(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
02 January 2025 (02.01.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/003144 A1

(51) International Patent Classification:
B62D 15/02 (2006.01) *G08G 1/14* (2006.01)
G06Q 10/02 (2012.01)

(21) International Application Number:
PCT/EP2024/067823

(22) International Filing Date:
25 June 2024 (25.06.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2309572.2 26 June 2023 (26.06.2023) GB

(71) Applicant: **JAGUAR LAND ROVER LIMITED** [GB/GB]; Abbey Road, Whitley, Coventry Warwickshire CV3 4LF (GB).

(72) Inventor: **PETTINGER, David**; c/o Jaguar Land Rover, Patents Department W/1/073, Abbey Road, Whitley, Coventry Warwickshire CV3 4LF (GB).

(74) Agent: **JAGUAR LAND ROVER PATENTS DEPARTMENT**; c/o Jaguar Land Rover, Patents Department W/1/073, Abbey Road, Whitley, Coventry Warwickshire CV3 4LF (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** CONTROL SYSTEM AND METHOD FOR PARKING ASSISTANCE

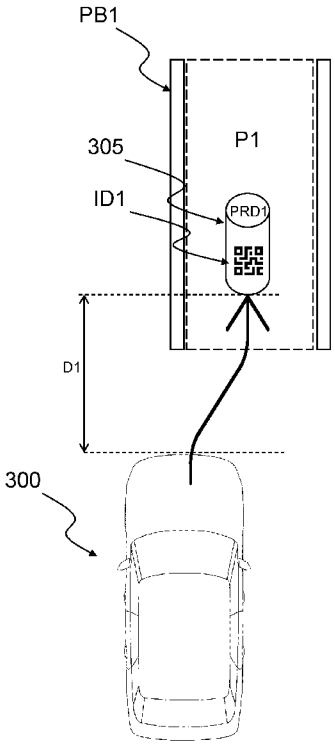


FIG. 2

(57) **Abstract:** Aspects of the present invention relate to a control system (100) for controlling a parking assistance system (200) of a vehicle (300). The control system (100) includes one or more controller (110). The control system (100) is configured to receive image data (315) captured by at least one imaging sensor (310) provided on the vehicle (300), the image data (315) representing a scene external to the vehicle (300); and to receive a parking space signal (275) identifying a parking space (P1) for the vehicle (300). The control system (100) processes the image data (315) to identify the presence of a parking space reservation object (PRD1) associated with the identified parking space (P1), and to characterise the identified parking space reservation object (PRD1) as being in one of a first state (S1) in which vehicle access to the parking space (P1) is not possible and a second state (S2) in which vehicle access to the parking space (P2) is possible. In dependence on the parking space reservation object (PRD1) being characterised as being in the first state (S1), the control system (100) is configured to output a request for confirmation that the vehicle (300) is to be parked in the identified parking space (P1). The control system (100) receives a confirmation signal confirming that the vehicle (300) is to be parked in the identified parking space (P1). A parking manoeuvre request signal (105A) is output to the parking assistance system (200) to perform a parking manoeuvre to park the vehicle (300) in the identified parking space (P1) when the parking space reservation object (PRD1) is characterised as being in the second state (S2). Aspects of the invention also relate to a system (160), a vehicle (300), a method (500) and a computer readable instructions.

WO 2025/003144 A1

CONTROL SYSTEM AND METHOD FOR PARKING ASSISTANCE

TECHNICAL FIELD

The present disclosure relates to a control system and method for parking assistance. In particular, the control system and method are configured to control operation of a parking assistance system. Aspects of the invention relate to a control system, a system, a vehicle, a method and a computer readable instructions.

BACKGROUND

A parking space reservation object (also known as a park lock device or a parking space locking device) may be provided to reserve a parking space. The parking space reservation object may, for example, be positioned at the leading edge of the parking space. The parking space reservation object can be deployed to form a physical barrier to inhibit or prevent unauthorised parking of a vehicle in the parking space. The parking space reservation object can be stowed to enable access to the parking space. The parking space reservation object typically comprises a locking mechanism operable to lock the parking space reservation object in the deployed position. The locking mechanism can be unlocked to enable the parking space reservation object to be stowed. The parking space reservation object may be locked and unlocked manually. Alternatively, the locking and unlocking of the parking space reservation object may be at least partially automated. For example, the parking space reservation object may comprise an actuator for operating the locking mechanism.

It is known to provide a vehicle with a parking assistance system. The parking assistance system may identify a parking space for a vehicle. The parking assistance system may optionally control the vehicle to perform a parking manoeuvre. The parking assistance system typically require a complete and clear view of the width of the parking space to determine that the space is available. A potential shortcoming of known parking assistance systems is the ability to take due account of a parking space reservation object associated with a parking space. The parking assistance system may determine that the parking space is not available if the parking space reservation object is detected.

It is an aim of the present invention to address one or more of the disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a control system, a system, a vehicle, a method and computer readable instructions as claimed in the appended claims.

According to an aspect of the present invention there is provided a control system for controlling a parking assistance system of a vehicle, the control system comprising one or more controller, the control system configured to:

receive image data captured by at least one imaging sensor provided on the vehicle, the image data representing a scene external to the vehicle;

identify a parking space for the vehicle;

process the image data to identify the presence of a parking space reservation object associated with the identified parking space, and to characterise the identified parking space reservation object as being

in one of a first state in which vehicle access to the parking space is not possible and a second state in which vehicle access to the parking space is possible;

in dependence on the parking space reservation object being characterised as being in the first state, the control system is configured to output a request for confirmation that the vehicle is to be parked in the identified parking space;

receive a confirmation signal confirming that the vehicle is to be parked in the identified parking space; and

output a parking manoeuvre request signal to the parking assistance system to perform a parking manoeuvre to park the vehicle in the identified parking space when the parking space reservation object is characterised as being in the second state.

In use, the control system identifies the presence of the parking space reservation object. Furthermore, the control system is operative to characterise the identified parking space reservation object as being in one of the first state and the second state. The control system thereby determines if parking in the parking space is possible or not possible in dependence on the determined state of the identified parking space reservation object. If the control system determines that the parking space reservation object is in the first state in which parking is not possible, a check is performed to determine if the vehicle is to be parked in the identified parking space. The control system outputs the parking manoeuvre request signal to perform the parking manoeuvre in dependence on receipt of the confirmation signal. At least in certain embodiments the control system can control the parking assistance system to initiate the parking manoeuvre when the parking space reservation object is in the first state. Thus, the control system enables the vehicle to be parked in the parking space even when the parking space reservation object is in the first state.

The processing of the image data to identify the presence of the parking space reservation object may be based in dependence on a surface area and/or a location of an object within the boundaries of the parking space. Alternatively, or in addition, the presence of the parking space reservation object may be determined using image-based recognition of the park lock device, for example utilising pattern matching.

The request for confirmation that the vehicle is to be parked into the identified parking space may be output to another vehicle system, such as an autonomous driving control unit. The confirmation signal may be received form the vehicle system. Alternatively, the request may be output to a driver of the vehicle, for example in the form of a driver notification. The confirmation signal may be generated in dependence on a user input to confirm that the vehicle is to be parked. The request may prompt a notification indicating that the parking space is blocked or obstructed. An output may be generated to notify the driver that the parking space reservation object should be reconfigured to enable performance of the parking manoeuvre.

At least in certain embodiments, the control system may initiate the parking manoeuvre while the parking space reservation object is in the first state. The control system may pause or interrupt the parking manoeuvre when the horizontal distance between the vehicle and the parking space reservation object is less than or equal to a predefined threshold. The control system may optionally output a signal or a prompt to request that the parking space reservation object is re-configured to the second state. The control system may re-start the

parking manoeuvre in dependence on a determination that the parking space reservation object is in the second state. For example, the control system may output the parking manoeuvre request signal to the parking assistance system to perform the parking manoeuvre in dependence on a determination that the parking space reservation object is in the second state in which vehicle access to the parking space is possible. The control system may re-start the parking manoeuvre automatically or in dependence on a confirmation request from a driver of the vehicle.

The control system may be configured to receive a parking space signal to identify the parking space. The parking space signal may be received from the parking assistance system. The parking space signal may identify the position of the parking space relative to the vehicle. The parking space signal may identify a perimeter or a boundary of the parking space. Alternatively, or in addition, the control system may be configured to process the image data to identify the parking space. The image data may be processed to identify the position of the parking space relative to the vehicle. The image data may be processed to identify a perimeter or a boundary of the parking space.

The control system comprises one or more controllers collectively comprising at least one electronic processor having an electrical input for receiving an input signal; and at least one memory device electrically coupled to the at least one electronic processor and having instructions stored therein. The electrical input is suitable for receiving an image data signal comprising the image data; and the confirmation signal. Optionally, the electrical input may be suitable for receiving the parking space signal to identify the parking space. The at least one electronic processor may comprise an electrical output for outputting a confirmation request signal to request confirmation; and the parking manoeuvre request signal. The at least one electronic processor is configured to access the at least one memory device and execute the instructions thereon to identify the presence of the parking space reservation object and to characterise the identified parking space reservation object as being in one of the first state and the second state. The at least one electronic processor may generate the parking manoeuvre request signal which is output to the parking assistance system.

The control system may be configured to identify a first state change of the parking space reservation object from the first state to the second state. The control system may thereby determine with the parking space reservation object is re-configured to such that parking in the parking space is possible. The parking manoeuvre resume signal may be output to the parking assistance system to initiate performance of the parking manoeuvre. The control system may output the parking manoeuvre request signal to the parking assistance system in dependence on the identification of the first state change. The parking manoeuvre may be performed when the parking space reservation object is re-configured to enable parking in the parking space. At least in certain embodiments, the parking manoeuvre request signal may be output to re-start or to continue performance of a parking manoeuvre, for example a parking manoeuvre which was paused when the vehicle was a predetermined distance from the parking space reservation object. The control system may be configured to process the image data to determine the first state change of the identified parking space reservation object (i.e., a change from the second state to the first state).

The control system may be configured to identify a second state change of the parking space reservation object from the second state to the first state. The control system may output the parking manoeuvre interrupt signal to interrupt the parking manoeuvre in dependence on the identification of the second state change. The parking manoeuvre interrupt signal may be output to the parking assistance system to interrupt or pause performance of the parking manoeuvre. The parking manoeuvre interrupt signal may be generated automatically to interrupt the parking manoeuvre. This may be appropriate, for example, if the parking space reservation object is deployed while the vehicle is performing a parking manoeuvre. The control system may be configured to process the image data to determine the second state change of the identified parking space reservation object (i.e., a change from the second state to the first state).

The parking assistance system may control the vehicle to perform an assisted (semi-autonomous) parking manoeuvre or an autonomous parking manoeuvre. The assisted parking manoeuvre may be classed as Level 2 autonomous control. The autonomous parking manoeuvre may be classed as Level 2 or Level 4 autonomous control. The parking assistance system may implement a remote parking function. The remote parking function may provide in-vehicle assistance (i.e., to assist a driver in the vehicle) or remote parking assistance (i.e., to assist a driver outside the vehicle).

The control system may be configured to identify a third state change of the parking space reservation object from the first state to the second state. The control system may output a parking manoeuvre resume signal to resume the parking manoeuvre in dependence on the identification of the third state change. The parking manoeuvre resume signal may be output to the parking assistance system to resume performance of the parking manoeuvre. An interrupted parking manoeuvre may be resumed when the parking space reservation object is re-configured to enable parking in the parking space. At least in certain embodiments, the parking manoeuvre request signal may re-start or continue performance of the parking manoeuvre. The control system may be configured to process the image data to determine the third state change of the identified parking space reservation object (i.e., a change from the first state to the second state).

Alternatively, or in addition, the control system may be configured to output a parking manoeuvre resume signal to resume performance of the parking manoeuvre in dependence on receipt of a user input. The user input may confirm that the parking space reservation object is in the second state. The parking manoeuvre resume signal may be output to the parking assistance system to resume performance of the parking manoeuvre. An interrupted parking manoeuvre may be resumed when the parking space reservation object is re-configured to enable parking in the parking space. At least in certain embodiments, the parking manoeuvre request signal may re-start or continue performance of the parking manoeuvre.

The control system may be configured to output a notification signal in dependence on the parking space reservation object being characterised as being in the first state. The notification signal may generate an alert for a user or a driver of the vehicle. For example, the notification signal may prompt the output of an alert indicating that a parking space reservation object has been identified.

The control system may be configured to output a state change request signal to request that the parking space reservation object is changed from the first state to the second state. The state change request signal may be output in dependence on the parking space reservation object being characterised as being in the first state.

The parking space reservation object may comprise one or more actuator for configuring the parking space reservation object in the first state and the second state. The one or more actuator may be controlled in dependence on one or more electrical signal. The one or more electrical signal may be output by the control system, for example as a wireless a radio frequency (RF) signal. The one or more electrical signal may comprise a first state request signal to request that the parking space reservation object is configured in the first state; and a second state request signal to request that the parking space reservation object is configured in the second state. The control system may be configured to generate the first state request signal and/or the second state request signal. The control system may output the second state request signal before or during performance of a parking manoeuvre. The parking space reservation object may be reconfigured to the second state to enable the vehicle to complete a parking manoeuvre to park the vehicle in the parking space. The control system may output the first state request signal after performance of the parking manoeuvre or after the vehicle exits the parking space. The first state request signal may be output to configure the parking space reservation object to reserve the parking space after the vehicle has exited the parking space. The control system may process the image data to determine that the vehicle is exiting or has exited the parking space.

Output of the first state request signal and/or the second state request signal by the control system provides for the parking space reservation object to be reconfigured between the first and second states automatically and without the user being required to exit the vehicle and manually reconfigure the parking space reservation object. Advantageously, the parking assistance system is enabled to autonomously conduct a complete parking manoeuvre with any parking space reservation object being configured automatically to allow passage of the vehicle.

The control system may be configured to process the image data to determine an identifier associated with the parking space reservation object. The identifier may be a unique identifier. The identifier may, for example, comprise a machine-readable optical code. The identification of the identifier may facilitate determination that an authorisation is in place for the identified parking space. The identification of the parking space reservation object may facilitate communication with the parking space reservation object, for example to request that the parking space reservation object is configured in the second state.

The at least one imaging sensor may comprise an optical sensor, for example a camera. Alternatively, or in addition, the at least one imaging sensor may comprise one or more of the following: an Imaging Radar and a Lidar. The at least one imaging sensor may comprise a combination of different types of imaging sensor.

According to a further aspect of the present invention there is provided a system comprising the control system of any preceding claim and a parking assistance system, the control system being configured to output the parking manoeuvre request signal to the parking assistance system.

According to a further aspect of the present invention there is provided a vehicle comprising the system described herein. According to a further aspect of the present invention there is provided a vehicle comprising the control system described herein.

According to a further aspect of the present invention there is provided a method of controlling a parking assistance system of a vehicle, the method comprising:

receiving image data captured by at least one imaging sensor provided on the vehicle, the image data representing a scene external to the vehicle;

identifying a parking space for the vehicle;

processing the image data to identify the presence of a parking space reservation object associated with the identified parking space, and to characterise the identified parking space reservation object as being in one of a first state in which vehicle access to the parking space is not possible and a second state in which vehicle access to the parking space is possible;

in dependence on the parking space reservation object being characterised as being in the first state, the method comprising requesting confirmation that the vehicle is to be parked in the identified parking space;

receiving a confirmation signal confirming that the vehicle is to be parked in the identified parking space; and

outputting a vehicle parking signal to the parking assistance system to perform a parking manoeuvre to park the vehicle in the identified parking space when the parking space reservation object being characterised as being in the second state.

The method may comprise receiving a parking space signal to identify the parking space. Alternatively, the method may comprise processing the image data to identify the parking space.

According to an aspect of the present invention there is provided a control system for controlling a parking assistance system of a vehicle, the control system comprising one or more controller, the control system configured to:

receive image data capturing by at least one imaging sensor provided on the vehicle, the image data representing a scene external to the vehicle;

process the image data to identify the presence of a parking space reservation object in the scene and to characterise the identified parking space reservation object as being in one of a first state and a second state; and

in dependence on the identification of the parking space reservation object in the first state, to output a signal indicating that the parking space reservation object is in the first state. The parking space reservation object in the first state prevents or inhibits vehicle access to the parking space such that parking is not possible. The parking space reservation object in the second state enables vehicle access to the parking space and parking is possible.

The signal is output to the parking assistance system provided on the vehicle. The signal may request that the parking assistance system pauses, interrupts or delays a parking manoeuvre while the parking space

reservation object is in the first state. The control system may output a request for confirmation that the vehicle is to be parked in the identified parking space. The control system may output a parking request signal to the parking assistance system to request performance of the parking manoeuvre in dependence on receipt of a confirmation signal. Alternatively, or in addition, the control system may output a parking request signal to the parking assistance system to request performance of the parking manoeuvre in dependence on a determination that the parking space reservation object is in the second state.

According to a further aspect of the present invention there is provided a computer readable instructions which, when executed by a computer, are arranged to perform a method(s) as described herein.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic representation of a vehicle incorporating a control system in accordance with an embodiment of the present invention;

Figure 2 shows the vehicle shown in Figure 1 in relation to a parking space having a parking space reservation object in accordance with an embodiment of the present invention;

Figure 3A shows the parking space reservation object in Figure 2 in a first deployed state to prevent vehicle access to the parking space in accordance with an embodiment of the present invention;

Figure 3B shows the parking space reservation object in Figure 2 in a second stowed state to allow vehicle access to the parking space in accordance with an embodiment of the present invention;

Figure 4 shows a schematic representation of the parking assistance system to identify the parking space in accordance with an embodiment of the present invention;

Figure 5 shows a schematic representation of the control system to control operation of the parking assistance system in accordance with an embodiment of the invention; and

Figure 6 shows a block diagram to illustrate a method of controlling a parking assistance system in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

A control system 100 for controlling a parking assistance system 200 in accordance with an embodiment of the present invention is described herein with reference to the accompanying Figures. As shown in Figure 1, the control system 100 and the parking assistance system 200 are installed in a vehicle 300.

The vehicle 300 is a road vehicle, such as an automobile, a sports utility vehicle (SUV) or a utility vehicle. The vehicle 300 in the present embodiment is an automobile. The vehicle 300 comprises at least one imaging sensor 310 configured to capture an image representing a scene external to the vehicle 300. The or each imaging sensor 310 is configured to output an image data signal 315. The image data signal 315 represents image data captured by the at least one imaging sensor 310. The at least one imaging sensor 310 comprises at least one optical sensor in the present embodiment. A first optical sensor 310A is provided for capturing a first scene to a front of the vehicle 300; and a second optical sensor 310B is provided for capturing a second scene to a rear of the vehicle 300. The first optical sensor 310A is mounted in a forward-facing orientation; and the second optical sensor 310B is mounted in a rearward-facing orientation. The first and second optical sensors 310A, 310B may each comprise a single- or stereo-optical sensor. Alternatively, or in addition, the at least one imaging sensor 310 may comprise a Light Detection and Ranging (LIDAR) sensor and/or a radar sensor. The vehicle 300 comprises at least one parking sensor 330 configured to output a proximity signal 335. The at least one parking sensor 330 comprises at least one first parking sensor 330A mounted at the front of the vehicle 300; and/or at least one second parking sensor 330B mounted at the rear of the vehicle 300. The or each parking sensor 330 comprises one or more proximity sensor configured to determine the proximity and position of an obstacle (denoted generally by the reference 305 in Figure 2) in relation to the vehicle 300. The or each parking sensor 330 comprises an ultrasonic (time-of-flight) sensor in the present embodiment. The vehicle 300 comprises a human-machine-interface (HMI) 345. The HMI 345 may, for example, comprise or consist of one or more input devices, such as a button, a switch or a touch screen; and an output device, such as a display screen.

The parking assistance system 200 is configured to identify a parking space (or parking bay) P1 suitable for parking the vehicle 300. The parking assistance system 200 also identifies the presence of the obstacle 305 which prevents or inhibits vehicle access to a candidate parking space P1. The parking assistance system 200 is configured to control the vehicle 300 to perform a parking manoeuvre when a suitable parking space P1 is identified. In particular, the parking assistance system 200 is configured to control the vehicle 300 to park the vehicle 300 in the parking space P1. As shown in Figure 2, the extent of the parking space P1 may be defined by a boundary PB1. The boundary PB1 represents a perimeter or outer limit of the parking space P1. The boundary PB1 may, for example, be defined by one or more lines or markings on the ground. Alternatively, or in addition, the boundary PB1 may be defined by one or more of the following: a structure, such as a wall; a column; a pillar; and a kerb.

The obstacle 305 in the illustrated example is in the form of a parking space reservation object PRD1 (also known as a parking space locking device or a parking lock). The parking space reservation object PRD1 is selectively configurable in one of a first (locked/deployed) state S1 in which vehicle access to the parking space P1 is not possible; and a second (unlocked/stowed) state S2 in which vehicle access to the parking space P1 is possible. The parking space reservation object PRD1 is illustrated in the first state S1 in Figure 3A; and in the second state S2 in Figure 3B. The parking space reservation object PRD1 is deployed in the first state S1 to inhibit vehicle access to the parking space P1; and undeployed (or stowed) in the second state S2 to enable vehicle access to the parking space P1. The parking space reservation object PRD1 can be selectively locked in each of the first and second states S1, S2 to prevent tampering or unauthorised access to the parking space P1. The parking space reservation object PRD1 in the present embodiment comprises a deployable bollard which is selectively configurable in the first state S1 and the second state S2. The bollard is in a deployed configuration in the first state S1, and in an un-deployed (or retracted) configuration in the second state S2. The parking space reservation object PRD1 in the present embodiment is manually configured in each of the first and second states S1, S2. Alternatively, the parking space reservation object PRD1 may be automatically configured in each of the first and second states S1, S2. For example, the parking space reservation object PRD1 may comprise an actuator (not shown) which is operable selectively to configure the parking space reservation object PRD1 in the first and second states S1, S2. Other types of parking space reservation object PRD1 are contemplated. For example, the parking space reservation object PRD1 may comprise a pivotally mounted arm which may be raised in the first state S1 and lowered in the second state S2. In another example, the parking space reservation object PRD1 may comprise a garage door. The garage door may be electrically actuated. The garage door may be of a type including an up & over door or a roller shutter. In such an example, the control system may be configured to identify the parking space by identifying the garage door. In other words, the control system does not necessarily identify the parking space P1 by recognising the boundary/shape of the parking space P1 directly, but rather identifies the parking space based on identification of a garage door having visual properties that are indicative of the existence of a parking space behind the garage door. Such visual properties may include signage or the presence of a building/garage around the garage door, or a pre-defined type of garage door stored in memory, behind which a parking space is known to exist.

The parking assistance system 200 as illustrated in Figure 4 comprises one first controller 210, although it will be appreciated that this is merely illustrative. The first controller 210 comprises first processing means 220 and first memory means 230. The first processing means 220 may be one or more electronic processing device 220 which operably executes computer-readable instructions. The first memory means 230 may be one or more memory device 230. The first memory means 230 is electrically coupled to the first processing means 220. The first memory means 230 is configured to store instructions, and the first processing means 220 is configured to access the first memory means 230 and execute the instructions stored thereon. The first controller 210 comprises an input means 240 and an output means 250. The input means 240 may comprise an electrical input 240 of the first controller 210. The output means 250 may comprise an electrical output 250 of the first controller 210.

The input 240 is arranged to receive the image data signal 315 from the at least one imaging sensor 310; and the proximity signal 335 from the at least one parking sensor 330. The image data signal 315 is an electrical signal which is indicative of the image captured by the at least one imaging sensor 310. The proximity signal 335 is an electrical signal which is indicative of the proximity and position of an obstacle, such as the parking space reservation object PRD1, relative to the vehicle 300.

The parking assistance system 200 implements a parking space identifier 270 (shown schematically in Figure 1) for identifying the parking space P1. The parking space identifier 270 receives signals from the vehicle sensors and processes the signals to identify the parking space P1. The input 240 comprises at least one of the image data signal 315 from the at least one imaging sensor 310; and the proximity signal 335 from the at least one parking sensor 330. The first processing means 220 processes the image data signal 315 to identify the parking space P1 and the boundary PB1 of the parking space P1. The image processing algorithm may, for example, identify a space or region having dimensions and/or characteristics associated with a parking space P1. The proximity signal 335 may optionally also be processed to identify the parking space P1 and/or to determine the boundary PB1 of the parking space P1. Other signals may be used to identify the parking space P1. For example, a geolocation of a parking space P1 associated with the vehicle 300 may be identified using a navigational system (not shown). The parking space identifier 270 generates a parking space signal 275 which identifies the parking space P1. The first processing means 220 identifies the presence of the obstacle 305 which inhibits or prevents vehicle access to the parking space P1. The obstacle 305 may be identified through processing of the image data signal 315 and/or the proximity signal 335. In a variant, the parking space identifier 270 may be separate from the parking assistance system 200. For example, the parking space identifier 270 may be implemented by a separate controller or combined with the control system 100 described herein.

The output 250 is arranged to output a parking space signal 275. The parking space signal 275 is an electrical signal which identifies the position of the parking space P1 relative to the vehicle 300. The parking space signal 275 also identifies the boundary PB1 of the parking space P1. The output 250 is arranged to output an obstacle identification signal 285 which identifies the presence of the obstacle 305 associated with the parking space P1.

The output 250 is arranged to output a plurality of vehicle control signals 290. The vehicle control signals 290 are electrical signals for controlling operation of one or more vehicle systems (denoted by the reference numeral 295 in Figure 4) to control the dynamic operation of the vehicle 300. The vehicle control signals 290 may, for example, be output to a vehicle control unit associated with the respective vehicle systems. In particular, the vehicle control signals 290 are operative to control the vehicle 300 to perform the parking manoeuvre. The vehicle control signals 290 may comprise one or more of the following: a steering control signal 290A output to a power steering control unit 295A; a torque demand signal 280B output to an engine/motor control unit 295B; a transmission control signal 290C output to a transmission control unit 295C; and a braking control system 280D output to a brake control unit 295D. As described herein, the parking assistance system 200 receives signals from a plurality of vehicle sensors to determine the relative location of obstacles proximal to the vehicle 300. The parking assistance system 200 may be configured to provide

autonomous or semi-autonomous control of the vehicle 300. The semi-autonomous control of the vehicle 300 may require one or more driver input to perform the parking manoeuvre. The semi-autonomous control of the vehicle may be classed as Level 2 autonomous control. The autonomous control may control the vehicle 300 to perform the parking manoeuvre without driver inputs. The autonomous parking manoeuvre may be classed as Level 2 or Level 4 autonomous control. Alternatively, or in addition, the parking assistance system 200 may implement a remote parking function which may provide in-vehicle or remote assistance to perform the parking manoeuvre.

The control system 100 is configured to control the parking assistance system 200. In particular, the control system 100 is configured to output one or more parking manoeuvre control signal 105A-D to the parking assistance system 200 to control performance of a parking manoeuvre. The control system 100 as illustrated in Figure 3 comprises one second controller 110, although it will be appreciated that this is merely illustrative. The second controller 110 comprises second processing means 120 and second memory means 130. The second processing means 120 may be one or more electronic processing device 120 which operably executes computer-readable instructions. The second memory means 130 may be one or more memory device 130. The second memory means 130 is electrically coupled to the second processing means 120. The second memory means 130 is configured to store instructions, and the second processing means 120 is configured to access the second memory means 130 and execute the instructions stored thereon. The second controller 110 comprises an input means 140 and an output means 150. The input means 140 may comprise an electrical input 140 of the second controller 110. The output means 150 may comprise an electrical output 150 of the second controller 110.

The input 140 is arranged to receive the parking space signal 275 identifying the parking space P1. The parking space signal 275 identifies the position of the parking space P1 relative to the vehicle 300 and the boundary PB1 of the parking space P1. In a variant, the control system 100 may implement the parking space identifier 270 and generate the parking space signal 275 to identify the parking space P1. The input 140 is arranged to receive the obstacle identification signal 285 identifying the obstacle 305. The input 140 is arranged also to receive the image data signal 315 from the at least one imaging sensor 310. As described herein, the image data signal 315 represents image data corresponding to a scene external to the vehicle 300.

The second controller 110 is configured to process the image data 115 to identify the parking space reservation object PRD1. The second controller 110 implements an image processing algorithm to identify the parking space reservation object PRD1. The image processing algorithm may, for example, implement an image (or pattern) matching algorithm in respect of at least a portion of the image represented by the image data 115. The image matching algorithm may be applied in respect of a sub-area of the image represented by the image data 115. For example, the image matching algorithm may be applied in respect of a sub-area of the image which corresponds to the parking space P1 identified by the parking space signal 275. Alternatively, or in addition, the image matching algorithm may identify a region of the image having a colour corresponding to a predefined colour (or within a predefined range of colours) associated with a parking space reservation object PRD1. The image matching algorithm may match one or more patterns present in the image to a stored representation of one or more parking space reservation object PRD1. The parking space reservation object

PRD1 shown in Figures 3A and 3B is in the form of a bollard which is in a raised position in the first state S1 and in a lowered position in the second state S2. It will be understood that the control system 100 may be configured to identify and characterise other types of parking space reservation object PRD1.

The control system 100 is configured to differentiate between a plurality of different operating states of the parking space reservation object PRD1. In particular, the second controller 110 is configured to characterise the identified parking space reservation object PRD1 as being in one of at least the first state S1 and the second state S2. The first state S1 corresponds to a configuration of the parking space reservation object PRD1 in which vehicle access to the parking space P1 is not possible; and the second state S2 corresponds to a second configuration of the parking space reservation object PRD1 in which vehicle access to the parking space P1 is possible. The second controller 110 is configured to process the image data 115 to differentiate between the first and second states S1, S2. The second controller 110 characterises the parking space reservation object PRD1 as being in one of the first and second states S1, S2. The second controller 110 is configured also to identify a change in the operating state of the parking space reservation object PRD1. For example, the second controller 110 can identify a first state change from the first state S1 to the second state S2; or a second state change from the second state S2 to the first state S1.

The image matching algorithm may be configured to differentiate between at least the first state S1 and the second state S2 in dependence on one or more of the following:

i. a shape/profile of the parking space reservation object PRD1;
ii. a size of the parking space reservation object PRD1;
iii. a position of the parking space reservation object PRD1 (relative to the parking space P1 and/or the vehicle 300);
iv. an orientation of the parking space reservation object PRD1;
v. a vertical height of the parking space reservation object PRD1;
vi. a width of the parking space reservation object PRD1; and
vii. a visible indicator or notice advising that unauthorized access to the parking space P1 is prohibited.

The control system 100 is configured to control operation of the parking assistance system 200 in dependence on a determination that the parking space reservation object PRD1 is in one of the first state S1 and the second state S2. The control system 100 is configured to control operation of the parking assistance system 200 in dependence on a determination that the parking space reservation object PRD1 has changed from the first state S1 to the second state S2; or from the second state S2 to the first state S1.

The output 150 is arranged to output one or more parking manoeuvre control signal 105A-D to control operation of the parking assistance system 200. The or each parking manoeuvre control signal 105A-D is an electrical signal arranged to control operation of the parking assistance system 200. In the present embodiment, the output 150 is arranged to output a plurality of the parking manoeuvre control signals 105. The parking manoeuvre control signals 105A-D comprise one or more of the following:

i. A parking manoeuvre request signal 105A to request that the parking assistance system 200 initiates performance of a parking manoeuvre.
ii. A parking manoeuvre interrupt signal 105B to request that the parking assistance system 200 pauses or interrupts performance of a parking manoeuvre.
iii. A parking manoeuvre resume signal 105C to request that the parking assistance system 200 resumes or continues performance of a parking manoeuvre.
iv. A parking manoeuvre halt signal 105D to request that the parking assistance system 200 halts performance of a parking manoeuvre.

The control system may optionally be configured to output a notification signal 105E in dependence on the parking space reservation object PRD1 being characterised as being in the first state. The notification signal 105E may be output to the HMI 345, for example to generate an alert for a user or a driver of the vehicle 300. The alert may notify the user or the drive that the parking space reservation object PRD1 has been identified. The notification signal 105E may prompt the generation of one or more of the following: a visual alert, a haptic alert and an audio alert.

The control system 100 is configured to control operation of the parking assistance system 200 in dependence on the determined state of the parking space reservation object PRD1 and/or in dependence on a change in the determined state of the parking space reservation object PRD1. The operation of the control system 100 will now be described in more detail.

The parking assistance system 200 may be activated by a user input, for example in dependence on a driver request for assistance to park the vehicle 300. The parking assistance system 200 commences a search for a parking space P1 suitable for parking the vehicle 300. The parking assistance system 200 identifies the parking space P1 and outputs the parking space signal 275 identifying the location of the parking space P1 relative to the vehicle 300 and the boundary PB1 of the parking space P1. The control system 100 receives the parking space signal 275 from the parking assistance system 200. The control system 100 processes the image data 115 to determine if there is a parking space reservation object PRD1 associated with the parking space P1. If the control system 100 determines that there is no parking space reservation object PRD1 associated with the parking space P1, the output 150 outputs a parking manoeuvre request signal 105A to the parking assistance system 200 to request that the parking manoeuvre is performed. The parking assistance system 200 outputs vehicle control signals 290 to control the vehicle 300 to perform the parking manoeuvre.

If the control system 100 determines that there is a parking space reservation object PRD1 is associated with the parking space P1, the second controller 110 is configured to characterise the identified parking space reservation object PRD1 as being in one of the first state S1 (in which vehicle access to the parking space P1 is not possible) and the second state S2 (in which vehicle access to the parking space P1 is possible). If the second controller 110 characterises the parking space reservation object PRD1 as being in the second state S2, a parking manoeuvre request signal 105A is output to the parking assistance system 200 to request that

the parking manoeuvre is performed. The parking assistance system 200 outputs vehicle control signals 290 to control the vehicle 300 to perform the parking manoeuvre.

If the second controller 110 characterises the parking space reservation object PRD1 as being in the first state S1, the second controller 110 determines a separation distance D1 (range) between the vehicle 300 and the parking space reservation object PRD1. The separation distance D1 may be determined through analysis of the image data 315 and/or the proximity signal 335. If the separation distance D1 is less than a predetermined threshold, the second controller 110 outputs a parking manoeuvre interrupt signal 105B to the parking assistance system 200 to interrupt performance of the parking manoeuvre. If the separation distance D1 is greater than a predetermined threshold, the second controller 110 outputs a parking manoeuvre request signal 105A to the parking assistance system 200 to request that the parking manoeuvre is initiated. The second controller 110 monitors the separation distance D1 as the parking manoeuvre is performed. When the separation distance D1 is less than the predetermined threshold, the second controller 110 outputs a parking manoeuvre interrupt signal 105B to the parking assistance system 200 to interrupt performance of the parking manoeuvre. The parking manoeuvre interrupt signal 105B is output to the HMI 345 and prompts the output of a driver notification advising that vehicle access to the parking space P1 is prevented by the parking space reservation object PRD1 (determined to be in the first state S1). The HMI 345 may prompt the driver to unlock the parking space reservation object PRD1.

The second controller 110 continues to determine the operating state of the parking space reservation object PRD1. In dependence on identification of a first state change in which the parking space reservation object PRD1 changes from the first state S1 to the second state S2, the second controller 110 is configured to output the parking resume signal 105C to request that the parking assistance system 200 resumes or continues performance of the parking manoeuvre. A prompt may optionally be output to the HMI 345 to receive confirmation from the user (driver) to proceed with the parking manoeuvre. The control system 100 may optionally be configured to output the parking manoeuvre resume signal 105C in dependence on receipt of a user input confirming that the parking manoeuvre is to proceed, which may take the form of a confirmation signal. The parking assistance system 200 outputs vehicle control signals 290 to control the vehicle 300 to perform the parking manoeuvre.

The second controller 110 monitors the operating state of the parking space reservation object PRD1. In dependence on identification of a second state change in which the parking space reservation object PRD1 changes from the second state S2 to the first state S1, the second controller 110 is configured to output the parking interrupt signal 105B to request that the parking assistance system 200 interrupts performance of the parking manoeuvre.

Figure 6 illustrates a method 500 according to an embodiment of the invention. The method 500 is a method of controlling the vehicle 300 to perform a parking manoeuvre to park the vehicle 300 in a parking space P1. The method 500 may be performed by the control system 100 and the parking assistance system 200 described herein.

The method 500 comprises receiving a driver request for assistance to park the vehicle 300 (BLOCK 510). A search is initiated for a parking space P1 suitable for parking the vehicle 300 (BLOCK 520). The parking assistance system 200 is activated (BLOCK 530). The parking assistance system 200 identifies a candidate parking space P1. The parking assistance system 200 identifies the obstacle 305 which prevents or inhibits vehicle access to the parking space P1 (BLOCK 540). The parking space signal 275 and the obstacle identification signal 285 are received by the control system 100. The control system 100 identifies the obstacle 305 as corresponding to the parking space reservation object PRD1 selectively configurable in the first and second states S1, S2 (BLOCK 550). The control system 100 confirms that the parking space P1 with the parking space reservation object PRD1 is valid (BLOCK 560). The parking space P1 is determined (BLOCK 570).

The parking space(s) P1 is presented to the driver of the vehicle 300 (BLOCK 570). The driver confirms the parking space and commences the parking manoeuvre (BLOCK 580). The parking assistance system 200 controls the vehicle 100 to start the parking manoeuvre to park the vehicle 300 in the selected parking space P1 (BLOCK 590). The second controller 110 determines the separation distance D1 (range) between the vehicle 300 and the parking space reservation object PRD1. The second controller 110 outputs a parking manoeuvre interrupt signal 105B to the parking assistance system 200 to pause the parking manoeuvre when the separation distance D1 is less than the predetermined threshold (BLOCK 600). The predetermined threshold in this scenario is predefined as an appropriate stopping distance from the parking space reservation object PRD1. The control system 1090 generates a prompt for the driver to stow the parking space reservation object PRD1 (BLOCK 610). The driver exits the vehicle 300 and stows the parking space reservation object PRD1 (BLOCK 620). The driver re-enters the vehicle 300 and requests that the control system 100 continues the parking manoeuvre (BLOCK 630). The control system 100 outputs the parking manoeuvre resume signal 105C. The parking assistance system 200 recommences the parking manoeuvre and controls the vehicle 300 to a final park position in the parking space P1 (BLOCK 640). The vehicle 300 is parked in the parking space P1 (BLOCK 650).

The method 500 described herein requires that the parking space reservation object PRD1 is manually reconfigured, for example by a driver of the vehicle 300. In a variant, the parking space reservation object PRD1 may comprise an actuator operable to change the operating state of the parking space reservation object PRD1. The actuator may be controlled in dependence on a state change request signal 355, for example selectively to change the parking space reservation object PRD1 from the first state S1 to the second state S2 and/or from the second state S2 to the first state S1. The control system 100 may be configured to output the state change request signal 355. The vehicle 300 may comprise a radio frequency (RF) transmitter 350 for transmitting the state change request signal 355 to the parking space reservation object PRD1. The control system 100 may be configured to output the state change request signal 355. The state change request signal 355 may be output to request that the parking space reservation object PRD1 is reconfigured from the first state S1 to the second state S2 in dependence on the parking space reservation object PRD1 being characterised as being in the first state S1. The state change request signal 355 may be output to request that the parking space reservation object PRD1 is reconfigured from the second state S2 to the first state S1 in dependence on a determination that the vehicle 300 has exited the parking space P1.

The parking space reservation object PRD1 optionally comprises an identifier ID1 suitable for identifying the parking space reservation object PRD1. In the arrangement illustrated in Figure 2, the identifier ID1 may, for example, comprises a machine-readable optical code which is displayed on an exterior of the parking space reservation object PRD1. In a variant, the identifier ID1 may comprise a wireless transmitter for transmitting an identification signal to the vehicle 300, for example in response to a handshake signal transmitted by the parking assistance system 200. The identifier ID1 may, for example, comprise a radio frequency identification device (RFID). The control system 100 may identify the parking space reservation object PRD1 in dependence on the identifier ID1. The control system 100 may thereby determine if the vehicle 300 is authorised to park in the parking space P1 associated with the parking space reservation object PRD1. Alternatively, or in addition, the control system 100 may use the identifier ID1 to determine a communication address, such as an IP address, of the parking space reservation object PRD1. This may facilitate communication between the control system 100 and the parking space reservation object PRD1, for example to address a state change request signal 355.

The control system 100 and the parking assistance system 200 described herein in combination for a system 160. The control system 100 is configured to output the parking manoeuvre request signal 105A to the parking assistance system 200 in the system 160. The system 160 is provided on the vehicle 300. The present invention has been described with reference to the control system 100 and the parking assistance system 200 as being separate from each other. It will be understood that the control system 100 and the parking assistance system 200 may be combined. For example, the control system 100 and may be integrated into the parking assistance system 200.

The at least one imaging sensor 310 in the above embodiment comprises an optical sensor, such as a camera. Alternatively, or in addition, the at least one imaging sensor 310 may comprise one or more of an Imaging Radar and a Lidar. The at least one imaging sensor 310 may comprise a combination of different types of imaging sensor.

The at least one imaging sensor 310 in any of the embodiments discussed herein may comprise both of i) an optical sensor, such as a camera, and ii) an ultrasonic radar. The ultrasonic radar may be configured to determine a proximity of objects based on time-of-flight signals of sound waves. In such embodiments, the control system is further configured to perform a sensor fusion process, comprising combining data from i) the optical sensor and ii) the ultrasonic radar, in order to output a combined sensor output for identifying the presence of a parking space reservation object. In such embodiments, the control system is may be configured to generate image data comprising an object map based on the combined sensor output and to identify the presence of a parking space reservation object based on the object map. In such embodiments, the control system may be yet further configured to process the image data using an artificial intelligence system (such as a neural network) to identify the presence of a parking reservation object. Such a neural network may have been trained using a set of images including different parking reservation objects.

The output from the ultrasonic radar can provide information relating to distance to obstacles. The output from the optical sensor can provide information relating to contours of the scene external to the vehicle. Advantageously, combining data from the optical sensor and the ultrasonic radar provides a highly granular level of information about the environment surrounding the vehicle hence enabling detection of static parking reservation objects with a high degree of accuracy.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application. For purposes of this disclosure, it is to be understood that reference to 'the control system being configured to' is to be understood to mean 'the one or more controllers of the control system are collectively configured to'. The controller(s) described herein can each comprise a control unit or computational device having one or more electronic processors, the one or more processors collectively configured to perform the control system functionality set out in the control system claims.

CLAIMS

1. A control system for controlling a parking assistance system of a vehicle, the control system comprising one or more controller, the control system configured to:

receive image data captured by at least one imaging sensor provided on the vehicle, the image data representing a scene external to the vehicle;

identify a parking space for the vehicle;

process the image data to identify the presence of a parking space reservation object associated with the identified parking space, and to characterise the identified parking space reservation object as being in one of a first state in which vehicle access to the parking space is not possible and a second state in which vehicle access to the parking space is possible;

in dependence on the parking space reservation object being characterised as being in the first state, the control system is configured to output a request for confirmation that the vehicle is to be parked in the identified parking space;

receive a confirmation signal confirming that the vehicle is to be parked in the identified parking space; and

output a parking manoeuvre request signal to the parking assistance system to perform a parking manoeuvre to park the vehicle in the identified parking space when the parking space reservation object is characterised as being in the second state.

2. A control system as claimed in claim 1, wherein the control system is configured to receive a parking space signal to identify the parking space.

3. A control system as claimed in claim 1, wherein the control system is configured to process the image data to identify the parking space.

4. A control system as claimed in any one of the preceding claims, wherein the control system is configured to identify a first state change of the parking space reservation object from the first state to the second state; and to output the parking manoeuvre request signal to the parking assistance system in dependence on the identification of the first state change.

5. A control system as claimed in any one of the preceding claims, wherein the control system is configured to identify a second state change of the parking space reservation object from the second state to the first state; and to output the parking manoeuvre interrupt signal to interrupt the parking manoeuvre in dependence on the identification of the second state change.

6. A control system as claimed in claim 5, wherein the control system is configured to identify a third state change of the parking space reservation object from the first state to the second state; and to output a parking manoeuvre resume signal to resume the parking manoeuvre in dependence on the identification of the third state change.

7. A control system as claimed in claim 5, wherein the control system is configured to output a parking manoeuvre resume signal to resume performance of the parking manoeuvre in dependence on receipt of a user input.

8. A control system as claimed in any one of the preceding claims, wherein the control system is configured to output a notification signal in dependence on the parking space reservation object being characterised as being in the first state.

9. A control system as claimed in any one of the preceding claims, wherein the control system is configured to output a state change request signal to request that the parking space reservation object is changed from the first state to the second state, the state change request signal being output in dependence on the parking space reservation object being characterised as being in the first state.

10. A control system as claimed in any one of the preceding claims, wherein the control system is configured to process the image data to determine an identifier associated with the parking space reservation object.

11. A system comprising the control system of any preceding claim and a parking assistance system, the control system being configured to output the parking manoeuvre request signal to the parking assistance system.

12. A vehicle comprising the system of claim 11 or the control system of any one of claims 1 to 10.

13. A method of controlling a parking assistance system of a vehicle, the method comprising:

receiving image data captured by at least one imaging sensor provided on the vehicle, the image data representing a scene external to the vehicle;

identify a parking space for the vehicle;

processing the image data to identify the presence of a parking space reservation object associated with the identified parking space, and to characterise the identified parking space reservation object as being in one of a first state in which vehicle access to the parking space is not possible and a second state in which vehicle access to the parking space is possible;

in dependence on the parking space reservation object being characterised as being in the first state, the method comprising requesting confirmation that the vehicle is to be parked in the identified parking space;

receiving a confirmation signal confirming that the vehicle is to be parked in the identified parking space; and

outputting a vehicle parking signal to the parking assistance system to perform a parking manoeuvre to park the vehicle in the identified parking space when the parking space reservation object being characterised as being in the second state.

14. A method as claimed in claim 13 comprising receiving a parking space signal to identify the parking space.

15. Computer readable instructions which, when executed by a computer, are arranged to perform a method according to claim 13 or claim 14.

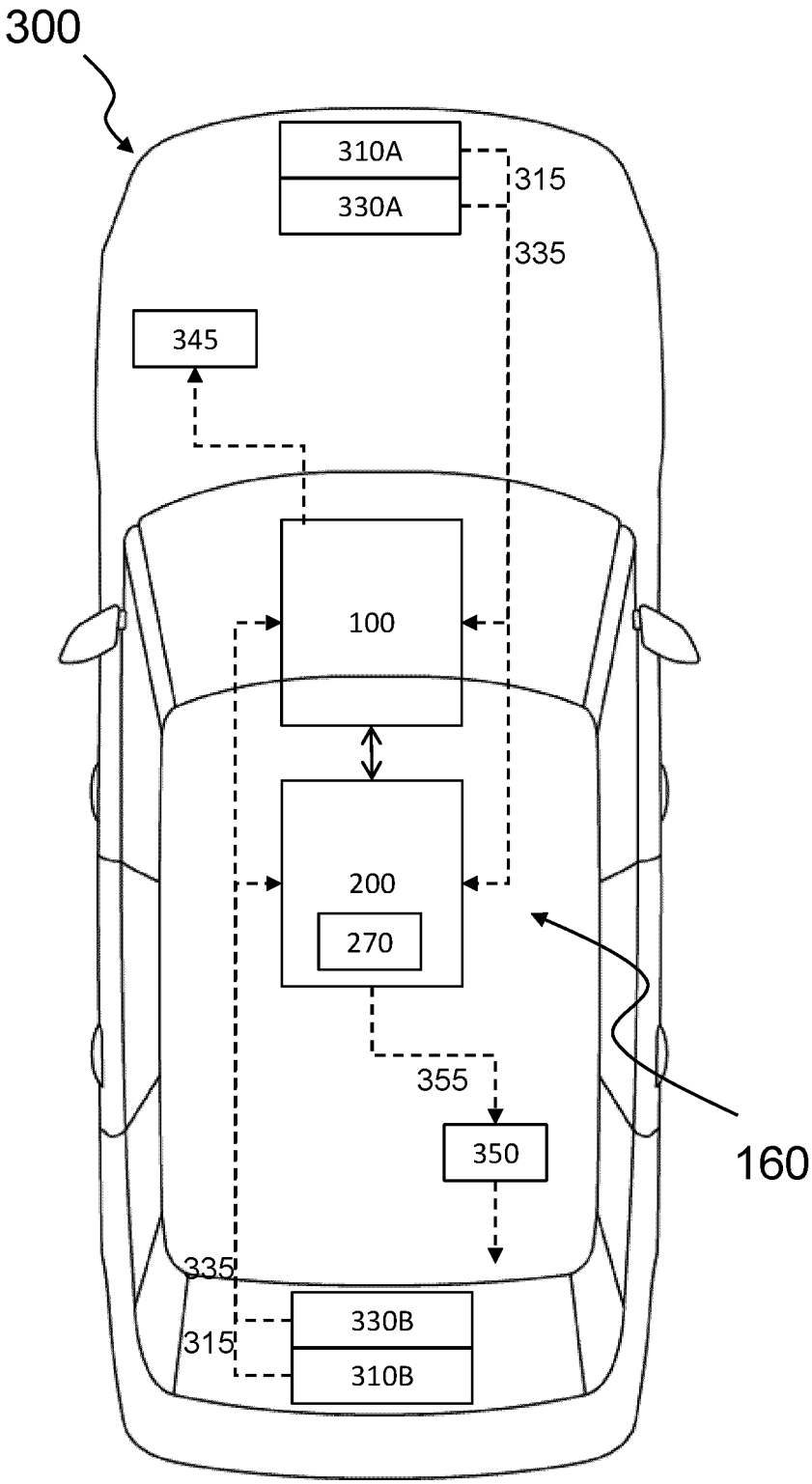

300
310A
330A
315
335
345
100
200
270
355
350
160
335
315
330B
310B

FIG. 1

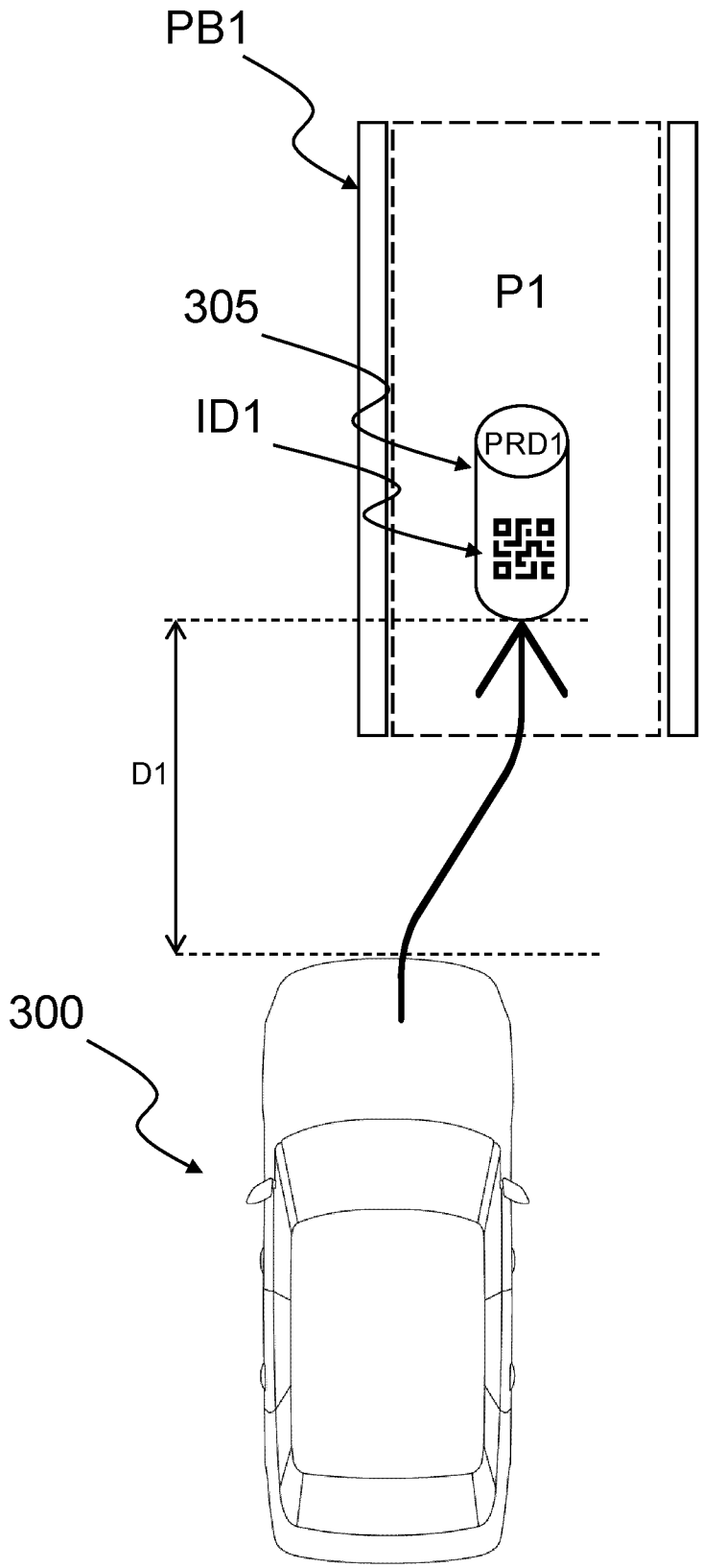


FIG. 2

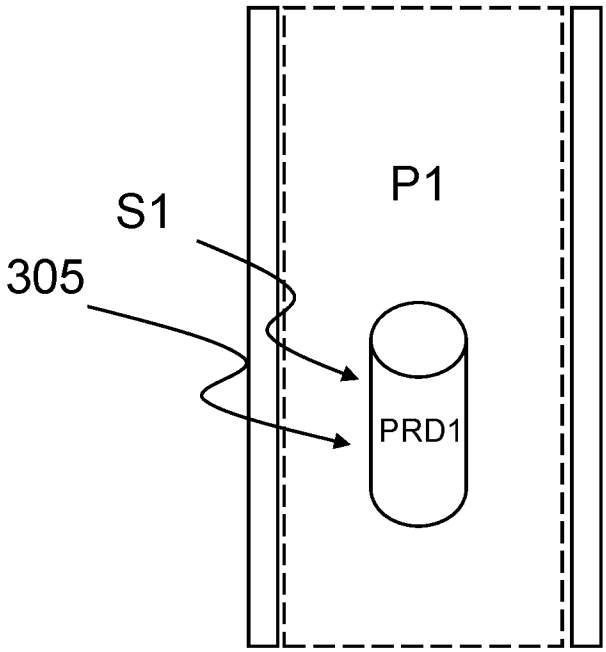


FIG. 3A

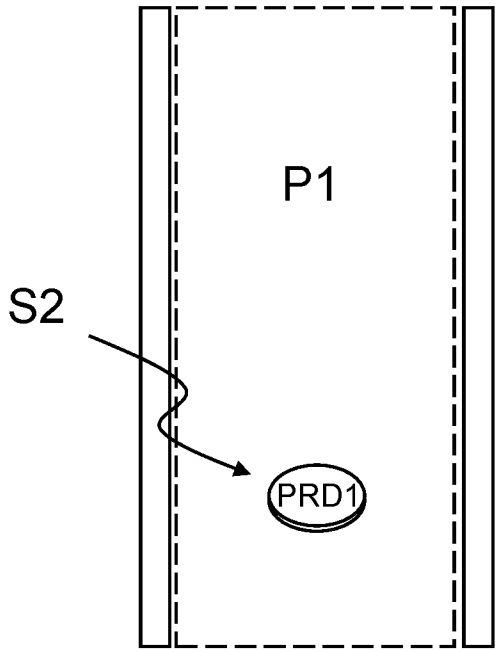


FIG. 3B

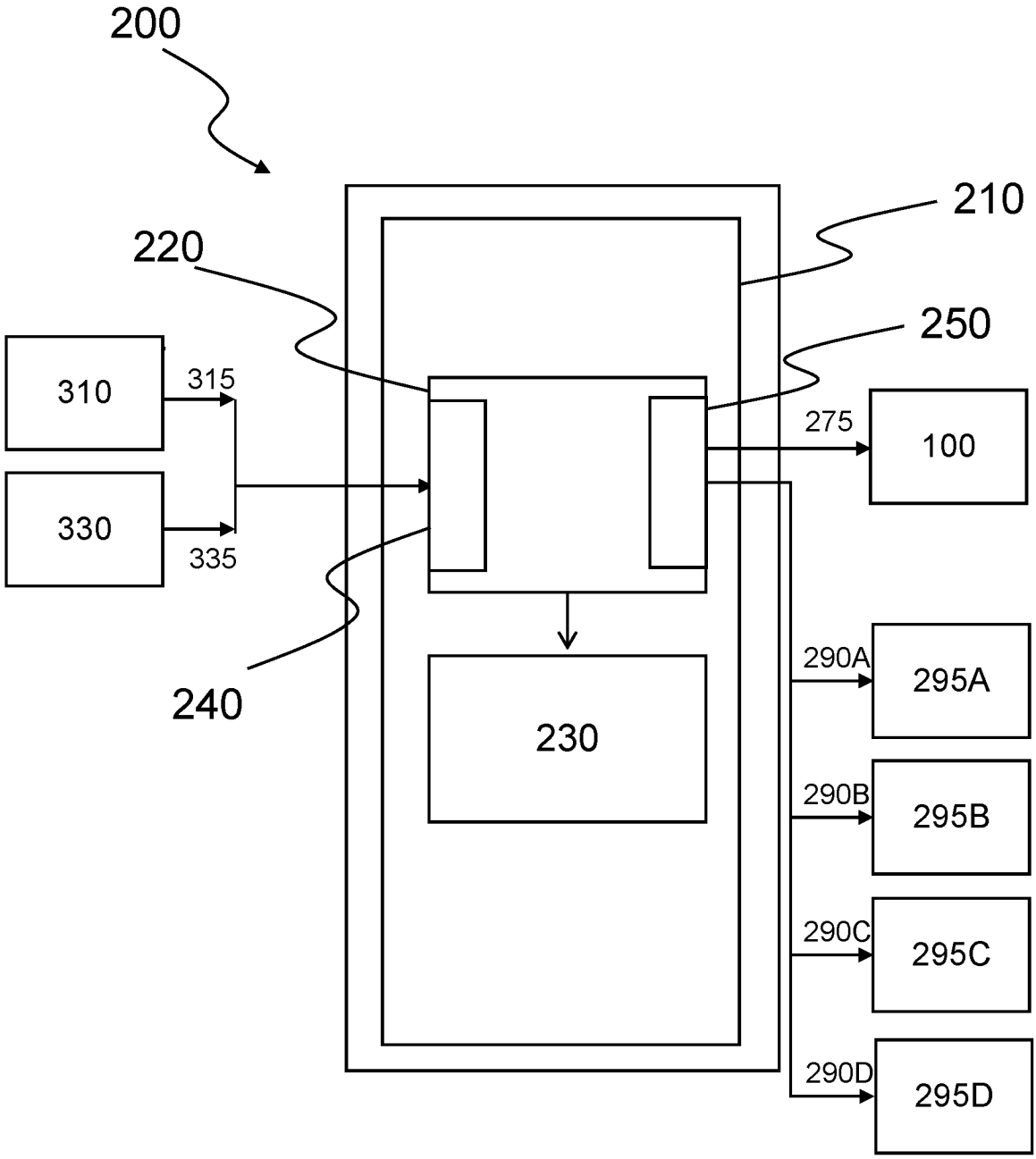

200
210
220
250
310
315
330
335
275
100
240
230
290A
295A
290B
295B
290C
295C
290D
295D

FIG. 4

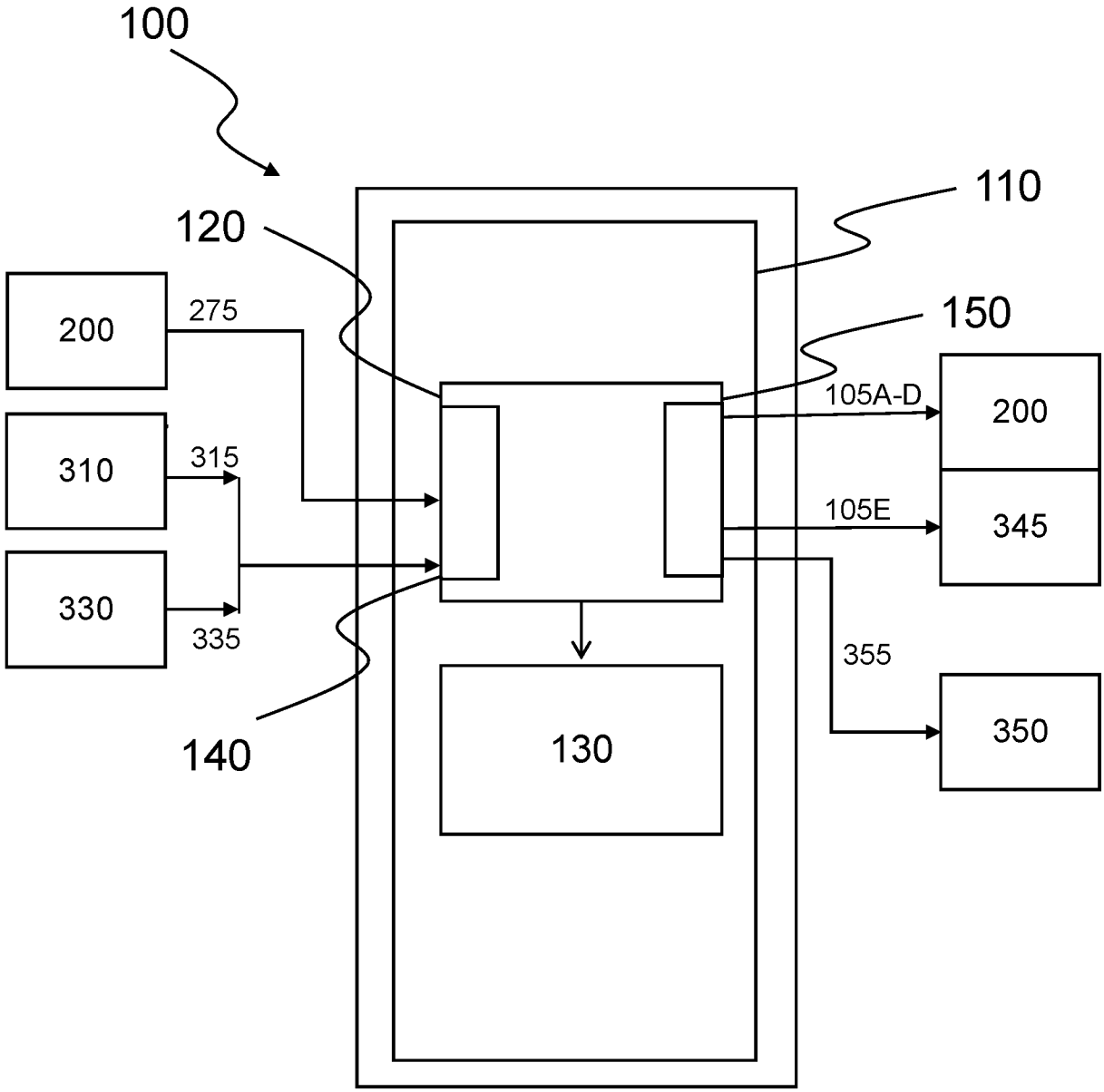

100
110
120
150
200
275
105A-D
200
310
315
345
105E
330
335
355
350
130
140

FIG. 5

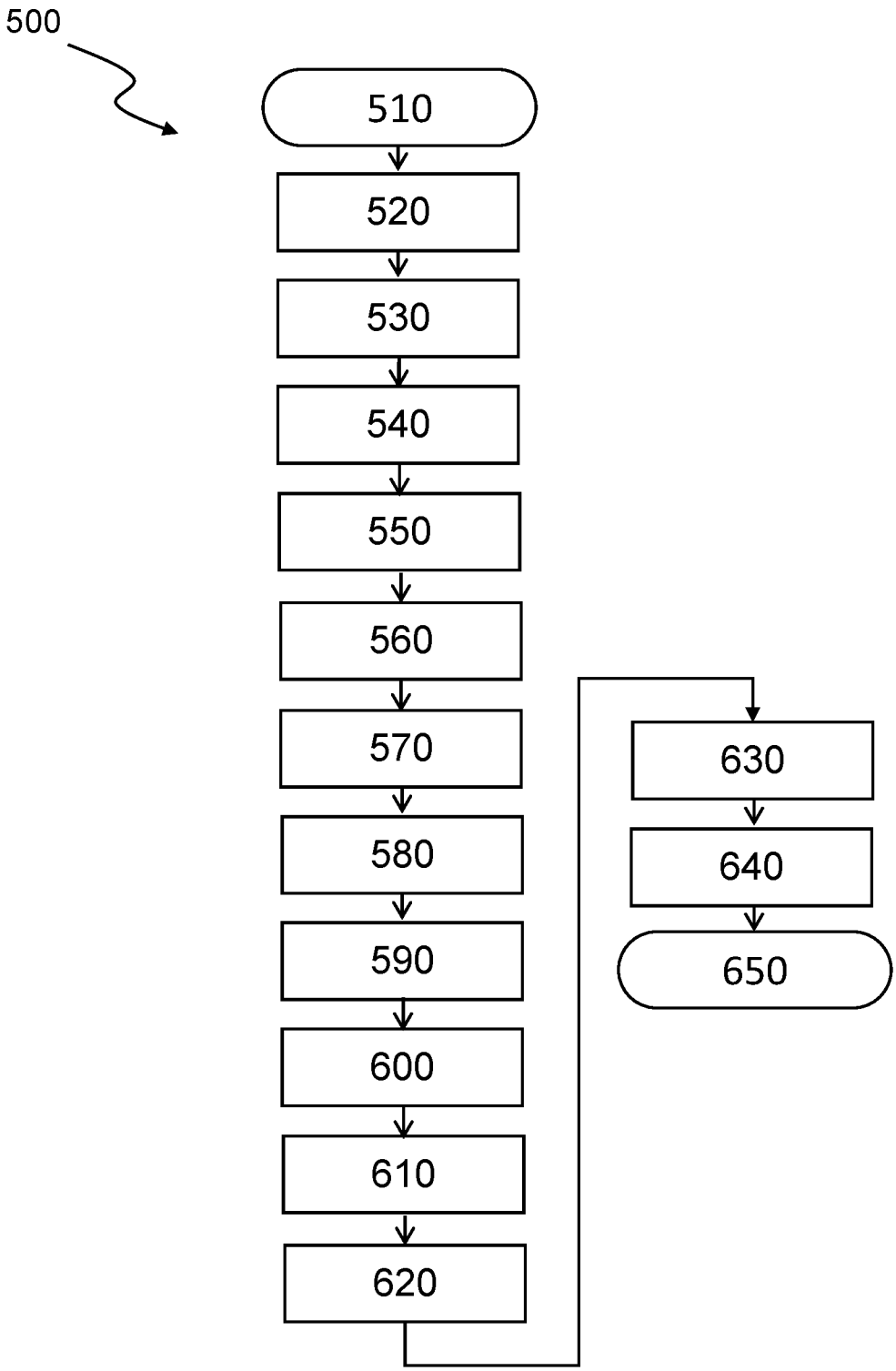


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/067823

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D15/02 G06Q10/02 G08G1/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B62D G06Q G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/334380 A1 (BONNET CHRISTOPHE [DE] ET AL) 23 November 2017 (2017-11-23) paragraphs [0008], [0014], [0027], [0028], [0035], [0059] - [0063], [0074] - [0075], [0079], [0081], [0082], [0098] - [0101], [0103], [0105]; claims; figures	1-15
X	DE 10 2014 018187 A1 (DAIMLER AG [DE]) 18 June 2015 (2015-06-18) paragraphs [0031], [0035]; claims; figures	1,11-13, 15
A	US 2018/321685 A1 (YALLA VEERA GANESH [US] ET AL) 8 November 2018 (2018-11-08) paragraphs [0046] - [0048]; claims; figures	1-15

-/--

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 September 2024	23/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ducher, Alban

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/067823

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/085109 A1 (STEFIK MARK J [US] ET AL) 27 March 2014 (2014-03-27) paragraphs [0081] - [0084]; claims; figures	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/067823

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017334380 A1	23-11-2017	CN 107000776 A	01-08-2017
		DE 102014018189 A1	09-06-2016
		JP 2018505085 A	22-02-2018
		US 2017334380 A1	23-11-2017
		WO 2016091338 A1	16-06-2016
DE 102014018187 A1	18-06-2015	NONE	
US 2018321685 A1	08-11-2018	NONE	
US 2014085109 A1	27-03-2014	EP 2711875 A1	26-03-2014
		US 2014085109 A1	27-03-2014