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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 May 2018 (24.05.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/093352 A1

(51) International Patent Classification:
G05D 1/02 (2006.01) *G08G 1/14* (2006.01)
G07B 15/02 (2011.01) *G08G 1/16* (2006.01)

(21) International Application Number: PCT/US2016/062054

(22) International Filing Date: 15 November 2016 (15.11.2016)

(25) Filing Language: English

(26) Publication Language: English

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(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, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, 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, 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: ASSIGNING PARKING LOCATIONS FOR AUTONOMOUS VEHICLES

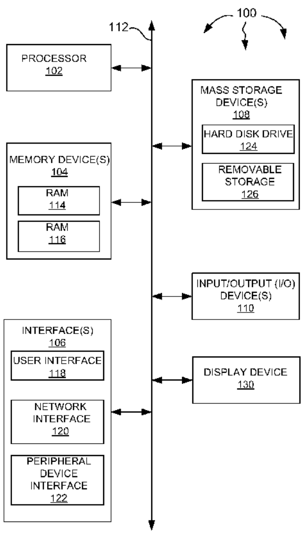

FIG. 1

(57) Abstract: The present invention extends to methods, systems, and computer program products for assigning parking locations to autonomous vehicles. In general, aspects include detecting and assigning available parking locations within a parking area to autonomous vehicles. The autonomous vehicles can then automatically travel to assigned parking locations. In one aspect, under pavement loop detectors, cameras, and vehicle to anything (V2X) technologies combine with cloud connectivity to provide parking reservations. A parking reservation system can detect empty parking locations using a fusion of induction loop detections, cameras using neural networks, and V2X communicating with cloud resources to confirm entries and exits from parking locations. Upon detecting an autonomous vehicle in or approaching a parking area, the parking reservation system sends a wireless transmission to the autonomous vehicle. The wireless transmission includes an assigned parking location, a map of the parking area, and a route to the assigned parking location.

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ASSIGNING PARKING LOCATIONS FOR AUTONOMOUS VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

BACKGROUND

[0002] 1. **Field of the Invention**

[0003] This invention relates generally to the field of parking space allocation systems, and, more particularly, to assigning parking locations to autonomous vehicles.

[0004] 2. **Related Art**

[0005] Parking can be a cumbersome process. In the case of perpendicular parking or angle parking, it can be difficult to estimate when to turn in to a parking space, if there is going to be enough room on both sides of the vehicle, how to position the steering wheel such that the vehicle is equally spaced between the parking lines, and how far to pull into a parking space. In the case of parallel parking, it can be difficult to know if there is sufficient space to park a vehicle, when to start turning the steering wheel, and how far to pull into a space before correcting the steering wheel. These parking maneuvers can be further complicated in the presence of uneven terrain or in the presence of moving objects such as pedestrians, bicyclists, or other vehicles.

[0006] Further, many parking lots do not have reservation systems. To find a parking space, a vehicle navigates a parking lot until an open parking space is located. For parking lots that do have reservation systems, spaces can be locked too long in advance. In other parking lots, signs can be used to indicate parking spot availability. However, indicated parking spots can be filled by other vehicles prior to arrival.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The specific features, aspects and advantages of the present invention will become better understood with regard to the following description and accompanying drawings where:

[0009] Figure 1 illustrates an example block diagram of a computing device.

[0010] Figure 2 illustrates an example computer architecture that facilitates assigning parking locations for autonomous vehicles.

[0011] Figure 3 illustrates a flow chart of an example method for assigning parking locations for autonomous vehicles.

[0012] Figure 4 illustrates an example parking area.

DETAILED DESCRIPTION

[0013] The present invention extends to methods, systems, and computer program products for assigning parking locations for autonomous vehicles.

[0014] In general, aspects of the invention can be used for detecting and assigning available parking locations within a parking area to autonomous vehicles. The autonomous vehicles can then automatically travel to assigned parking locations. As used herein, a "parking area" includes any type of area in which one or more vehicles can be parked, such as a parking lot, a parking garage, a parking structure, a street, an open field, and the like.

[0015] In one aspect, under pavement loop detectors, cameras, and vehicle to anything (V2X) technologies combine with connectivity to the cloud to provide parking reservations to autonomous vehicles. A parking reservation system can detect empty parking locations using a fusion of induction loop detections, cameras using neural networks, and V2X communicating with cloud resources to confirm entries and exits from parking spaces.

[0016] Upon detecting an autonomous vehicle in or approaching a parking area, the parking reservation system sends a wireless transmission to the autonomous vehicle. The wireless transmission includes an assigned parking location in the parking area, an electronic map of the parking area, and a route to the assigned parking location. The route to each parking location is stored in the parking reservation system. Reservations can be made at any distance from the parking area based upon estimated time of arrival. Reservations can include estimated parking time based on the vehicle event (grocery shopping, dining, etc.), drive history (adaptively learned attributes from previous parking events), or voice command (natural language processing).

[0017] When a reservation is made, one less parking location is available during that specific time slot. Specific parking locations need not be reserved. Internal counters can be used to track the number of parking locations available at specific time slots. Once a counter for a specific time slot reaches full capacity, reservations can be stopped. Additional reservation requests can be placed on a waitlist. The waitlist can be used to account for no-shows or cancellations so that vehicles on the waitlist can get a parking location. There can also be counters for specific parking location sizes in addition for specific time slots.

[0018] By not reserving specific parking locations, more optimal reservations can be made. For example, if an autonomous vehicle leaves early that parking location can then be used for another autonomous vehicle. So the parking reservation system can assign a parking spot to each autonomous vehicle at time of arrival based on closest available parking location.

[0019] Autonomous vehicles with fold-in mirrors or mirrors that are obviated by cameras can be parked tightly with little space between them since the doors do not need to be opened to allow the driver to exit. Passengers will embark/disembark after/before the vehicle is withdrawn/parked from/in the parking space. Tighter parking obviates requirements for individual spaces and lines. In one aspect, an algorithm finds an open parking location large enough for a requesting autonomous vehicle and wirelessly transmits GPS coordinates of the open parking location to the autonomous vehicle.

[0020] Upon entering a parking area, an autonomous vehicle can wirelessly transmit vehicle dimensions to the parking reservation system. Alternately, vehicle dimensions be determined via parking area sensors and a neural network. For example, upon detecting a new autonomous vehicle, a parking reservation system can estimate vehicle size using an overhead camera or a fusion of data from cameras, Radar sensors, LIDAR sensors, etc.

[0021] For delineated parking spaces, it is optimal to park autonomous vehicles near the center of the two parking lines. However, there may be varying sized parking spaces where vehicle dimensions can be used to park larger vehicles into larger delineated parking spaces and smaller vehicles to smaller delineated parking spaces. If there are no delineated parking spaces (white or yellow lines), an algorithm can determine optimal virtual parking spaces based on autonomous vehicles currently entering parking spaces and/or autonomous vehicles on a reservation list.

[0022] In some aspect, there are multiple cameras, LIDAR sensors, Radar sensors, ultrasonic sensors, infrared sensors, etc. placed at designated (e.g., optimal) locations and angles within a parking area for more accurate state estimation. Night Vision Cameras can be used for night-time parking reservations. Abnormal activity can also be detected using a neural network trained to recognize abnormal activity, for example, using both RGB and Infrared cameras. Abnormal activity can include criminal activity as well as vehicles that take up more than one space or vehicles that park in unconventional ways.

[0023] Aspects of the invention can be used for diagonal front-in parking, parallel parking, orthogonal front-in parking, etc. in assigned parking locations as well as in assigned delineated parking spaces. Aspects of the invention can be used for automated parking, autonomous valet parking, and autonomous parking security. Aspects of the invention optimize vehicle parking because a vehicle is essential guaranteed a parking spot and the vehicle can be optimally routed to the parking spot.

[0024] Aspects of the invention can be implemented in a variety of different types of computing devices. Figure 1 illustrates an example block diagram of a computing device 100. Computing device 100 can be used to perform various procedures, such as those discussed herein. Computing device 100 can function as a server, a client, or any other computing entity. Computing device 100 can perform various communication and data transfer functions as described herein and can execute one or more application programs, such as the application programs described herein. Computing device 100 can be any of a wide variety of computing devices, such as a mobile telephone or other mobile device, a desktop computer, a notebook computer, a server computer, a handheld computer, tablet computer and the like.

[0025] Computing device 100 includes one or more processor(s) 102, one or more memory device(s) 104, one or more interface(s) 106, one or more mass storage device(s) 108, one or more Input/Output (I/O) device(s) 110, and a display device 130 all of which are coupled to a bus 112. Processor(s) 102 include one or more processors or controllers that execute instructions stored in memory device(s) 104 and/or mass storage device(s) 108. Processor(s) 102 may also include various types of computer storage media, such as cache memory.

[0026] Memory device(s) 104 include various computer storage media, such as volatile memory (e.g., random access memory (RAM) 114) and/or nonvolatile memory (e.g., read-only memory (ROM) 116). Memory device(s) 104 may also include rewritable ROM, such as Flash memory.

[0027] Mass storage device(s) 108 include various computer storage media, such as magnetic tapes, magnetic disks, optical disks, solid state memory (e.g., Flash memory), and so forth. As depicted in Figure 1, a particular mass storage device is a hard disk drive 124. Various drives may also be included in mass storage device(s) 108 to enable reading from and/or writing to the various computer readable media. Mass storage device(s) 108 include removable media 126 and/or non-removable media.

[0028] I/O device(s) 110 include various devices that allow data and/or other information to be input to or retrieved from computing device 100. Example I/O device(s) 110 include cursor control devices, keyboards, keypads, barcode scanners, microphones, monitors or other display devices, speakers, printers, network interface cards, modems, cameras, lenses, radars, CCDs or other image capture devices, and the like.

[0029] Display device 130 includes any type of device capable of displaying information to one or more users of computing device 100. Examples of display device 130 include a monitor, display terminal, video projection device, and the like.

[0030] Interface(s) 106 include various interfaces that allow computing device 100 to interact with other systems, devices, or computing environments as well as humans. Example interface(s) 106 can include any number of different network interfaces 120, such as interfaces to personal area networks (PANs), local area networks (LANs), wide area networks (WANs), wireless networks (e.g., near field communication (NFC), Bluetooth, Wi-Fi, etc., networks), and the Internet. Other interfaces include user interface 118 and peripheral device interface 122.

[0031] Bus 112 allows processor(s) 102, memory device(s) 104, interface(s) 106, mass storage device(s) 108, and I/O device(s) 110 to communicate with one another, as well as other devices or components coupled to bus 112. Bus 112 represents one or more of several types of bus structures, such as a system bus, PCI bus, IEEE 1394 bus, USB bus, and so forth.

[0032] Figure 2 illustrates an example computer architecture 200 that facilitates assigning parking locations for autonomous vehicles. As depicted, computer architecture 200 includes autonomous vehicle 201, cloud resources 239, and parking reservation system 221. Autonomous vehicle 201 can be a car, truck, or bus. As depicted, autonomous vehicle 201 includes external sensor(s) 202, communication module 208, vehicle control systems 254, and vehicle components 211.

[0033] Each of external sensor(s) 202, communication module 208, vehicle control systems 254, and vehicle components 211, as well as their respective components can be connected to one another over (or be part of) a network, such as, for example, a PAN, a LAN, a WAN, a controller area network (CAN) bus, and even the Internet. Accordingly, each of external sensor(s) 202, communication module 208, vehicle control systems 254, and vehicle components 211, as well as any other connected computer systems and their components, can create message related data and exchange message related data (e.g., near field communication (NFC) payloads, Bluetooth packets, Internet Protocol (IP) datagrams and other higher layer protocols that utilize IP datagrams, such as, Transmission Control Protocol (TCP), Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), etc.) over the network.

[0034] External sensors 202 include one or more of: camera(s) 203, radar sensor(s) 204, and LIDAR sensor(s) 206. External sensors 202 may also include other types of sensors (not shown), such as, for example, acoustic sensors, ultrasonic sensors, and electromagnetic sensors. In general, external sensors 202 can sense and/or monitor objects in and/or around autonomous vehicle 201. External sensors 202 can output sensor data 273 indicating the position and optical flow (i.e., direction and speed) of monitored objects. External sensors 202 can send sensor data 273 to vehicle control systems 254.

[0035] Communication module 208 can include hardware components (e.g., a wireless modem or wireless network card) and/or software components (e.g., a protocol stack) for wireless communication with other vehicles and/or computer systems. Communication module 208 can be used to facilitate vehicle to vehicle (V2V) communication as well as vehicle to infrastructure (V2I) communication. In some aspects, communication module 208 can receive instructions from other systems to driver to a specified location. Communication module 208 can forward the instructions to vehicle control systems 254. In one aspect, communication module 208 receives a parking location assignment, including a parking location, a map of a parking area, and a route to parking location within the map. Communication module 208 can forward the parking location assignment to vehicle control systems 254.

[0036] In general, vehicle control systems 254 include an integrated set of control systems, including Global Positioning System (GPS) module 256, for fully autonomous driving. For example, vehicle control systems 254 can include a cruise control system to control throttle 242, a steering system to control wheels 241, a collision avoidance system to control brakes 243, etc. Vehicle control systems 254 can receive sensor data from external sensors 202 and can receive instructions forwarded from communication module 208. Vehicle control systems 254 can send automated controls 253 to vehicle components 211 to control autonomous vehicle 201.

[0037] In one aspect, vehicle control systems 254 receive a parking location assignment forwarded from communication module 208. The parking location assignment includes a parking location, a map of a parking area, and a route to the parking location within the map. GPS module 256 determines the GPS coordinates of the parking location. Other vehicle control systems 254 use sensor data on an ongoing basis to safely navigate autonomous vehicle 201 along the route to the parking location.

[0038] Autonomous vehicle 201 can also include vehicle data 271 describing autonomous vehicle 201. Vehicle data can include a variety of information about autonomous vehicle 201, including dimensions 272, such as, for example, length, width, and height. Other data, such as, for example, the make, model, and owner of autonomous vehicle 201 can also be included in vehicle data 271.

[0039] In general, parking reservation system 221 can manage parking reservations for parking area 277. Parking reservation system 221 includes sensors 212, communication module 218, neural network module 227, and parking location assignment module 223. Each of sensors

212, communication module 218, neural network module 227, and parking location assignment module 223, as well as their respective components can be connected to one another over (or be part of) a network, such as, for example, a PAN, a LAN, a WAN, a controller area network (CAN) bus, and even the Internet. Accordingly, sensors 212, communication module 218, neural network module 227, and parking location assignment module 223, as well as any other connected computer systems and their components, can create message related data and exchange message related data (e.g., near field communication (NFC) payloads, Bluetooth packets, Internet Protocol (IP) datagrams and other higher layer protocols that utilize IP datagrams, such as, Transmission Control Protocol (TCP), Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), etc.) over the network.

[0040] Sensors 212 include camera(s) 213, inductive loops 214, radar sensor(s) 216, and LIDAR sensor(s) 217. Sensors 212 may also include other types of sensors (not shown), such as, for example, acoustic sensors, ultrasonic sensors, and electromagnetic sensors. In general, sensors 212 can sense an arrangement of vehicles in parking area 277. Sensors 212 can be located in and/or around parking area 277 and transmit sensor data to neural network module 227 for classification.

[0041] In one aspect, neural network module 227 includes a neural network architected in accordance with a multi-layer (or "deep") model. A multi-layer neural network model can include an input layer, a plurality of hidden layers, and an output layer. A multi-layer neural network model may also include a loss layer. For classification of sensor data (e.g., an image), values in the sensor data (e.g., pixel-values) are assigned to input nodes and then fed through the plurality of hidden layers of the neural network. The plurality of hidden layers can perform a number of non-linear transformations. At the end of the transformations, an output node yields a perceived environment of parking area 277.

[0042] The perceived environment can include detecting occupied parking locations and detecting open parking locations within parking area 277. In one aspect, the neural network is also able to detect vehicle dimensions from a perceived environment. Neural network module 227 can send a perceived environment, including detected occupied and open parking locations and, when appropriate vehicle dimensions, to parking location assignment module 223 and communication module 218.

[0043] Communication module 218 can include hardware components (e.g., a wireless modem or wireless network card) and/or software components (e.g., a protocol stack) for wireless communication with vehicles and/or computer systems. Communication module 218 can be used to facilitate infrastructure to vehicle (I2V) communication. In some aspects, communication module 218 can receive a parking location assignment from parking location assignment module 223 and send the parking location assignment to an autonomous vehicle. The parking location assignment can include a parking location in parking area 277, a map of parking area 277, and a route to the parking location within the map.

[0044] Communication module 218 can also forward a perceived environment, including detected occupied and open parking locations and, when appropriate vehicle dimensions, to cloud resources 239. Cloud resources 239 can include processor and memory resources for determining parking area state 238 from a perceived environment for parking area 277. Cloud resources 239 can store parking area state 238 in parking area data 278. From time to time, communication module 218 can request parking area state 238 and forward parking area state 238 to parking location assignment module 223.

[0045] Based on parking area state 238 and detections from neural network module 227, parking location assignment module 223 can formulate parking location assignments for autonomous vehicles desiring to park in parking area 277. Parking location assignment module 223 can forward the parking location assignments to communication module 218. Communication module 218 can then send parking location assignments to appropriate vehicles.

[0046] In one aspect, sensor data from sensors 212 is sent to a neural network running on cloud resources 239. The neural network yields a perceived environment of parking area 277. The perceived environment can include detecting occupied parking locations and detecting open parking locations within parking area 277 as well as vehicle dimensions of vehicles within parking area 277. Other processor and memory resources in cloud resources 239 are used to determine parking area state 238 from the perceived environment.

[0047] Figure 3 illustrates a flow chart of an example method 300 for assigning parking locations for autonomous vehicles. Method 300 will be described with respect to the components and data of computer architecture 200.

[0048] Method 300 includes entering a parking area (301). For example, autonomous vehicle 201 can enter parking area 277 (e.g., parking lot, a parking garage, a parking structure, a street, an open field, etc.). Method 300 includes detecting an autonomous vehicle entering the parking area (302). Method 300 includes fusing sensor data from one or more parking reservation system sensors to identify one or more available parking locations within the parking area (303). For example, a plurality of sensors 212 can sense parking area 277. Sensor data from the plurality of sensors can be fused into sensor data 236. For example, sensor data from cameras 213 and inductive loops 214 can be fused into sensor data 236.

[0049] Sensor data 236 can be sent to neural network module 227. From sensor data 236, neural network module 227 can output detections 237, including the presence of vehicle 201, indications of available parking locations in parking area 277, and indications of occupied parking locations in parking area 277. For example, detections 237 can indicate that parking locations 232 and 281 are available and that other parking locations are occupied by vehicles 261, 262, and 263. In one aspect, detections 237 can also include the dimensions 272 for autonomous vehicle 201. In another aspect, communication module 208 sends dimensions 272 to parking reservation system 221 upon establishing communication with parking reservation system 221.

[0050] Method 300 includes assigning a parking location from among the one or more available parking locations to the autonomous vehicle (304). For example, based on detections 237 and parking area state 238, parking location assignment module 223 can assign parking location 232 to autonomous vehicle 201. Parking location assignment module 223 can formulate parking location assignment 231, including parking location 232, map 233, and route 234, for autonomous vehicle 201. Map 233 is an electronic map of parking area 277. Route 234 indicates how to navigate within parking area 277 to reach parking location 232. Method 300 includes sending a transmission to the autonomous vehicle, the transmission including the assigned parking location, an electronic map of the parking area, and a route, the route indicating how to navigate within the parking area to reach the assigned parking location (305). For example, communication module 218 can send parking location assignment 231, including parking location 232, map 233, and route 234, to autonomous vehicle 201.

[0051] Method 300 includes receiving a transmission from a parking reservation system that manages parking reservations for the parking area, the transmission including an assigned parking location, an electronic map of the parking area, and a route, the route indicating how to navigate within the parking area to reach the assigned parking location (306). For example, communication module 208 can receive parking location assignment 231, including parking location 232, map 233, and route 234, from parking reservation system 221. Communication module 208 can forward parking location assignment 231 to vehicle control systems 254.

[0052] Method 300 includes using data from the one or more sensors for navigating through the parking area to the assigned parking location in accordance with the route (307). For example, vehicle control systems 254 can use sensor data 273 on an ongoing basis to send automated controls 253 to vehicle components 211. Automated controls 253 change vehicle components 211 as appropriate to navigate autonomous vehicle 201 though parking area 277 to parking location 232 in accordance with route 234. GPS module 256 can convert parking location 232 to GPS coordinates. Route 234 can include dropping passengers off at a designated location, for example, a building entrance, prior to parking.

[0053] Method 300 includes using data from the one or more sensors for park in the assigned parking location within a specified distance of any adjacently parked vehicles (308). Upon approaching parking location 232, vehicle control systems 254 can use sensor data 273 to park in parking location 232 within a specified distance of vehicle 261. When autonomous vehicle 201 contains no passengers, there is little, if any, need to allow room for opening doors. As such, autonomous vehicle 201 can park within inches of vehicle 261.

[0054] Method 300 includes updating the one or more available parking locations based on assigning the parking space to the autonomous vehicle (309). For example, a plurality of sensors 212 can again sense parking area 277. Sensor data from the plurality of sensors can be fused into additional sensor data 236. The additional sensor data can be sent to neural network module 222.

From sensor data 236, neural network 222 can output additional detections, including indications of available parking locations in parking area 277 and indications of occupied parking locations in parking area 277. For example, the additional detections can indicate that parking location 281 is available, that parking location 232 is occupied by autonomous vehicle 201, and that other parking locations are occupied by vehicles 261, 262, and 263.

[0055] Figure 4 illustrates an example parking area 400. Parking area 400 includes larger parking spaces 441 and smaller parking spaces 442. Parking reservation system 421 and cloud computing resources 439 interoperate to assign parking spaces in parking area 400 to vehicles. Parking system 421 can obtain dimensions 472 for vehicle 401 (either through neural network detection or transmission from vehicle 401). Based on dimensions 472, parking reservation system 421 and/or cloud computing resources 439 can determine that vehicle 401 is a larger vehicle (e.g., a truck). As such, parking reservation system 421 can send parking assignment 432 to vehicle 401. Parking assignment 432 can instruct vehicle 401 to take route 434 through parking area 400 to parking space 451 (one of larger parking spaces 441).

[0056] Similarly, parking reservation system 421 can obtain dimensions 473 for vehicle 411 (either through neural network detection or transmission from vehicle 411). Based on dimensions 473, parking reservation system 421 and/or cloud computing resources 439 can determine that vehicle 411 is a smaller vehicle (e.g., a car). As such, parking reservation system 421 can send parking assignment 432 to vehicle 411. Parking assignment 432 can instruct vehicle 411 to take route 436 through parking area 400 to parking space 452 (one of smaller parking spaces 442).

[0057] In one aspect, one or more processors are configured to execute instructions (e.g., computer-readable instructions, computer-executable instructions, etc.) to perform any of a plurality of described operations. The one or more processors can access information from system memory and/or store information in system memory. The one or more processors can transform information between different formats, such as, for example, sensor data, vehicle data, dimensions, parking location assignments, parking locations, maps, routes, GPS coordinates, detections, parking area state, etc.

[0058] System memory can be coupled to the one or more processors and can store instructions (e.g., computer-readable instructions, computer-executable instructions, etc.) executed by the one or more processors. The system memory can also be configured to store any of a plurality of other types of data generated by the described components, such as, for example, sensor data, vehicle data, dimensions, parking location assignments, parking locations, maps, routes, GPS coordinates, detections, parking area state, etc.

[0059] In the above disclosure, reference has been made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific implementations in which the disclosure may be practiced. It is understood that other implementations may be utilized and structural changes may be made without departing from the scope of the present disclosure. References in the specification to “one embodiment,” “an embodiment,” “an example embodiment,” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0060] Implementations of the systems, devices, and methods disclosed herein may comprise or utilize a special purpose or general-purpose computer including computer hardware, such as, for example, one or more processors and system memory, as discussed herein. Implementations within the scope of the present disclosure may also include physical and other computer-readable media for carrying or storing computer-executable instructions and/or data structures. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer system. Computer-readable media that store computer-executable instructions are computer storage media (devices). Computer-readable media that carry computer-executable instructions are transmission media. Thus, by way of example, and not limitation, implementations of the disclosure can comprise at least two distinctly different kinds of computer-readable media: computer storage media (devices) and transmission media.

[0061] Computer storage media (devices) includes RAM, ROM, EEPROM, CD-ROM, solid state drives ("SSDs") (e.g., based on RAM), Flash memory, phase-change memory ("PCM"), other types of memory, other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer.

[0062] An implementation of the devices, systems, and methods disclosed herein may communicate over a computer network. A "network" is defined as one or more data links that enable the transport of electronic data between computer systems and/or modules and/or other electronic devices. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computer, the computer properly views the connection as a transmission medium.

Transmissions media can include a network and/or data links, which can be used to carry desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer. Combinations of the above should also be included within the scope of computer-readable media.

[0063] Computer-executable instructions comprise, for example, instructions and data which, when executed at a processor, cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions. The computer executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, or even source code. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the described features or acts described above. Rather, the described features and acts are disclosed as example forms of implementing the claims.

[0064] Those skilled in the art will appreciate that the disclosure may be practiced in network computing environments with many types of computer system configurations, including, an in-dash or other vehicle computer, personal computers, desktop computers, laptop computers, message processors, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, mobile telephones, PDAs, tablets, pagers, routers, switches, various storage devices, and the like. The disclosure may also be practiced in distributed system environments where local and remote computer systems, which are linked (either by hardwired data links, wireless data links, or by a combination of hardwired and wireless data links) through a network, both perform tasks. In a distributed system environment, program modules may be located in both local and remote memory storage devices.

[0065] Further, where appropriate, functions described herein can be performed in one or more of: hardware, software, firmware, digital components, or analog components. For example, one or more application specific integrated circuits (ASICs) can be programmed to carry out one or more of the systems and procedures described herein. Certain terms are used throughout the description and claims to refer to particular system components. As one skilled in the art will appreciate, components may be referred to by different names. This document does not intend to distinguish between components that differ in name, but not function.

[0066] It should be noted that the sensor embodiments discussed above may comprise computer hardware, software, firmware, or any combination thereof to perform at least a portion of their functions. For example, a sensor may include computer code configured to be executed in one or more processors, and may include hardware logic/electrical circuitry controlled by the computer code. These example devices are provided herein purposes of illustration, and are not intended to be limiting. Embodiments of the present disclosure may be implemented in further types of devices, as would be known to persons skilled in the relevant art(s).

[0067] At least some embodiments of the disclosure have been directed to computer program products comprising such logic (e.g., in the form of software) stored on any computer useable medium. Such software, when executed in one or more data processing devices, causes a device to operate as described herein.

[0068] While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the disclosure. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents. The foregoing description has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. Further, it should be noted that any or all of the aforementioned alternate implementations may be used in any combination desired to form additional hybrid implementations of the disclosure.

CLAIMS

What is claimed:

1. At an autonomous vehicle, a method for parking in a parking area comprising:

entering the parking area;

receiving a transmission indicating a route to an assigned parking location within the parking area;

navigating through the parking area to the assigned parking location based on the route; and

using data from one or more sensors to park in the assigned parking location within a specified distance of any adjacent vehicles.

2. The method of claim 1, wherein receiving a transmission indicating a route to an assigned parking location comprises receiving a wireless transmission from a parking reservation system, the wireless transmission including the assigned parking location, an electronic map of the parking area, and the route, the route indicating how to navigate within the parking area to reach the assigned parking location.

3. The method as recited in claim 1, wherein using data from one or more sensors compromises using data from one or more sensors attached to the autonomous vehicle that sense the external environment in the vicinity of the autonomous vehicle.

4. The method as recited in claim 1, wherein receiving a transmission indicating a route to an assigned parking location within the parking area comprises receiving a transmission indicating a route to the assigned parking location, wherein the assigned location is assigned based on the dimensions of the autonomous vehicle.

5. The method as recited in claim, wherein receiving a transmission indicating a route to an assigned parking location within the parking area comprises receiving a transmission indicating a route to a delineated parking space.

6. At an autonomous vehicle, the autonomous vehicle comprising:

one or more processors;

system memory coupled to one or more processors, the system memory storing instructions that are executable by the one or more processors;

one or more sensors for sensing the external environment in the vicinity of the autonomous vehicle;

the one or more processors configured to execute the instructions stored in the system memory to park the autonomous vehicle in a parking space within a parking area, including the following:

enter the parking area;

receive a transmission from a parking reservation system that manages parking reservations for the parking area, the transmission including an assigned parking location, an electronic map of the parking area, and a route, the route indicating how to navigate within the parking area to reach the assigned parking location; and

use data from the one or more sensors to:

navigate through the parking area to the assigned parking location in accordance with the route; and

park in the assigned parking location within a specified distance of any adjacently parked vehicles.

7. The autonomous vehicle of claim 6, wherein the one or more sensors comprises a set of sensors, the set of sensors including one or more sensors selected from among: cameras, LIDAR sensors, Radar sensors, and Ultra Sonic sensors.

8. The autonomous vehicle of claim 7, wherein the one or more processors configured to execute the instructions stored in the system memory to use data from the one or more sensors to park in the assigned parking location comprises the one or more processors configured to execute the instructions stored in the system memory to use data use data from the set of sensors to park in the assigned parking location.

9. The autonomous vehicle of claim 6, wherein the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including an assigned parking location comprises the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including an assigned parking location, wherein the assigned parking location was assigned based on the dimensions of the autonomous vehicle.

10. The autonomous vehicle of claim 6, wherein the one or more processors configured to execute the instructions stored in the system memory to receive a transmission from a parking reservation system comprises the one or more processors configured to execute the instructions stored in the system memory to receive the transmission from the parking reservation system prior to the autonomous vehicle entering the parking area.

11. The autonomous vehicle of claim 6, wherein the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including an assigned parking location comprises the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including an assigned delineated parking space, the assigned delineated parking space selected from among: a front-in parking space, a parallel parking space, or an orthogonal front-in parking space.

12. The autonomous vehicle of claim 6, wherein the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including an assigned parking location system comprises the one or more processors configured to execute the instructions stored in the system memory to receive a transmission including a Global Positioning System (GPS) coordinates for the assigned parking location.

13. A parking reservation system, the parking reservation system comprising:

one or more processors;

system memory coupled to one or more processors, the system memory storing instructions that are executable by the one or more processors;

one or more sensors for detecting the configuration of a parking area managed by the parking reservation system;

the one or more processors configured to execute the instructions stored in the system memory to assign a parking space within the parking area to an autonomous vehicle, including the following:

detect the autonomous vehicle entering the parking area;

fuse sensor data from the one or more sensors to identify one or more available parking spaces within the parking area;

assign a parking location from among the one or more available parking locations to the autonomous vehicle;

send a transmission to the autonomous vehicle, the transmission including the assigned parking location, an electronic map of the parking area, and a route, the route indicating how to navigate within the parking area to reach the assigned parking location; and

update the one or more available parking locations based on assigning the parking space to the autonomous vehicle.

14. The parking reservation system of claim 13, wherein the one or more sensors comprise a set of sensors, the set of sensors including one or more sensors selected from among: inductive loops, cameras, LIDAR sensors, Radar sensors, and Ultra Sonic sensors.

15. The parking reservation system of claim 13, wherein the one or more processors configured to execute the instructions stored in the system memory to fuse sensor data form the one or more sensors to identify one or more available parking locations within the parking area comprises the one or more processors configured to execute the instructions stored in the system memory to fuse sensor data from one or more inductive loops and one or more cameras to detect the one or more available parking locations.

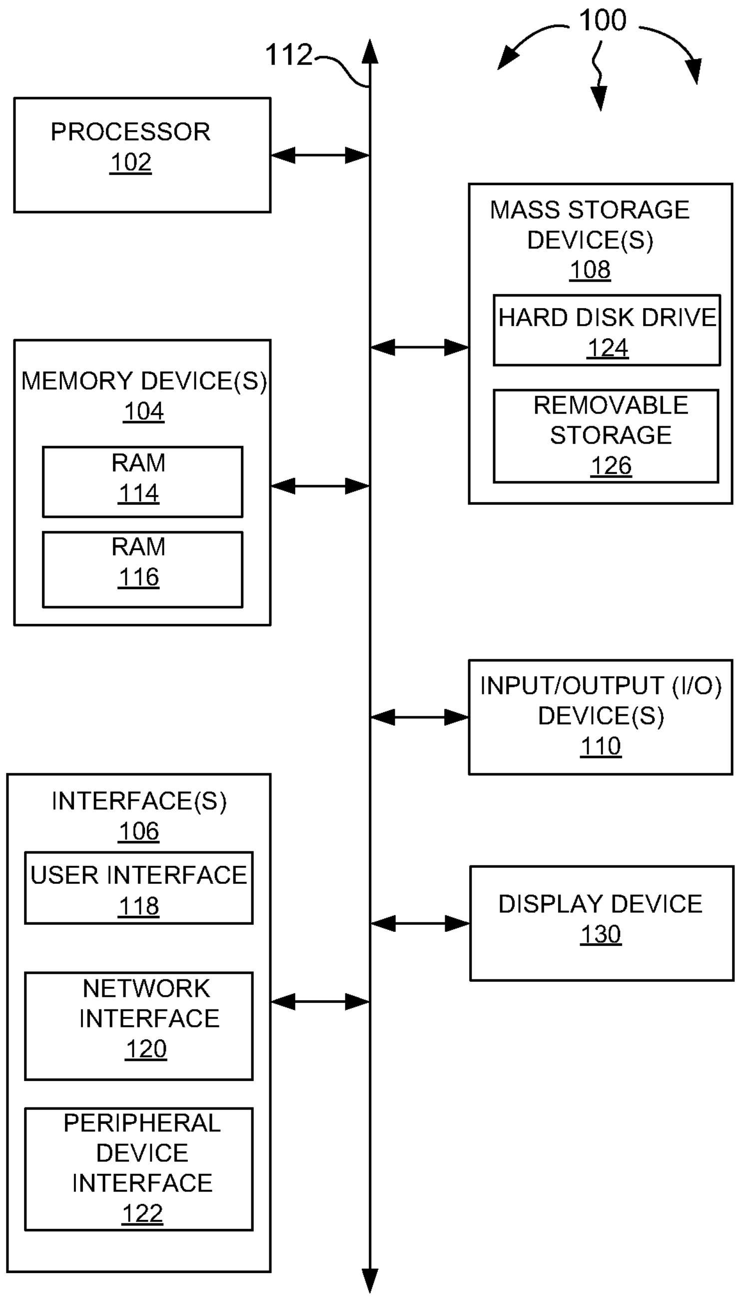
16. The parking reservation system of claim 13, wherein the one or more processors configured to execute the instructions stored in the system memory to send a transmission to the autonomous vehicle comprises the one or more processors configured to execute the instructions stored in the system memory to send Global Positioning System (GPS) coordinates for the assigned parking location to the autonomous vehicle.

17. The parking reservation system of claim 13, wherein the one or more processors configured to execute the instructions stored in the system memory to assign a parking location to the autonomous vehicle comprises the one or more processors configured to execute the instructions stored in the system memory to assign the parking location to the autonomous vehicle based on the dimensions of the autonomous vehicle.

18. The parking reservation system of claim 17, further comprising the one or more processors configured to execute the instructions stored in the system memory to use the one or more sensors to determine the dimensions of the autonomous vehicle.

19. The parking reservation system of claim 17, further comprising the one or more processors configured to execute the instructions stored in the system memory to receive the dimensions of the autonomous vehicle in a transmission from the autonomous vehicle.

20. The parking reservation system of claim 13, wherein the one or more processors configured to execute the instructions stored in the system memory to assign a parking location to the autonomous vehicle comprises the one or more processors configured to execute the instructions stored in the system memory to assign a delineated parking space to the autonomous vehicle the assigned delineated parking space selected from among: a front-in parking space, a parallel parking space, or an orthogonal front-in parking space.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HARD DISK DRIVE
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REMOVABLE
STORAGE
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MEMORY DEVICE(S)
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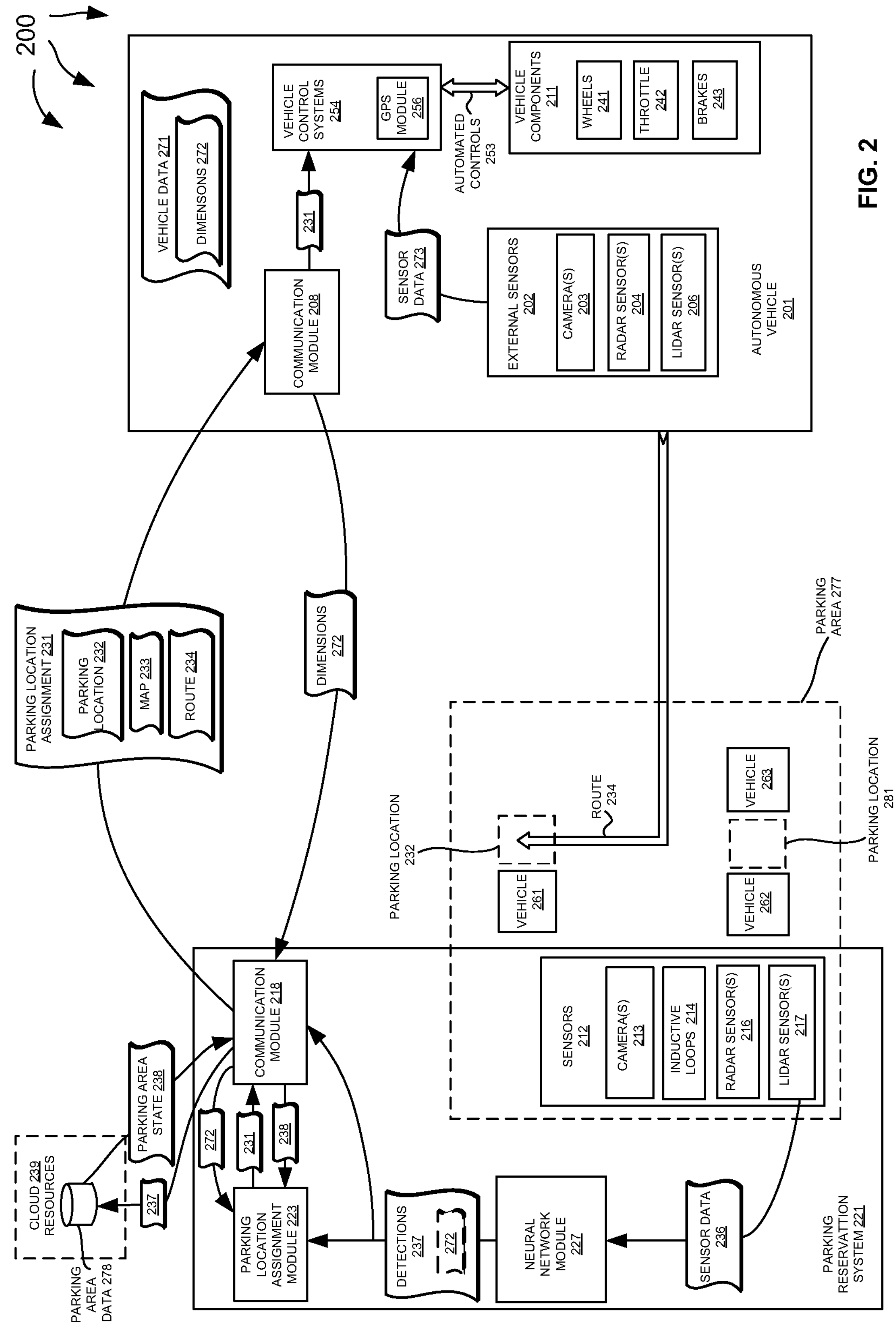
RAM
114
RAM
116
INPUT/OUTPUT (I/O)
DEVICE(S)
110
INTERFACE(S)
106
USER INTERFACE
118
DISPLAY DEVICE
130
NETWORK
INTERFACE
120
PERIPHERAL
DEVICE
INTERFACE
122

FIG. 1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VEHICLE DATA 271
DIMENSONS 272
VEHICLE CONTROL SYSTEMS 254
GPS MODULE 256
VEHICLE COMPONENTS 211
WHEELS 241
THROTTLE 242
BRAKES 243
AUTOMATED CONTROLS 253
231
COMMUNICATION MODULE 208
SENSOR DATA 273
EXTERNAL SENSORS 202
CAMERA(S) 203
RADAR SENSOR(S) 204
LIDAR SENSOR(S) 206
AUTONOMOUS VEHICLE 201
PARKING LOCATION ASSIGNMENT 231
PARKING LOCATION 232
MAP 233
ROUTE 234
DIMENSIONS 272
PARKING AREA 277
PARKING LOCATION 232
ROUTE 234
VEHICLE 261
VEHICLE 262
VEHICLE 263
PARKING LOCATION 281
CLOUD 239 RESOURCES
PARKING AREA DATA 278
PARKING AREA STATE 238
237
COMMUNICATION MODULE 218
272
231
238
PARKING LOCATION ASSIGNMENT MODULE 223
DETECTIONS 237
272
NEURAL NETWORK MODULE 227
SENSOR DATA 236
SENSORS 212
CAMERA(S) 213
INDUCTIVE LOOPS 214
RADAR SENSOR(S) 216
LIDAR SENSOR(S) 217
PARKING RESERVATTION SYSTEM 221

FIG. 2

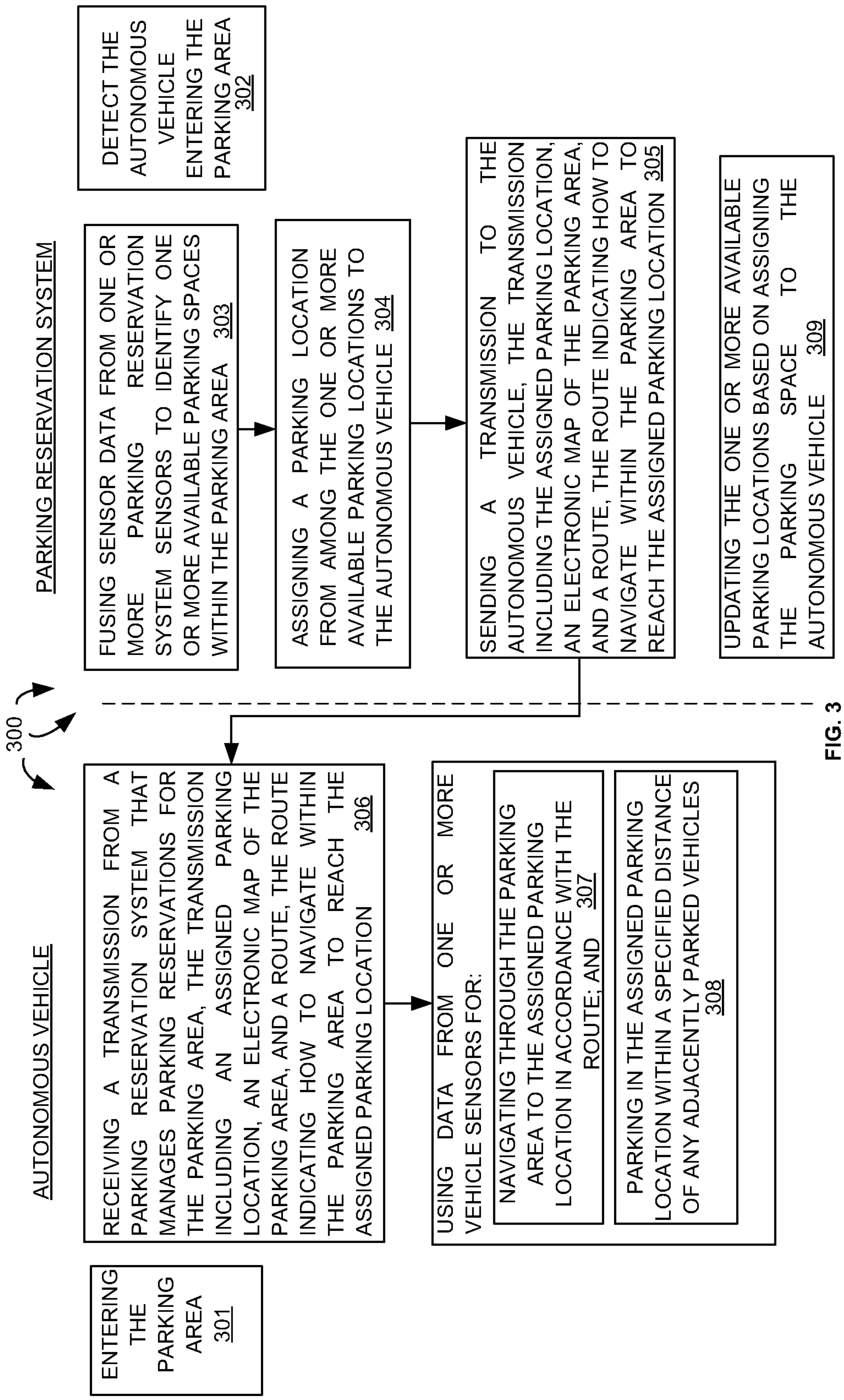
300
AUTONOMOUS VEHICLE
ENTERING THE PARKING AREA 301
RECEIVING A TRANSMISSION FROM A PARKING RESERVATION SYSTEM THAT MANAGES PARKING RESERVATIONS FOR THE PARKING AREA, THE TRANSMISSION INCLUDING AN ASSIGNED PARKING LOCATION, AN ELECTRONIC MAP OF THE PARKING AREA, AND A ROUTE, THE ROUTE INDICATING HOW TO NAVIGATE WITHIN THE PARKING AREA TO REACH THE ASSIGNED PARKING LOCATION 306
USING DATA FROM ONE OR MORE VEHICLE SENSORS FOR:
NAVIGATING THROUGH THE PARKING AREA TO THE ASSIGNED PARKING LOCATION IN ACCORDANCE WITH THE ROUTE; AND 307
PARKING IN THE ASSIGNED PARKING LOCATION WITHIN A SPECIFIED DISTANCE OF ANY ADJACENTLY PARKED VEHICLES 308
PARKING RESERVATION SYSTEM
DETECT THE AUTONOMOUS VEHICLE ENTERING THE PARKING AREA 302
FUSING SENSOR DATA FROM ONE OR MORE PARKING RESERVATION SYSTEM SENSORS TO IDENTIFY ONE OR MORE AVAILABLE PARKING SPACES WITHIN THE PARKING AREA 303
ASSIGNING A PARKING LOCATION FROM AMONG THE ONE OR MORE AVAILABLE PARKING LOCATIONS TO THE AUTONOMOUS VEHICLE 304
SENDING A TRANSMISSION TO THE AUTONOMOUS VEHICLE, THE TRANSMISSION INCLUDING THE ASSIGNED PARKING LOCATION, AN ELECTRONIC MAP OF THE PARKING AREA, AND A ROUTE, THE ROUTE INDICATING HOW TO NAVIGATE WITHIN THE PARKING AREA TO REACH THE ASSIGNED PARKING LOCATION 305
UPDATING THE ONE OR MORE AVAILABLE PARKING LOCATIONS BASED ON ASSIGNING THE PARKING SPACE TO THE AUTONOMOUS VEHICLE 309

FIG. 3

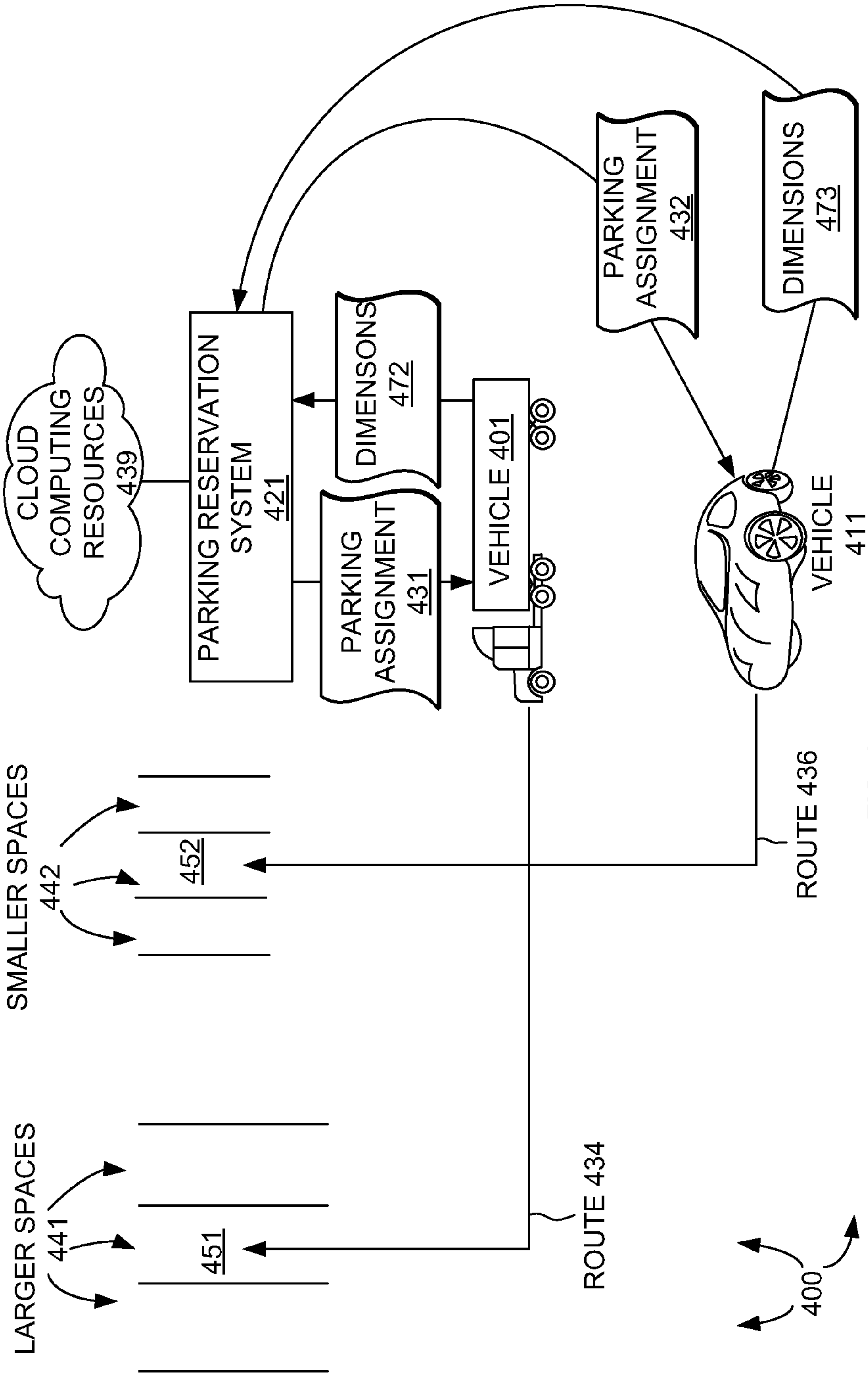
CLOUD COMPUTING RESOURCES 439
PARKING RESERVATION SYSTEM 421
PARKING ASSIGNMENT 431
DIMENSONS 472
VEHICLE 401
PARKING ASSIGNMENT 432
DIMENSIONS 473
VEHICLE 411
SMALLER SPACES 442
452
LARGER SPACES 441
451
ROUTE 434
ROUTE 436
400

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/62054

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G05D 1/02; G07B 15/02; G08G 1/14, 1/16 (2017.01)
CPC - G05D 1/0088, 1/0212; G07B 15/02; G08G 1/141, 1/168
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)
IPC(8) Classifications: G01C 21/34; G05D 1/00, 1/02; G07B 15/02; G08G 1/14, 1/16; H04W 4/02 (2017.01)
CPC Classifications: G01C 21/34; G05D 1/0088, 1/0212; G07B 15/02; G08G 1/141, 1/149, 1/168; H04W 4/025, 4/027

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); EBSCO; IEEE; Google/Google Scholar; Keywords: autonomous, vehicle, parking, area, route, assigned, location, navigating, sensors, distance, wireless, transmission, reservation, map, external, environment, navigation, map, vicinity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2004/0254840 A1 (SLEMMER, J et al.) 16 December 2004; figures 3, 12; paragraphs [0057], [0067], [0089].	13, 14 -------- 15-20
Y	WO 2016/066353 A1 (ROBERT BOSCH GMBH) 06 May 2016; page 4, 2nd and 4th paragraphs; page 5, last paragraph – page 6, 1st paragraph; page 6, 7th paragraph.	1-12
Y	US 5,967,727 A (RITSCH, I et al.) 19 October 1999; page 7; 4th paragraph; page 9; 6th paragraph.	1-12, 17-20
Y	US 2014/0121883 A1 (ROBERT BOSCH GMBH) 01 May 2014; paragraphs [0046], [0049].	10-12, 16, 20
Y	US 2011/0221624 A1 (KAVALER, R) 15 September 2011; figure 6; paragraphs [0073], [0074], [0076].	15
Y	US 2008/0288104 A1 (SHANI, H) 20 November 2008; figure 10; paragraph [0065].	18
Y	US 2015/0213715 A1 (BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT) 30 July 2015; paragraphs [0030], [0040].	19

☐ Further documents are listed in the continuation of Box C. ☐ 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
22 February 2017 (22.02.2017)	24 MAR 2017
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/62054

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-12 are directed towards a method of parking an autonomous vehicle in a parking area.
Group II: Claims 13-20 are directed towards a parking reservation system identifying available parking spaces.

- continued in Extra Sheet -

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report coves only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-***-Continued from Box III Observations where unity of invention is lacking -***-

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include at least one or more sensors for sensing the external environment in the vicinity of the autonomous vehicle; enter the parking area; receive a transmission from a parking reservation system that manages parking reservations for the parking area, and use data from the one or more sensors to: navigate through the parking area to the assigned parking location in accordance with the route; and park in the assigned parking location within a specified distance of any adjacently parked vehicles, which are not present in Group II.

The special technical features of Group II include at least one or more sensors for detecting the configuration of a parking area managed by the parking reservation system; detect the autonomous vehicle entering the parking area; fuse sensor data from the one or more sensors to identify one or more available parking spaces within the parking area; assign a parking location from among the one or more available parking locations to the autonomous vehicle; and update the one or more available parking locations based on assigning the parking space to the autonomous vehicle, which are not present in Group I.

The common technical features shared by Groups I-II are one or more processors; system memory coupled to one or more processors, the system memory storing instructions that are executable by the one or more processors; the one or more processors configured to execute the instructions stored in the system memory to park the autonomous vehicle in a parking space within a parking area, including the following: the transmission including an assigned parking location, an electronic map of the parking area, and a route, the route indicating how to navigate within the parking area to reach the assigned parking location.

However, these common features are previously disclosed by WO 2016/066353 A1 to ROBERT BOSCH GMBH (hereinafter "Bosch"). Bosch discloses one or more processors; system memory coupled to one or more processors, the system memory storing instructions that are executable by the one or more processors (a processor, and computer program code run (executed) on a computer, inherently requiring a system memory for storing the instructions; page 4, 3rd paragraph); the one or more processors configured to execute the instructions stored in the system memory to park the autonomous vehicle in a parking space within a parking area (the processor running the instructions to park an autonomous vehicle in a parking space in a parking lot (area); page 4, 2rd and 4th paragraphs), including the following: the transmission including an assigned parking location, an electronic map of the parking area, and a route (transmit a digital (electronic) map of the target position (assigned) parking space and a route; page 4, 2nd and 4th paragraphs), the route indicating how to navigate within the parking area to reach the assigned parking location (the navigation device guides the autonomous vehicle to the target position parking space; page 4, 1st and 6th paragraphs).

Since the common technical features are previously disclosed by the Bosch reference, these common features are not special and so Groups I-II lack unity.