assist system and method may automatically enable and disable the overtake assist mode or the braking assist mode, upon determining the overtaking operational parameters and the braking operational parameters of the electrically powered vehicle. Further, the disclosed overtaking and braking system and method may send the real-time status of the overtake assist mode and the braking assist mode to the driver via the HMI of the vehicle. The overtaking and braking assist system may determine the intent of the driver by detecting the engaging of the acceleration pedal, the status of the indicator or the brake pedal and may even by the expressions of the driver using the image processing device. The overtaking and braking assist system may automatically disable the overtake assist mode or the braking assist mode upon determining the change in the intent of the driver. The driver may manually enable or disable the overtake assist mode and the braking assist mode through the HMI of the vehicle in case of an emergency or as per the driver needs.

[047] In light of the above-mentioned advantages and the technical advancements provided by the disclosed method and system (i.e., overtaking assist and braking assist for electrically powered vehicles), the claimed system and method as discussed above are not routine, conventional, or well understood in the art, as the claimed system and method enable the following solutions to the existing problems in conventional technologies. Further, the claimed system and method clearly bring an improvement in the functioning of the system itself as the claimed system and method provide a technical solution to a technical problem.

[048] The specification has described a method and system of overtaking and braking for electrically powered vehicles. The illustrated steps are set out to explain the exemplary embodiments shown, and it should be anticipated that ongoing technological development will change the manner in which particular functions are performed. These examples are presented herein for purposes of illustration, and not limitation. Further, the boundaries of the functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternative boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed. Alternatives (including equivalents, extensions, variations, deviations, etc., of those described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternatives fall within the scope and spirit of the disclosed embodiments.

[049] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[050] It will be appreciated that, for clarity purposes, the above description has described embodiments of the invention with reference to different functional units and processors. However, it will be apparent that any suitable distribution of functionality between different functional units, processors or domains may be used without detracting from the invention. For example, functionality illustrated to be performed by separate processors or controllers may be performed by the same processor or controller. Hence, references to specific functional units are only to be seen as references to suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organization.

[051] Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art

would recognize that various features of the described embodiments may be combined in accordance with the invention.

[052] Furthermore, although individually listed, a plurality of means, elements or process steps may be implemented by, for example, a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also, the inclusion of a feature in one category of claims does not imply a limitation to this category, but rather the feature may be equally applicable to other claim categories, as appropriate.

WE CLAIM:

1. A method of braking and overtaking in an electrically powered vehicle, the method comprising:

detecting, by a controller, one or more objects around the electrically powered vehicle based on signals received from one or more sensors associated with the electrically powered vehicle, wherein at least a part of traction power is provided by an electric motor in the electrically powered vehicle;

receiving, by the controller and upon detecting an object in front of the electrically powered vehicle, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system;

detecting, by the controller, an intent of a driver to overtake the object or brake the electrically powered vehicle based on the user input;

activating, by the controller, an assist mode for the electrically powered vehicle based on the intent of the driver, wherein the assist mode comprises an overtake assist mode or a braking assist mode, and wherein activating the assist mode comprises deactivating a current driving mode of the electrically powered vehicle; and

determining, by the controller, a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

2. The method as claimed in claim 1, comprising transmitting, by the controller, to a motor controller the maximum output torque in the overtake assist mode based on detection of an increased acceleration by the user, or the maximum negative torque in the braking assist mode based on detection of a braking by the user.

3. The method as claimed in claim 1, wherein the maximum output torque of the electric motor is computed based on at least one of: a charge level of a battery providing traction power to the electrically powered vehicle, a real-time torque of the electric motor, a reserve torque level of the electric motor, and a thermal threshold level of the electric motor.

4. The method as claimed in claim 1, comprising providing, by the controller, a notification on an information display of the electrically powered vehicle upon the activation of the assist mode.

5. The method as claimed in claim 1, comprising deactivating, by the controller, the assist mode upon one of:

a charge level of a battery providing traction power to the electrically powered vehicle,

a presence of an object in an overtake lane,

a user input corresponding to one of a relaxation of acceleration, a relaxation of brake, or a manual override of the assist mode, or

a predefined time interval.

6. The method as claimed in claim 1, wherein the maximum negative torque of the electric motor is computed based on at least one of: a thermal threshold of the electric motor and a charge level of a battery providing traction power to the electrically powered vehicle.

7. A system of braking and overtaking in an electrically powered vehicle, the system comprises:

a controller; and

a memory coupled to the controller, wherein the memory stores controller-executable instructions, which, on execution, causes the controller to:

detect one or more objects around the electrically powered vehicle based on signals received from one or more sensors associated with the electrically powered vehicle, wherein at least a part of traction power is provided by an electric motor in the electrically powered vehicle;

receive upon detecting an object in front of the electrically powered vehicle, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system;

detect an intent of a driver to overtake the object or brake the electrically powered vehicle based on the user input;

activate an assist mode for the electrically powered vehicle based on the intent of the driver, wherein the assist mode comprises an overtake assist mode or a braking assist mode, and wherein activating the assist mode comprises deactivating a current driving mode of the electrically powered vehicle; and

determine a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

8. The system as claimed in claim 7, the controller is configured to:

transmit to a motor controller the maximum output torque in the overtake assist mode based on detection of an increased acceleration by the user, or the maximum negative torque in the braking assist mode based on detection of a braking by the user.

9. The system as claimed in claim 7, wherein the maximum output torque of the electric motor is computed based on at least one of: a charge level of a battery providing traction power to the electrically powered vehicle, a real-time torque of the electric motor, a reserve torque level of the electric motor, and a thermal threshold level of the electric motor.

10. The system as claimed in claim 7, the controller is configured to:
provide a notification on an information display of the electrically powered vehicle upon the activation of the assist mode.

11. The system as claimed in claim 7, the controller is configured to:
deactivate the assist mode upon one of:

a charge level of a battery providing traction power to the electrically powered vehicle,
a presence of an object in an overtake lane,
a user input corresponding to one of a relaxation of acceleration, a relaxation of brake, or a manual override of the assist mode, or
a predefined time interval.

12. The system as claimed in claim 7, wherein the maximum negative torque of the electric motor is computed based on at least one of: a thermal threshold of the electric motor and a charge level of a battery providing traction power to the electrically powered vehicle.

Dated this 17th day of March 2023

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ABSTRACT

METHOD AND SYSTEM OF BRAKING AND OVERTAKING IN AN ELECTRICALLY POWERED VEHICLE

A method and system of braking and overtaking in an electrically powered vehicle is disclosed. The system includes a controller that detects objects around the electrically powered vehicle based on signals received from one or more sensors. Upon detecting an object in front, a user input corresponding to at least one of an indicator light, a steering, a brake, or one or more signals from an in-vehicle system is received by the controller. An intent of a driver to overtake the object or brake the vehicle based on the user input is detected. Based on the detection of the intent of the driver, activate an assist mode for the electrically powered vehicle. The controller determines a maximum output torque for the electric motor in the overtake assist mode or a maximum negative torque for the electric motor in the braking assist mode.

[To be published with FIG. 1]

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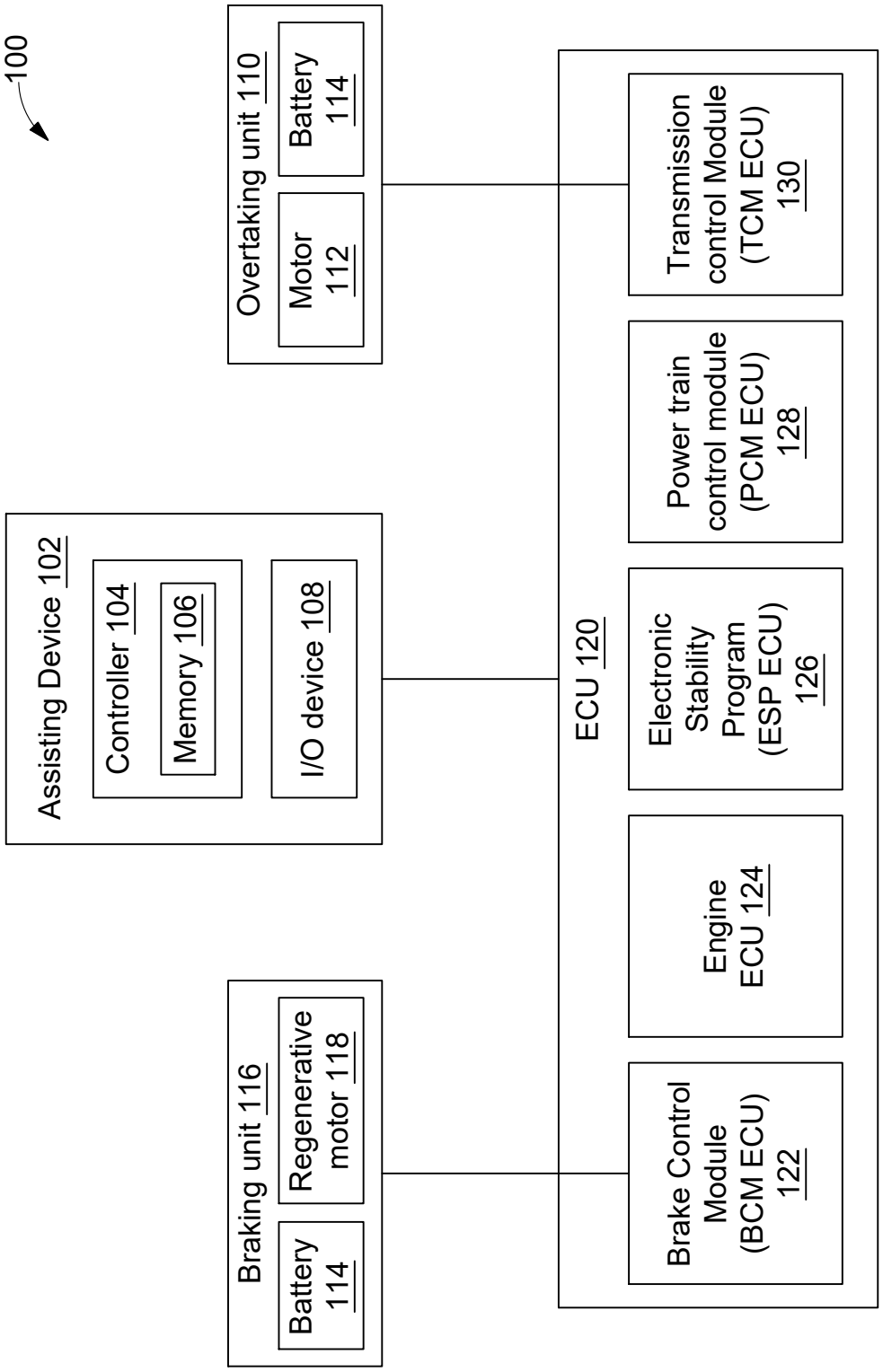

FIG. 1

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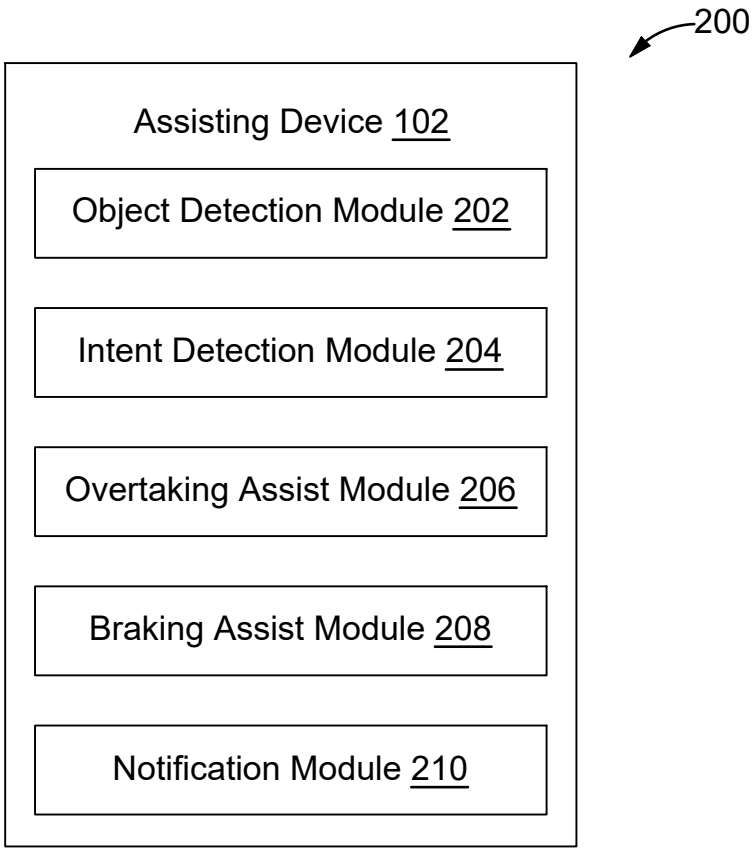

FIG. 2

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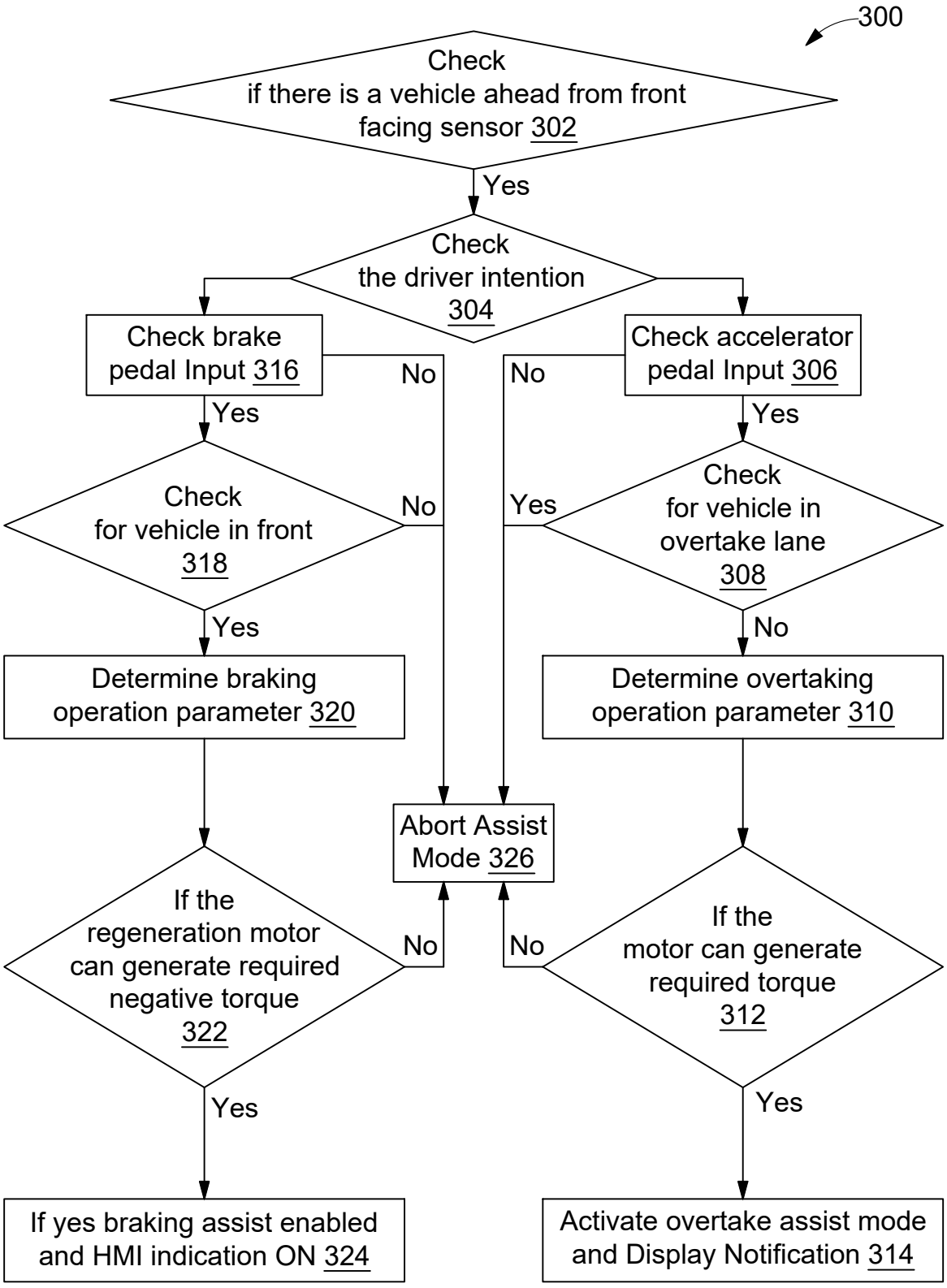

FIG. 3

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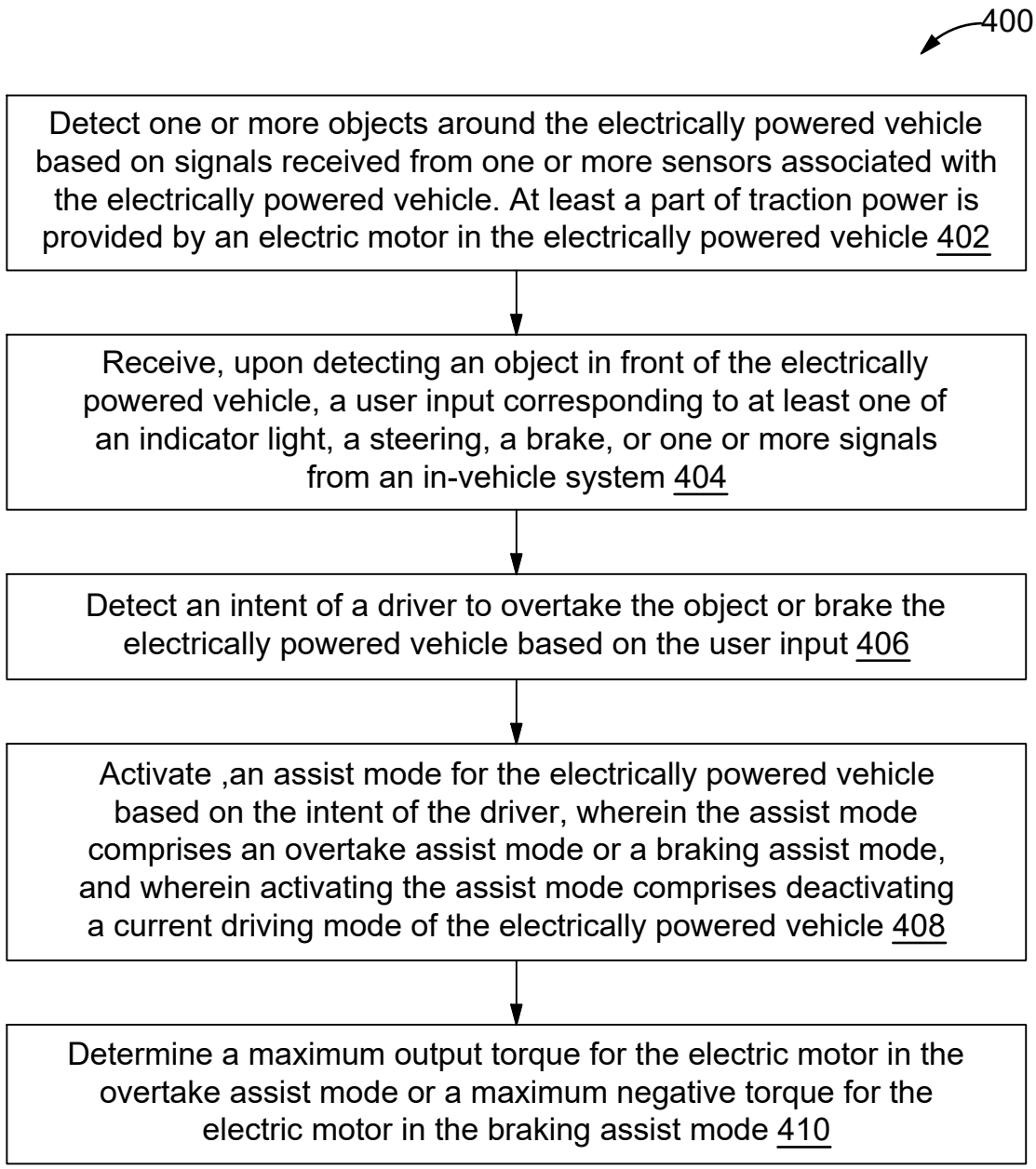

FIG. 4

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