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(54) **Title:** ACTIVE LANE MARKERS HAVING DRIVER ASSISTANCE FEEDBACK

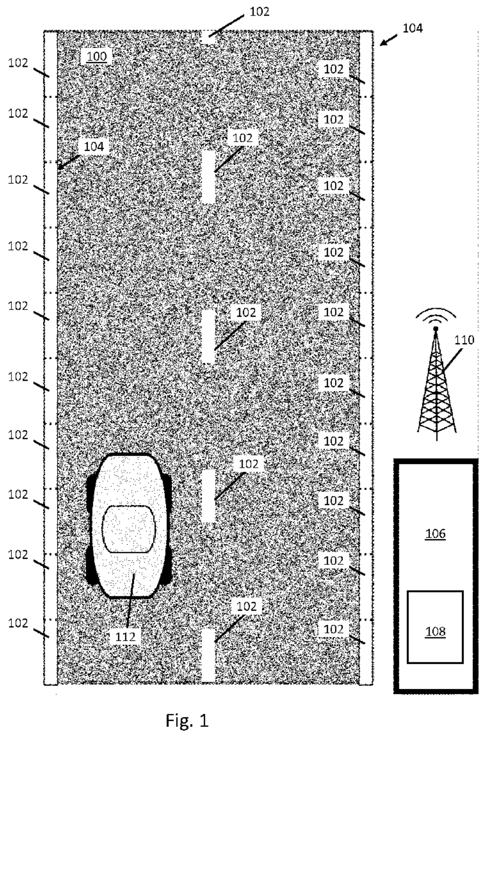

Fig. 1

(57) **Abstract:** A system of active lane markers in a roadway, the active lane markers comprising sensors, transmitters and receivers to monitor the status of the roads and provide vehicle guidance to vehicles in response to analysis of sensor data.

WO 2019/086301 A2

ACTIVE LANE MARKERS HAVING DRIVER ASSISTANCE FEEDBACK

TECHNICAL FIELD

[0001] This disclosure relates to the field of driver assisted motor vehicles and the applications thereof to improving traffic safety conditions.

BACKGROUND

[0002] An Advanced Driver Assistance System (ADAS) of a vehicle provides functions to enhance the safety of operating the vehicle. The ADAS may utilize data pertaining to driving conditions, the status of the passengers or the surrounding traffic conditions to provide the driver with additional information, warning indicators, or augmented control of the vehicle.

[0003] Prior ADAS implementations have utilized environmental sensors, cameras, and self-contained vehicle functions to adjust vehicle operation in response to driving conditions. ADAS-supported vehicles could advantageously benefit from environments designed to provide active safety feedback in response to driving conditions. Such active environments may enhance the safety of passengers by providing additional data to ADAS-supported vehicles.

SUMMARY

[0004] One aspect of this disclosure is directed to a vehicle guidance system for providing active feedback to ADAS-supported vehicles. The vehicle guidance system is comprised of a control center having a processor for performing traffic analysis, a number of active lane marker devices, and a number of vehicle receivers. The active lane marker devices provide conventional passive lane marker functionality by providing visual indication of the lanes in a roadway, while also providing additional functions providing driving and traffic conditions to the vehicle guidance system. The vehicle receivers are configured to receive ADAS-supported guidance signals from the active lane markers that correspond to the results of the traffic analysis performed by the control center.

[0005] In some embodiments of the system, the vehicle receivers may not be included as a part of the system. Instead, in such embodiments, the vehicle receivers may be implemented as a permanent component of a vehicle.

[0006] A further aspect of this disclosure is an active lane marker device having a number of sensors operable to monitor driving conditions, a control transmitter operable to transmit the driving conditions to a traffic analysis processor, a control receiver operable to receive data from the traffic analysis processor, and a vehicle transmitter operable to transmit guidance data to vehicles within a range of the active lane marker device.

[0007] Some embodiments of the active lane marker device may further comprise a heating element operable to prevent formation of ice on an exposed surface of the active lane marker device.

[0008] Some embodiments of the active lane marker device may further comprise a solar panel operable to provide solar power to the active lane marker device.

[0009] The above aspects of this disclosure and other aspects will be explained in greater detail below with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is a diagrammatic view of a vehicle guidance system.

[0011] Fig. 2 is a diagrammatic view of an active lane marker device for use within a vehicle guidance system.

[0012] Fig. 3 is a diagrammatic view of a dongle embodiment of a vehicle receiver for use within a vehicle guidance system.

[0013] Fig. 4 is a diagrammatic illustration of a first exemplary embodiment of a vehicle guidance system.

[0014] Fig. 5 is a diagrammatic illustration of a second exemplary embodiment of a vehicle guidance system.

DETAILED DESCRIPTION

[0015] The illustrated embodiments are disclosed with reference to the drawings. However, it is to be understood that the disclosed embodiments are intended to be merely examples that may be embodied in various and alternative forms. The figures are not necessarily to scale and some features may be exaggerated or minimized to show details of particular components. The specific structural and functional details disclosed are not to be interpreted as limiting, but as a representative basis for teaching one skilled in the art how to practice the disclosed concepts.

[0016] Fig. 1 shows a diagrammatic view of a vehicle guidance system according to one embodiment of the teachings herein. The system is implemented for use on a roadway **100**. The roadway **100** is comprised of lanes delineated by a number of lane markings, the lane marking comprising active lane markers **102** and outer lane lines **104**. Active lane markers **102** each comprise a number of sensors, a data transmitter, and a data receiver. The shoulder of roadway **100** and the driving surface are distinguished by the outer lane lines **104** on either edge of the driving surface of roadway **100**. The outer lane lines **104** may comprise a series of additional active lane markers **102**, but given visual continuity with conventional paint between the active portions thereof. For purposes of describing the embodiment herein, references to active lane markers **102** shall include the active lane markers embodied within outer lane lines **104**. Other embodiments of the system may comprise other embodiments of outer lane lines **104**, such as conventional passive paint lines. In some embodiments, outer lanes **104** may comprise entirely-active embodiments, or may comprise additional active lane markers arranged in the same manner as active lane markers **102**. In other embodiments featuring embodiments of roadway **100** having more than two lanes, multiple series of active lane markers **102** may be disposed between outer lane lines **104**.

[0017] The system further comprises a control center **106** having a traffic analysis processor **108** and a control center transceiver **110**. Active lane markers **102** are in operable communication with traffic analysis processor **108** via control center transceiver **110**. Active lane markers **102** are configured to monitor driving conditions of roadway **100** and generate sensor data corresponding to the driving conditions. Active lane markers **102** are configured to transmit the sensor data to traffic analysis processor **108** via control center transceiver **110**. Traffic analysis processor **108** analyzes the sensor data and based on the analysis transmits guidance data to active lane markers **102** via control center transceiver **110**. The guidance data is utilized by the active lane markers **102** to transmit vehicle signals to supported vehicles **112** within an appropriate range of the active lane marker **102**. Examples of vehicle signals may include commands to adjust the operation of the vehicle, such as changing direction or changing velocity (including stopping). Other embodiments may comprise additional forms of vehicle signals.

[0018] In the depicted embodiment, control center **106** is disposed along the roadway **100**, but in other embodiments control center **106** may be located elsewhere without deviating from the teachings of the invention herein. In some embodiments, a network of control centers **106** may be utilized to control a network of active lane markers **102**. In some embodiments having a plurality of control centers **106**, each control center **106** may be in operable communication with only a portion of the entire network of active lane markers **102**. In some embodiments having a plurality of control centers **106**, each control center **106** may be in operable communication with the entirety of the network of active lane markers **102**. In some embodiments, a single hub control center **106** may be in operable communication with a series of optional repeaters (not shown) to provide communication with active lane markers **102**. In the depicted embodiment, control center transceiver **110** is comprised of a single element providing both sending and receiving communication functions, but other embodiments may comprise multiple components operable to performing sending or receiving of communications, including redundant devices each performing one or more of the sending or receiving functions. In the depicted embodiment, control center transceiver **110** utilizes a wireless communication protocol, but other embodiments may comprise a wired operable communication between control center **106** and active lane markers **102**. In some embodiments, control center **106** may be operable to acquire data from sources other than active lane markers **102**, such as traffic databases, emergency notification systems, government broadcast services, weather information services, or the Internet. In some embodiments, control center **106** may comprise a user interface for traffic analysis processor **108**, permitting a user to generate guidance data or to override the guidance data transmitted by control center transceiver **110**.

[0019] In the depicted embodiment, vehicle **112** is operable to respond to guidance data by changing direction, changing velocity, or coming to a complete stop. Other embodiments of vehicle **112** may comprise other functions instead of, or in addition to, these functions. In some embodiments, vehicle **112** may support different amounts of ADAS control. In some embodiments, the ADAS of vehicle **112** may provide a fully autonomous driving experience for the passengers. In some embodiments, the ADAS of vehicle **112** may provide additional support a driver in abnormal conditions or circumstances, such as icy road conditions or driving in the vicinity of an existing vehicle collision. In some embodiments, the ADAS of vehicle **112** may provide warning indicators and display information useful for navigation, avoiding collision, or the like. In some embodiments, vehicle **112** may have user-adjustable configurations such that a driver of vehicle **112** may control the level of ADAS assistance provided by vehicle **112**. In some embodiments, the level of ADAS assistance provided by vehicle **112** may depend upon the physical location of vehicle **112**, based upon the availability of local ADAS-supported services, local laws, or other conditions of roadway **100** in a particular location. Other embodiments of vehicle **112** may comprise a combination of some or all of the above implementations of ADAS support.

[0020] In some embodiments, the guidance data transmitted by the control center **106** to active lane markers **102** may be in the form of direct ADAS-control commands, but in other embodiments the guidance data may include information useful for an ADAS-supported vehicle. Useful information for an ADAS-supported vehicle may include driving conditions. Driving conditions may comprise traffic conditions or environmental conditions. Traffic conditions are described herein as information pertaining to the vehicles and other users of the roadway, such as proximity and moving velocity of other vehicles, presence of pedestrians, presence of non-motor vehicles, the presence of wild animals, or the like. Environmental conditions are described herein as information pertaining to the environment and physical state of the roadway such as weather patterns, physical condition of the roadway, whether the roadway is under construction, or the like. Some driving conditions of roadway **100** may be characterized as both a traffic condition and an environmental condition, such as the presence of slow-moving construction vehicles within a construction zone, the presence of pedestrians near a school or park, or the like.

[0021] In some embodiments, vehicle **112** may be configured to receive guidance data using built-in vehicle components, such as a telematics system, media system, or an electronic control unit (ECU) of vehicle **112**. However, older vehicles may not be originally built with appropriate components to interact with active lane markers **102**, and instead may be retrofitted with aftermarket components to provide that functionality. Fig. 2 shows an embodiment of an aftermarket dongle **200** that is configured to aid in vehicle compatibility with the systems disclosed herein. In the depicted embodiment, dongle **200** is compatible with an on-board diagnostic (OBD) protocol, but other embodiments may comprise other forms without deviating from the teachings disclosed herein. In some embodiments, dongle **200** may instead be embodied as an aftermarket telematics system, an aftermarket media system, an aftermarket ECU, or any other alternative configuration for providing to a vehicle the functions described without deviating from the teachings disclosed herein.

[0022] Dongle **200** comprises a dongle processor **202**, a dongle memory **204** and a dongle transceiver **206**. Dongle processor **202** is configured to provide operable communication between dongle **200** and the diagnostic port of a vehicle. Dongle memory **204** may comprise data storage for vehicle identification information, vehicle route information, processor-readable instructions usable by diagnostic processor **202**, diagnostic logs of vehicle functions, or a data log of received guidance data from active lane markers **102**. Dongle transceiver **206** is operable to receive guidance data from active lane markers **102**. The guidance data may be stored in dongle memory **204** for later processing, or may be immediately utilized by dongle processor **202** in order to relay the guidance data to the vehicle. In some embodiments, dongle transceiver **206** may also be operable to transmit useful information regarding the status of the vehicle to active lane markers **102**, such as vehicle identification, vehicle location, the active moving velocity of the vehicle, data from vehicle sensors, or any other information available to vehicle **112** which may be useful for operation of active lane markers **102** or useful to control center **106** after being relayed by active lane markers **102**. In some embodiments, the functions of dongle transceiver **206** may instead be performed by a separate transmitter and receiver disposed within dongle **200**.

[0023] Fig. 3 provides a diagrammatic illustration of the features of an active lane marker **102** according to one embodiment of the teachings disclosed herein. In the depicted embodiment, active lane marker **102** comprises a marker body **300** having a top surface **302**. Marker body **300** is configured to be disposed within the road or ground **304** such that top surface **302** is substantially flush with the road surface **306**, road surface **306** being the driving surface of roadway **100** (not shown). In the depicted embodiment, top surface **302** is configured to be substantially the same color as a conventional lane marker or other marking of roadway **100** (e.g., white or yellow in accordance with local requirements). The depicted embodiment is a diagrammatic illustration of an active lane marker **102**, but may also represent an embodiment of the active lane marker portions of outside lane lines **104**.

[0024] Disposed within marker body **300** is a power supply **308**, operable to provide electrical power to the other components of active lane marker **102**. In the depicted embodiment, power source **308** comprises a battery, but other embodiments may comprise other implementations, such as a hard-wired connection to an external power source. Electronically connected to power supply **308** is a solar panel **310** in this shown embodiment. Solar panel **310** is operable to provide electrical power to active lane marker **102** during periods of sufficient sunlight, and further operable to charge power supply **308** for continued operation during periods of insufficient sunlight, such as nighttime. In one embodiment, power supply **308** is operable to power active lane marker **102** for up to 72 hours when at full capacity, but other embodiments may comprise other implementations. In embodiments having a hard-wired connection to an external power source, power supply **308** and solar panel **310** may still be present to provide auxiliary power to active lane marker **102** in case of power failure. In the depicted embodiment, solar panel **310** is operably disposed beneath top surface **302**, and top surface **302** is operable to permit passage of sufficient sunlight energize the cells of solar panel **310**, but other configurations may be used without deviating from the teachings disclosed herein. In some embodiments, top surface **302** and solar panel **310** may comprise a single component of active lane marker **102**. Some embodiments of active lane marker **102** may not comprise solar panel **310**.

[0025] Active lane marker **102** further comprises a number of traffic sensors **312**. Traffic sensors **312** are operable to monitor traffic conditions of roadway **100**. In the depicted embodiment, traffic sensors **312** comprise a motion sensor **312a**, an acoustic/vibration sensor **312b**, a light sensor **312c**, and an electromagnetic (EM) sensor **312d**, though other embodiments may comprise other forms of traffic sensors **312** instead of, or in addition to, the forms of traffic sensors **312** disclosed herein.

[0026] Motion sensor **312a** is operable to detect moving objects within the vicinity of active lane marker **102**. Motion sensor **312a** may advantageously further detect the velocity or direction of moving objects to generate more complete sensor data, which may be utilized to more accurately predict traffic conditions. For example, a fast-moving object moving in substantially the same direction as other fast-moving objects is more likely to be a motor vehicle than a fast-moving object moving in a substantially different direction. Active lane marker **102** may comprise multiple motion sensors **312** disposed at various points within marker body **300**. Advantageously, an embodiment having multiple motion sensors may more accurately detect the location and velocity of moving objects. Some embodiments of active lane marker **102** may comprise a plurality of motion sensors, and those embodiments may further comprise motion sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise a motion sensor.

[0027] Acoustic/vibration sensor **312b** is operable to detect acoustic signals in the atmosphere or vibration signals through the ground **304**. Acoustic/vibration sensor **312b** may advantageously further detect the spectral content, duration, or acoustic intensity of the acoustic or vibration signals, which may be utilized to more accurately predict traffic conditions. Acoustic/vibration sensor **312** may further advantageously detect both acoustic and vibration signals. For example, a loud, repeating, high-pitched acoustic signal without a strongly-correlated vibration signal is more likely to be a car alarm than a passing truck, while a low-pitched acoustic signal exhibiting Doppler characteristics strongly correlated to a low-frequency vibration signal is more likely to be a passing truck than a car alarm. In some embodiments, the functions of acoustic/vibration sensor **312b** may be accomplished using multiple sensors disposed advantageously at different within marker body **300**. For example, an acoustic-only sensor may have optimal sensitivity and accuracy being disposed near top surface **302** (see Fig. 3), where the acoustic vibrations of the outside environment are more likely to penetrate marker body **300**. Conversely, a vibration-only sensor may have optimal sensitivity and accuracy being disposed away from top surface **302**, and closer to a surface of marker body **300** in direct contact with ground **304**. In some embodiments, active lane marker **102** may only comprise an acoustic-only version sensor or a vibration-only version of the sensor. Some embodiments of active lane marker **102** may comprise a plurality of acoustic/vibration sensors, and those embodiments may further comprise acoustic/vibration sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise any form of an acoustic/vibration sensor.

[0028] Light sensor **312c** is operable to detect light emissions in the environment of active lane marker **102**. Light sensor **312c** may advantageously further detect the spectral content, duration, intensity of light emissions, or differential changes in the light emissions, which may be utilized to more accurately predict traffic conditions. The environment may be subjected to relatively static lighting conditions, such as natural sunlight or static artificial lighting to illuminate roadway **100** at night. For example, a change in spectral content and drop in light intensity at a rate substantially faster than normally-observed rates may indicate a moving object, such as a vehicle, moving into the proximity of light sensor **312c** such that it at least partially blocks the surrounding light emissions. Similarly, a change in spectral content and an increase in light intensity at a rate substantially faster than normally-observed rates may indicate an approaching vehicle with active headlights. Some embodiments of active lane marker **102** may comprise a plurality of light sensors, and those embodiments may comprise light sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise a light sensor.

[0029] Electromagnetic (EM) sensor **312d** is operable to detect EM emissions in the environment of active lane marker **102**. EM emissions may be utilized by vehicles within roadway **100** to assist in ADAS functions of other vehicles, or to interact with the environment. EM sensor **312d** may advantageously further detect the spectral content, duration, or intensity of EM emissions, which may be utilized to more accurately predict traffic conditions or to interpret a greater variety of EM signals. By way of example and not limitation, emergency response vehicles may be configured to emit an EM signal in the form of a traffic light preemption signal when the siren is active. Thus, when the emergency response vehicle is traveling to the site of an emergency, the traffic light preemption signal is broadcast by the vehicle. Compatible traffic lights can then detect the preemption signal and change states to prevent cross-traffic from entering intersections. EM sensor **312d** may be configured to detect existing traffic light preemption signals, or to detect other proprietary emergency vehicle signals. Other embodiments may further be directed to other forms of EM emissions, such as consumer vehicles emitting EM presence signals to assist ADAS functions of other vehicles. Some embodiments of lane marker **102** may comprise a plurality of EM sensors, and those embodiments may comprise EM sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise an EM sensor.

[0030] Active lane marker **102** further comprises a number of environmental sensors **314**. Environmental sensors **314** are operable to monitor the environmental conditions of roadway **100**. In the depicted embodiment, environmental sensors **314** comprise an ice sensor **314a** and a pollution sensor **314b**, though other embodiments may comprise other forms of environmental sensors **314** instead of, or in addition to, the forms of environmental sensors **314** disclosed herein.

[0031] Ice sensor **314a** comprises a temperature probe operable to monitor the temperature of active lane marker **102** at top surface **302**. Because top surface **302** is substantially flush with road surface **306**, the temperature of top surface **302** may be substantially similar to the temperature of road surface **306**. Low temperatures nearing or below 0°C may experience adverse icy conditions on road surface **306**. Ice sensor **314a** may also an optical probe operable to detect changes in optical opacity or changes in refractive index when light is reflected off top surface **302**. Changes in opacity or refractive index at sufficiently low temperatures may indicate the formation of ice on top surface **302**. Some embodiments may comprise multiple ice sensors, and those embodiments may comprise ice sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise an ice sensor.

[0032] Pollution sensor **314b** is operable to detect particulates and emissions common to combustion engines of motor vehicles in the environment of active lane marker **102**, which may be utilized to more accurately predict traffic conditions. For example, pollution sensor **314b** detecting pollution at elevated levels may be an indication of heavy traffic or traffic congestion. Additionally, some municipalities may have temporary or permanent pollution restrictions, and active lane marker **102** may detect vehicles that are operating outside of the required conditions. Some embodiments of active lane marker **102** may comprise multiple pollution sensors, and those embodiments may comprise pollutions sensors of varying functionality or specification. Some embodiments of active lane marker **102** may not comprise an ice sensor.

[0033] The traffic sensors **312** and environmental sensors **314** of active lane marker **102** are utilized to generate sensor data for transmission to control center **106**. Active lane marker **102** further comprises a marker processor **316**, marker memory **318**, marker transmitter **320**, and marker receiver **322** to enable operable communication between active lane marker **102** and control center **106**. Marker processor **316** may be configured to collect from traffic sensors **312** and environmental sensors **314** and assemble a set of sensor data for transmission to control center **106**. The sensor data may comprise raw data from the sensors reflecting the driving conditions, or marker processor **316** may perform partial or complete analysis of the raw data to be transmitted to control center **106**. In the depicted embodiment, the sensor data comprises raw data to be analyzed by traffic analysis processor **108**, which advantageously reduces the power requirements of marker processor **316**. The data reported by the traffic sensors **312** or environmental sensors **314** may be stored in marker memory **318** as data logs. Marker memory **318** may further store instructions operable to be executed by marker processor **316**. Marker memory **318** may further store identification information for the active lane marker **102**, such as positional data, an identification number for use within a network of active lane markers **102**, installation/maintenance records, or version information for any software instructions or firmware embodied within active lane marker **102**. In the depicted embodiment, marker processor **316** is a specialized processor device, but other embodiments may comprise a general-purpose processing device operable to execute software instructions, a general-purpose processing device operable to execute firmware instructions, a digital signal processor having internal instructions, a field-programmable gate array, or any other equivalent alternative configuration known to one of ordinary skill in the art. In the depicted embodiment, marker memory **318** comprises a flash memory, but other embodiments may comprise a hard disk drive, random-access memory (RAM), programmable memory (PROM), electronic programmable memory (EPROM), secure digital (SD) card, or any other alternative configuration known to one of ordinary skill in the art without deviating from the teachings disclosed herein.

[0034] Marker transmitter **320** is operable to transmit the sensor data to control center **106**. Marker transmitter **320** may be configured to transmit sensor data provided by marker processor **316**, or stored by marker memory **318**. In response to receiving sensor data transmitted by marker transmitter **320**, traffic analysis processor **108** generates guidance data in response to the sensor data that is then transmitted by control center **106** and received by marker receiver **322**. The guidance data may comprise operational instructions for active lane marker. Active lane marker **102** is configured to respond to the guidance data according to the operational instructions. Operational instructions may include instructions for active lane marker **102** to transmit vehicle signals, which are detectable by vehicles **112** in roadway **100**. In the depicted embodiment, the active lane marker **102** transmits vehicle signals using marker transmitter **322**, but other embodiments may have other implementations with a distinct transmitter. Vehicle signals may comprise information useful for an ADAS-supported vehicle **112**, or direct commands to control ADAS-supported vehicle **112**. In some embodiments the vehicle signals may be included within the guidance data transmitted from control center **106**, with active lane marker **102** acting as a repeater of the vehicle signal. In some embodiments, the vehicle signals may be encoded within the guidance data transmitted from control center **106**, with active lane marker **102** decoding the vehicle signals before transmission. In some embodiments, the vehicle signals comprise a set of pre-determined commands stored in marker memory **318**, to be accessed and selected by marker processor **316**. In some embodiments, marker processor **316** may generate vehicle signals based upon the contents of the guidance data received by marker receiver **322**. The vehicle signals generated by marker transmitter **320** may have an active range that is controllable based upon detected traffic conditions. For example, in faster-moving traffic, the marker transmitter **320** may be configured to transmit vehicle signals with more power and greater range in order to optimize the reaction times of drivers of vehicles. In some embodiments, the transmission power of marker transmitter **320** may be correlated to the type of signal for transmission. For example, sensor data may be transmitted at a higher power in order to reach a distant control center, while vehicle signals may be transmitted at a lower power to optimize reception by ADAS-supported vehicles.

[0035] In the depicted embodiment, active lane marker **102** further comprises an antenna **324** to optimize transmission and reception of signals by marker transmitter **320** and marker receiver **324**. In some embodiments, active lane marker **102** may not comprise an antenna. In the depicted embodiment, active lane marker **102** comprises a distinct marker transmitter **320** and marker receiver **322** but other embodiments may comprise a single marker transceiver that is operable to perform all the functions of marker transmitter **320** and marker receiver **322**.

[0036] Active lane marker **102** may further comprise other features. In the depicted embodiment, active lane marker **102** further comprises a heating element **326**. Heating element **326** is powered by power source **308** and is operable to raise the temperature of top surface **302** above a threshold temperature. In some embodiments, the threshold temperature may be 0°C to prevent formation of ice on top surface **302**, but other embodiments may use alternative threshold temperatures without deviating from the teachings disclosed herein. In the depicted embodiment, heating element **326** may be activated and deactivated in response to additional data acquired by active lane marker **102**. In some embodiments, heating element **326** may be activated only when environmental sensors **314** indicate that formation of ice on top surface **302** is occurring. In some embodiments, heating element **326** may be activated in response to guidance data received from control center **106** that includes a command to activate heating element **326**.

[0037] In the depicted embodiment, active lane marker **102** further comprises a number of indicators **328**. Indicators **328** are operable to provide vehicle-recognizable or human-recognizable indications, such as electromagnetic transmissions, visual lights, or audible sounds. In the depicted embodiment, light-emitting diode (LED) indicators **328a** comprise an LED operable to provide static or dynamic light displays. In the depicted embodiment, LED indicators **328** are operable to provide illumination of active lane marker **102** in a number of different colors to help provide visual indication of traffic conditions to drivers of motor vehicles, including motor vehicles lacking ADAS-supported functions. In one exemplary embodiment, active lane marker **102** is operable to illuminate LED indicators **328a** in a bright yellow color to match the passive color of top surface **302** while providing a higher visibility. If environmental sensors **314** indicate heavy fog conditions, or if control center **106** receives data indicating such conditions, along roadway **100**, active lane marker **102** may illuminate LED indicators **328a** in order to visually indicate the lane positions within roadway **100** for a driver.

[0038] In the depicted embodiment, active lane marker **102** further comprises a presence indicator **328b**. Presence indicator **328b** is operable to continuously emit a short-range electromagnetic signal used by vehicles to detect the bounds of lanes on a roadway. In the depicted embodiment, the emitted signals of presence indicator **328b** further comprises identification information for active lane marker **102**, such as the position of the active lane marker **102** with respect to roadway **100** (i.e., which lanes of the roadway are bounded by the active lane marker **102**), the direction of traffic (e.g., Northbound, Southbound, etc.), the network address of the active lane marker **102**, or the distance between the active lane marker **102** and the adjacent lane markings. In some embodiments, the functions of presence indicator **328b** may instead be performed by marker transmitter **320**. In the depicted embodiment, presence indicator **328b** may advantageously comprise a passive implementation, such as an RFID tag, which advantageously results in lower power consumption than continuous active transmission by marker transmitter **320**. A presence indicator **328b** may comprise other embodiments known to one of ordinary skill in the art without deviating from the teachings disclosed herein. Presence indicator **328b** may further have a shorter transmission range than marker transmitter **320**. A shorter transmission range is advantageous because it further reduces power consumption requirements of active lane marker **102**, while also only providing presence data in vehicle signals that are within a desired proximity to the active lane marker **102**. Thus, because presence indicator signals are only discoverable within a shortened range within proximity of active lane marker **102**, a vehicle driving along roadway **100** will only need to receive and interpret vehicle signals transmitted from active lane markers **102** that are near enough to the vehicle to be of utility to the ADAS.

[0039] Active lane marker **102** may comprise other embodiments having other forms of indicators **328** instead of, or in addition to, the embodiments depicted. Such other alternative embodiments may comprise alternative light-based indicators, but may also comprise sound-emitters, radio-frequency emitters, infrared emitters, or any other equivalent embodiment known to one of ordinary skill in the art without deviating from the teachings disclosed herein.

[0040] Fig. 4 provides a diagrammatic illustration of an exemplary embodiment used according to one function of the teachings disclosed herein. Fig. 4 depicts a roadway **400** having a network of active lane markers **402**, with outer lane lines **404** also comprised of active lane markers **402**. The active lane markers **402** and comprising outer lane lines **404** comprise one embodiment of an active lane marker as disclosed above with respect to Fig. 3.

[0041] In the depicted embodiment, an emergency response vehicle **406** is traveling in a fast-moving lane of roadway **400** in a direction **408** with an emergency signal active. Active lane markers **402** gather sensor data that indicates the conditions of an emergency vehicle using traffic sensors **312** and environmental sensors **314**. Traffic sensors **312** (see Fig. 3) include an EM sensor **312d** (see Fig. 3), which receives a traffic light preemption signal from emergency response vehicle **406**. Traffic sensors **312** may also include an acoustic/vibration sensor **312b** (see Fig. 3), which detects the acoustic signal created by the siren of emergency response vehicle **406**. The sensor data is transmitted to a control center **106** (see Fig. 1) via marker transmitter **320** (see Fig. 3), wherein a traffic analysis processor **108** (see Fig. 1) provides an optimal traffic pattern comprised of civilian vehicles traveling in direction **408** at a reduced speed in only the slow-moving lane of roadway **400**. The control center transmits the guidance data to active lane markers **402**, and each marker processor **316** (see Fig. 3) generates vehicle signals directing ADAS-supported vehicles to conform to the optimal traffic pattern. A first vehicle **412** supporting ADAS functions is already traveling in direction **408** in the slow-moving lane, but at a faster velocity than is determined to be optimal. In response, first vehicle **412** persists in its current direction and lane position, but reduces its velocity. A second vehicle **414** supporting ADAS functions is traveling in direction **408** in the fast-moving lane and at a faster velocity than the optimal velocity. In response, second vehicle **414** must change course to direction **416** until second vehicle **414** has successfully changed lanes into the slow-moving lane. At the same time that second vehicle **414** is changing lanes, it also reduces velocity to conform to the optimal traffic patterns in a safe manner. Once second vehicle **414** has completed the lane change, it resumes traveling in direction **408**. These actions create a safe traffic pattern permitting emergency response vehicle **406** to pass in the fast-moving lane unimpeded. When emergency response vehicle **406** is no longer within range of the sensors of active lane markers **402**, the active lane markers will resume providing sensor data indicated routine driving conditions, and the control center will no longer transmit guidance data corresponding to the presence of an emergency response vehicle. Thus, operation of the ADAS-supported vehicles will resume to their states prior to the presence of emergency response vehicle **406**. The depicted embodiment comprises fully-autonomous ADAS-support for each of first vehicle **412** and second vehicle **414**, but other embodiments having different compatibility may instead only partially control the functions of a vehicle, or may simply provide driver indications of the optimal traffic pattern.

[0042] Fig. 5 is a diagrammatic illustration of another exemplary embodiment of the teachings herein. Fig. 5 depicts a roadway **500** having a network of active lane markers **502**, with outer lane lines **504** also comprised of active lane markers **502**. In this depicted embodiment, outer lane lines **504** comprise substantially contiguous active portions, with no conventional passive lines. The lane markings depicted herein comprise active lane markers **502** and outer lane lines **504** according to one embodiment of an active lane marker as disclosed above with respect to Fig. 3. In the depicted embodiment, active lane markers **502a** and outer lane lines **504a** designate lane markings wherein their respective LED indicators **328** (see Fig. 3) are currently inactive. Because the respective LED indicators **328** are inactive, the respective lane markings have their conventional appearance (e.g., yellow). In the depicted embodiment, active lane markers **502b** and outer lane lines **504b** designate lane markings wherein their respective LED indicators **328** (see Fig. 3) are currently active. Because of the active state of the respective LED indicators, these respective lane markings are given an altered appearance (e.g., flashing between illuminated red and yellow).

[0043] In the depicted embodiment of Fig. 5, the illuminated lane markings **502b** and **504b** are illuminated in response to detection of an abnormal status. The abnormal status depicted is a first vehicle **506** and a second vehicle **508** stopped in a right-hand lane of the roadway **500**. First vehicle **506** and second vehicle **508** may have collided or have another service need and remain unmoving while blocking a portion of one lane of roadway **500**. In the depicted embodiment, first vehicle **506** or second vehicle **508** may each be ADAS-supported such that they transmit a distress signal indicating a collision, service need, or unmoving status. The distress signal may be received by marker receivers **322** (see Fig. 3) of the surrounding lane markings, and lane markings **502** and **504** may utilize the signals to determine the presence of stopped traffic within the lane. However, even if neither first vehicle **506** nor second vehicle **508** have ADAS-supported functions, the traffic sensors **312** and environmental sensors **314** (see Fig. 3) of active lane markers **502** and outer lane lines **504** could detect the presence of unmoving objects. Active lane markers **502** and outer lane lines **504** then transmit the sensor data to a control center **106** for traffic analysis by a traffic analysis processor **108** (see Fig. 1). The control center then transmits guidance data to active lane markers **502** and outer lane lines **504**. The transmitted guidance data identifies active lane markers **502b** and outer lane lines **504b** specifically in order to include commands for those lane markings to illuminate their respective LED indicators **328a** (see Fig. 3). The same guidance data does not identify active lane markers **502a** or outer lane lines **504a**, so those lane markings do not illuminate their respective LED indicators **328a**. Active lane markers **502b** and outer lane lines **504b** are explicitly identified and chosen for these commands based upon their proximal relation to the location of the collision. Outer lane line **504b** is disposed upstream of traffic in the right-hand lane, the same lane as the detected collision, giving drivers of vehicles without ADAS-supported functions advance notice of a hazardous traffic condition. When the proximity of the collision is lower than a threshold distance, active lane markers **502b** also illuminate, to indicate to the driver of a vehicle to leave the lane of obstruction. In the depicted embodiment, lane markings **502b** and **504b** do not only illuminate LED indicators **328a**, but also transmit vehicle signals to merge left into the unobstructed lane. In the depicted embodiment, a third vehicle **510** having ADAS-supported functions is driving upstream of the collision in the same lane. Third vehicle **510** receives the lane-change vehicle signals from the outer lane lines **504b** at a safe distance from the site of the stopped vehicles, and begins veering to direction **512** to change lanes away from the obstructing condition. After shifting into the unobstructed lane, third vehicle **510** continues driving with the flow of traffic. Near the site of the collision, active lane markers **502b** continue transmitting vehicle signals indicating an unsafe condition in the right-hand lane, and also instructing third vehicle **510** to remain in the left-hand lane. These vehicle signals are persistently transmitted by active lane markers **502b** and outer lane line **504b** until the flow of traffic has advanced far enough downstream of the collision that it is again safe to utilize the right-hand lane. In the depicted embodiment, if the stopped vehicles obstructed all lanes of roadway **500**, the vehicle signals may comprise commands to direct third vehicle **510** to come to a complete stop. Such vehicle signals may persist until such time that the sensors of the lane markings indicate that at least one lane of roadway **500** is safe enough to continue driving.

[0044] These depictions are intended to provide illustration and not limitation to the teachings disclosed herein. One of ordinary skill in the art will recognize additional or alternative scenarios or environments that are applicable to the teachings herein without deviating from the disclosure provided. Alternative embodiments may comprise alternative vehicles, including mass transit automobiles, shipping automobiles, railway cars, monorail cars, maglev vehicles, or any other ground-based vehicles having partially-assisted or fully-autonomous functions.

[0045] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the disclosed apparatus and method. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the disclosure as claimed. The features of various implementing embodiments may be combined to form further embodiments of the disclosed concepts.

WHAT IS CLAIMED IS:

1. A vehicle guidance system comprising:

a control center having a traffic analysis processor operable to receive sensor data and configured to transmit guidance data;

a number of active lane markers configured to be disposed along lanes of a road, the number of active lane markers in operable communication with the control center, each active lane marker having a number of sensors operable to monitor environmental conditions or traffic conditions of the road, generate the sensor data corresponding to the environmental conditions or traffic conditions, and transmit the sensor data to the traffic analysis processor, and each active lane marker further operable to receive the guidance data and transmit vehicle signals to vehicles within a range of the active lane marker; and

a number of vehicle receivers, each of the number of vehicle receivers operably coupled to a vehicle, the number of vehicle receivers being operable to receive the vehicle signals, the vehicle signals providing vehicle data for driver assistance functions of the vehicle.

2. The vehicle guidance system of claim 1, wherein the number of vehicle receivers are embodied as a dongle that is operably coupled to the vehicle using a diagnostic port of the vehicle.

3. The vehicle guidance system of claim 1, wherein the number of active lane markers further comprise a heating element operable to raise the temperature of a top surface of the active lane marker, the top surface being disposed such that it is substantially flush with a driving surface of the road.

4. The vehicle guidance system of claim 3, wherein the number of active lane markers further comprise a temperature probe operable to measure the temperature of the top surface of the active lane marker.

5. A vehicle guidance system comprising:

a control center having a traffic analysis processor operable to receive sensor data and configured to transmit guidance data; and

a number of active lane markers configured to be disposed along lanes of a road, the number of active lane markers in operable communication with the control center, each active lane marker having a number of sensors operable to monitor environmental conditions and traffic conditions, generate the sensor data corresponding to the environmental conditions and traffic conditions, and transmit the sensor data to the traffic analysis processor, and each active lane marker further operable to receive the guidance data and transmit vehicle signals to vehicles within a range of the active lane marker.

6. The vehicle guidance system of claim 5, wherein the vehicle signals comprise vehicle data for driver assistance functions of a vehicle.

7. The vehicle guidance system of claim 5, wherein the number of active lane markers are in operable communication with the control center via a wireless connection to the traffic analysis processor, the wireless connection being operable to send and receive data between the active lane marker and the traffic analysis processor.

8. An active lane marker device configured to be disposed along the lanes of a road, the device comprising:

a power supply disposed within the active lane marker device;

a number of sensors, each connected to the power supply, operable to monitor environmental conditions or traffic conditions of the road and to generate corresponding sensor data;

a control transmitter connected to the power supply and in communication with the number of sensors, the control transmitter operable to transmit the sensor data to a control processor;

a control receiver connected to the power supply and operable to receive guidance data from the control processor; and

a vehicle transmitter connected to the power supply and operable to transmit vehicle data corresponding to the guidance data received from the control processor to vehicles within a range of the vehicle transmitter.

9. The active lane marker device of claim 8, wherein the power supply comprises a battery.

10. The active lane marker device of claim 9, wherein the power supply further comprises a solar panel, the solar panel being operable to charge the battery.

11. The active lane marker device of claim 8, wherein the number of sensors comprise a temperature sensor operable to measure the temperature of a top surface of the active lane marker, the top surface being disposed such that it is substantially flush with the driving surface of the road.

12. The active lane marker device of claim 11, further comprising a heating element disposed along the top surface of the active lane marker device, the heating element operable to raise the temperature of the top surface of the active lane marker.

13. The active lane marker device of claim 8, wherein the number of sensors comprise a motion sensor operable to detect movement of vehicles in the road.

14. The active lane marker device of claim 13, wherein the motion sensor is further operable to measure the velocity of vehicles in the road.

15. The active lane marker device of claim 8, wherein the number of sensors comprises a first-responder sensor operable to detect an emergency vehicle engaging in active emergency response.

16. The active lane marker device of claim 8, wherein the number of sensors comprises a motion sensor operable to detect movement of vehicles in the road and a temperature sensor operable to measure the temperature of a top surface of the active lane marker, the top surface of the active lane marker being disposed such that it is substantially flush with the driving surface of the road.

17. The active lane marker device of claim 16, wherein the number of sensors comprises a first-responder sensor operable to detect an emergency vehicle engaging in active emergency response.

18. The active lane marker device of claim 8, further comprising a persistent memory operable to store data comprising a device identification information for the active lane marker.

19. The active lane marker device of claim 8, wherein the control transmitter comprises a wireless transmitter.

20. The active lane marker device of claim 8, wherein the control transmitter and the vehicle transmitter comprise a single transmitter operable to transmit both the sensor data to the control processor and the vehicle data to corresponding to the guidance data to vehicles within a range of the single transmitter.

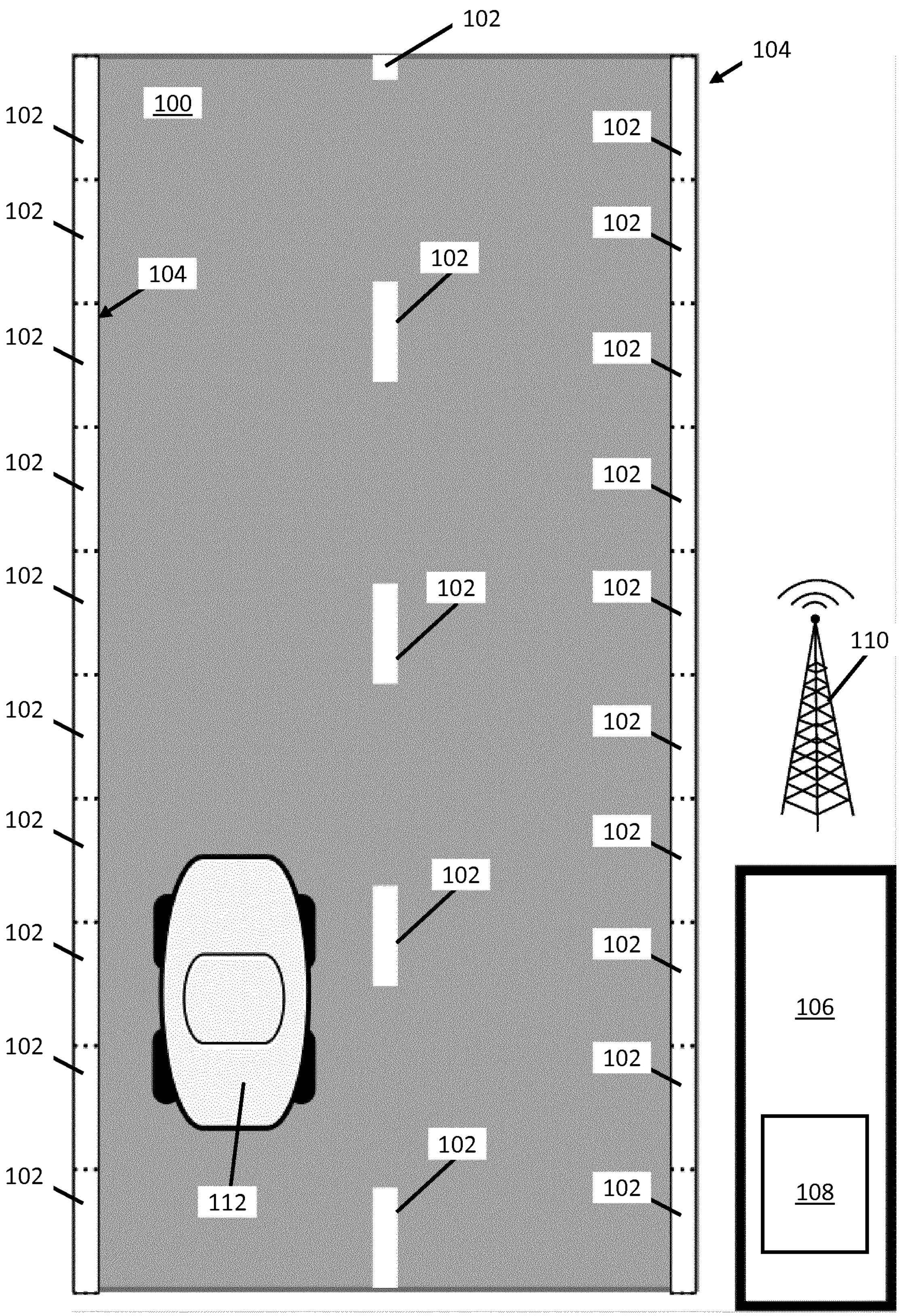
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Fig. 1

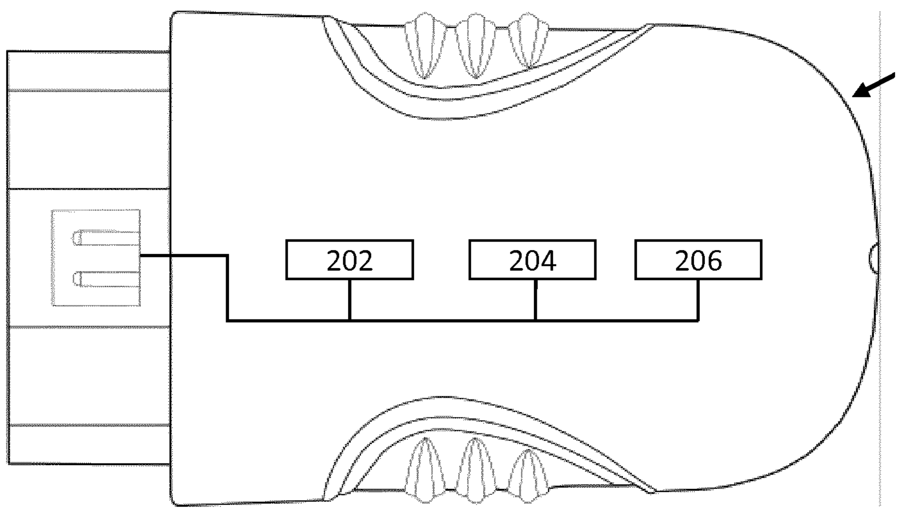
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Fig. 2

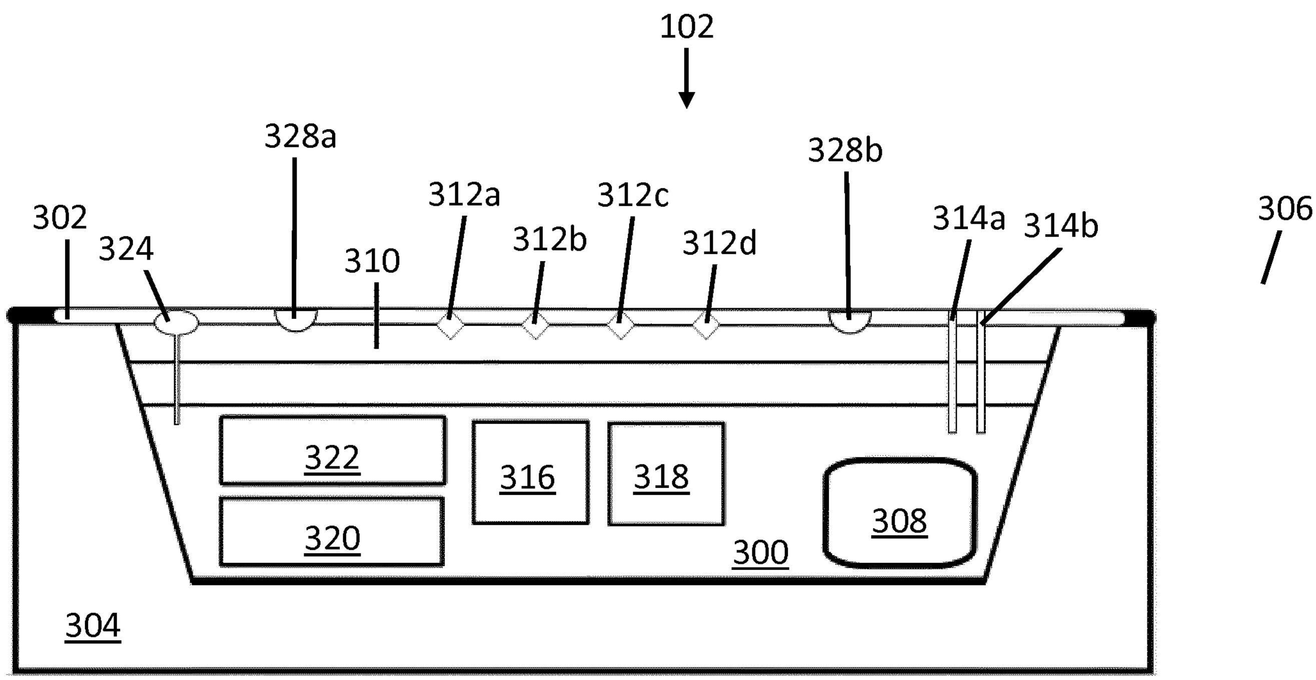
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Fig. 3

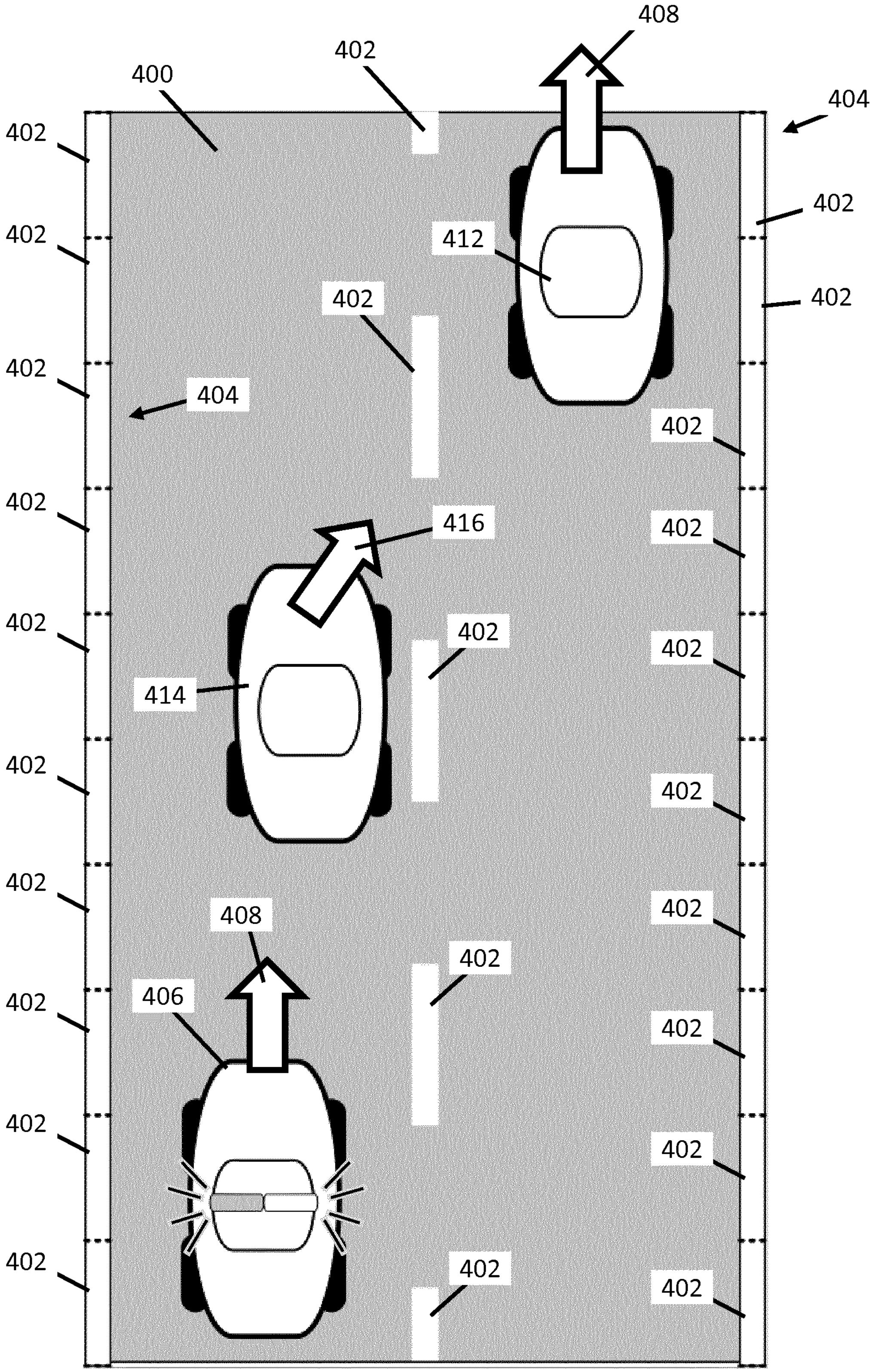

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Fig. 4

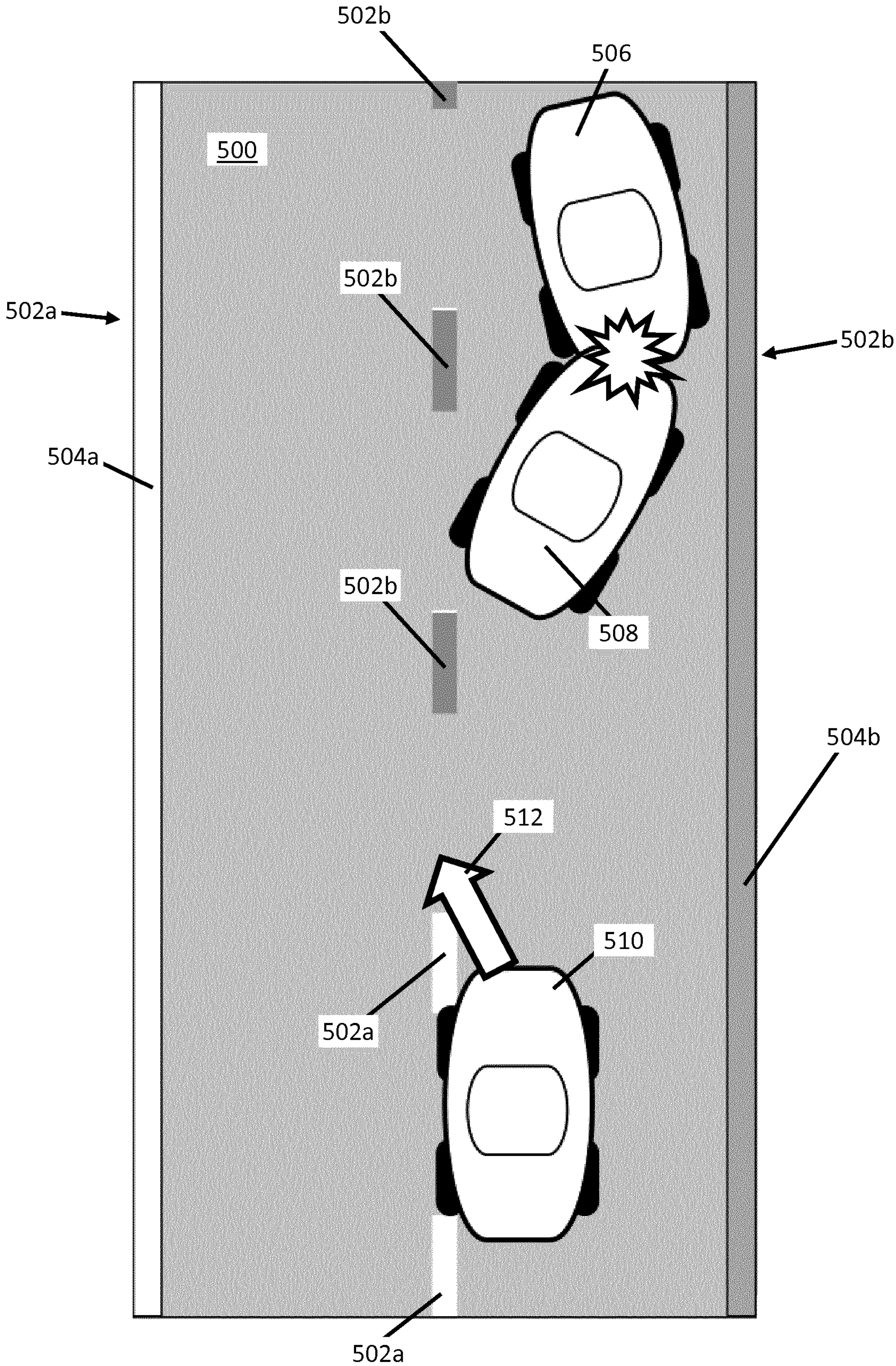
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Fig. 5