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(54) Title: COLLISION AVOIDANCE SYSTEM AND METHOD FOR VEHICLES

(57) Abstract: The present invention describes a collision avoidance system (200) for vehicles. The system (200) comprises one or more sensor units (202) mounted on a vehicle and configured to transmit a signal to a plurality of objects ahead of the vehicle. The system (200) further comprises a controller (204) operatively coupled to the one or more sensor units (202) and configured to identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object. The controller (204) may be configured to calculate a time required by the vehicle to encounter the at least one object based on the identified frequency information, and the identified time information. Furthermore, the controller (204) may be configured to communicate the calculated time with one or more other vehicles behind the vehicle.

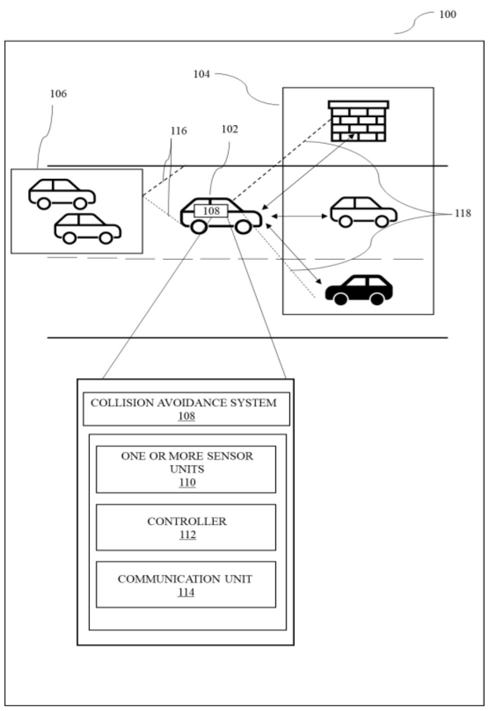

FIG. 1

<u>FORM 2</u>

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

Complete Specification
(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

COLLISION AVOIDANCE SYSTEM AND METHOD FOR VEHICLES

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

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

TECHNICAL FIELD

[001] The present invention generally relates to a method and a system capable of avoiding collision between vehicles.

BACKGROUND

[002] The following description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[003] Autonomous or semi-autonomous vehicles (e.g., trucks, long haulers, cars, buses, minivans, etc.) may encounter a front vehicle traveling ahead of the vehicle. In certain situations, it may be desirable for the vehicle to overtake the front vehicle. For example, the front vehicle may be traveling at a slower speed than a specified speed limit on the vehicle route, which may be delaying the travel time of the vehicle to its destination. Therefore, the driver may want to overtake that vehicle to continue driving at their desired speed.

[004] In the conventional process, the driver checks the view of the oncoming and ongoing lane. After that the driver overtake the vehicle in front of them. However, if the view of the oncoming lane and ongoing lane are obstructed by other vehicle or any other object such as oversized truck, a bus, a blind turn, and so forth, the driver may not be able to see if there is any oncoming traffic and ongoing traffic, and if there is, they may not be able to accurately judge its speed and distance. This can result in a collision if the driver attempts to overtake when it is unsafe to do so.

[005] Thus, there is a need for a system that avoids hazardous situations when overtaking and ensure a clear view of the oncoming lane before attempting to overtake.

SUMMARY

[006] The present disclosure overcomes one or more shortcomings of the prior art and provides additional advantages discussed throughout the present disclosure. Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed disclosure.

[007] In an aspect, the present disclosure recites a collision avoidance system for vehicles. The system comprises one or more sensor units mounted on a vehicle and configured to transmit a signal to a plurality of objects ahead of the vehicle. The system further comprises a controller operatively coupled to the one or more sensor units and configured to identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object. Sequentially, the controller is further configured to identify a state of the at least one object based on the identified at least one of frequency information and time information. The state of the at least one object indicates the at least one object as stationery or moving. The controller may be configured to calculate a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information. Furthermore, the controller is configured to communicate the calculated time with one or more other vehicles behind the vehicle.

[008] In another aspect, the one or more sensor units are further configured to receive reflected signal from the at least one object based on the signal transmitted to the at least one object. The frequency information is associated with a frequency of the transmitted signal and a frequency of the reflected signal. The time information is associated with a time at which the signal is transmitted and a time at which the reflected signal is received.

[009] In another aspect, the present disclosure recites the controller to identify the state of the at least one object. The controller is further configured to identify velocity of the at least one object based on the identified frequency information and time information. The controller is further configured to compare the identified velocity of at least one object with velocity of the vehicle and identify the state of the at least one object based on the comparison.

[0010] In another aspect, the present disclosure recites the controller that is further configured to calculate the time required by the vehicle to encounter the at least one object based on the identification that the least one object is the moving object. The controller is further configured to compare the calculated time with a threshold value and communicate one of the calculated time and an indication information including direction of travel, based on the comparison of time.

[0011] In another aspect, the present disclosure recites the controller that is further configured to one or more processing unit configured to communicate the calculated time, along with the indication of direction of travel of the at least one object, with the one or more vehicles behind the vehicle, if the calculated time is greater than the threshold value. The controller is further configured to communicate, with the one or more vehicles behind the vehicle, an indication that the at least one object is travelling ahead of the vehicle, if the calculated time is less than the threshold value.

[0012] In an aspect, the present disclosure may recite a collision avoidance method for vehicles. The method includes transmitting a signal to a plurality of objects ahead of a vehicle. The method further includes identifying at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object. The method further includes identifying a state of the at least one object based on the identified at least one of frequency information and time information, The state of the at least one object indicates the at least one object as stationery or moving. The method further includes calculating a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information. Finally, the method includes communicating the calculated time with one or more other vehicles behind the vehicle.

[0013] In another aspect, the present disclosure recites a method for identifying time information and the frequency information, that includes identifying velocity of the at least one object based on the identified frequency information and time information. The method further includes comparing the identified velocity of the at least one object with velocity of the vehicle and identifying the state of the at least one object based on the comparison.

[0014] In another aspect, the present disclosure recites a method for identifying the state of the at least one object that includes identifying velocity of the at least one object based on the identified frequency information and time information. The method further includes comparing the identified velocity of the at least one object with velocity of the vehicle and identifying the state of the at least one object based on the comparison.

[0015] In another aspect, the present disclosure recites a method for calculation and communication of the time that includes calculating the time required by the vehicle to encounter the at least one object based on the identification that the least one object is the moving object. The method further includes comparing the calculated time with a threshold value and communicating one of the calculated time and an indication information including direction of travel, based on the comparison of time.

[0016] In another aspect, the present disclosure recites a method for communication of the time that includes communicating the calculated time, along with the indication of direction of travel of the at least one object, with the one or more vehicles behind the vehicle, if the calculated time is greater than the threshold value. The method further includes communicating, with the one or more vehicles behind the vehicle, an indication that the at least one object is travelling ahead of the vehicle, if the calculated time is less than the threshold value.

[0017] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF DRAWINGS

[0018] The embodiments of the disclosure itself, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings. One or more embodiments are now described, by way of example only, with reference to the accompanying drawings in which:

[0019] **FIG. 1** illustrates an environment architecture for a collision avoidance system, in accordance with an embodiment of the present disclosure.

[0020] **FIG. 2** illustrates by way of a block diagram a collision avoidance system for vehicles, in accordance with an embodiment of the present disclosure.

[0021] **FIG. 3** illustrates an exemplary embodiment of display of generated information, in accordance with an embodiment of the present disclosure

[0022] **FIG. 4** illustrates by way of a block diagram a collision avoidance system for identifying state of a plurality of objects, in accordance with an embodiment of the present disclosure.

[0023] **FIG. 5** illustrates by way of block diagram a collision avoidance system for calculation of encounter time and communication of the encounter time, in accordance with an embodiment of the present disclosure.

[0024] **FIG. 6** a flow diagram illustrating a collision avoidance method for vehicles, in accordance with an embodiment of the present disclosure.

[0025] The figures depict embodiments of the disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

DETAILED DESCRIPTION

[0026] The foregoing has broadly outlined the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure.

[0027] Various embodiments of the present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. The term “or” is used herein in both the alternative and conjunctive sense, unless otherwise indicated. The terms “illustrative,” “example,” and “exemplary” are used to be examples with no indication of quality level. Like numbers refer to like elements throughout.

[0028] The phrases “in an embodiment,” “in one embodiment,” “according to one embodiment,” and the like generally mean that the particular feature, structure, or characteristic following the phrase may be included in at least one embodiment of the present disclosure and may be included in more than one embodiment of the present disclosure (importantly, such phrases do not necessarily refer to the same embodiment).

[0029] The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any implementation described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other implementations.

[0030] If the specification states a component or feature “can,” “may,” “could,” “should,” “would,” “preferably,” “possibly,” “typically,” “optionally,” “for example,” “often,” or “might” (or other such language) be included or have a characteristic, that particular component or feature is not required to be included or to have the characteristic. Such component or feature may be optionally included in some embodiments, or it may be excluded.

[0031] The phrase “vehicle” may be used throughout the disclosure. The vehicle may be a car, truck, semi-truck, motorcycle, moped, scooter, or other type of transportation.

[0032] Disclosed herein is a collision avoidance system for vehicles. The system may transmit a signal to a plurality of objects ahead of the vehicle. After transmitting the signal, the system may identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object. Then the system may identify a state of the at least one object based on the identified at least one of frequency information and time information, wherein the state of the at least one object indicates the at least one object as stationery or moving. Thereafter, the system may calculate a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information. Finally, the system may communicate the calculated time with one or more other vehicles behind the vehicle. Thus, the system may avoid hazardous situation of accidents that may occur due to overtaking by providing real-time information about the vehicle in front of them. Precisely, the system may reduce risk of accidents and improve safety on the road by providing visibility of the ongoing and oncoming traffic.

[0033] Turning now to the drawings, the detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts with like numerals denote like components throughout the several views. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details.

[0034] **FIG. 1** illustrates an environment architecture 100 for implementing a collision avoidance system 108 for vehicles, in accordance with an embodiment of the present disclosure. The environment architecture 100 may constitute a vehicle 102, a plurality of objects 104 ahead of the vehicle 102, one or more vehicles 106 behind the vehicle 102, and a collision avoidance system 108 installed inside the vehicle 102. All the constituent elements of the environment architecture 100 illustrated in FIG. 1 are essential constituent elements, however the environment architecture 100 may be implemented by more constituent elements than the constituent elements illustrated in FIG. 1. However, the same are not explained for the sake of brevity.

[0035] In an embodiment, the vehicle 102 may comprise the collision avoidance system 108 for the one or more vehicles 106 to prevent occurrence of accidental situation from at least one of the plurality of objects 104. The system 108 may comprise one or more sensor units 110, a controller 112, and a communication unit 114. The detailed functioning of the system 108, in conjunction with other elements disclosed in Fig. 1, is further explained in Fig. 2 in forthcoming paragraphs of the present disclosure. Those skilled in the art will appreciate that the system 108 may be an integral part of the vehicle 102.

[0036] In an embodiment, a plurality of objects 104 may be a stationary object or a moving object. The stationary object may be, not limited to, breakers, trees, traffic signs, concrete barriers, Guardrails, and so on. Further, the moving object may be, not limited to, automobile, human, animal, and so on. The automobile may be, not limited to, a two-wheeler, a three-wheeler, a four-wheeler, a truck, a trailer, and so forth. In an embodiment, the plurality of objects 104 may be ahead of the vehicle 102 and travelling in same direction as that of the vehicle 102. In another embodiment, the plurality of objects 104 may be ahead of the vehicle

102 and travelling in opposite direction as that of the vehicle 102 i.e., may be moving toward the vehicle 102.

[0037] Further, the one or more vehicles 106 may be travelling behind the vehicle 102 in a direction same as the travelling direction of the vehicle 102.

[0038] In a non-limiting example of the present embodiment, the one or more vehicles 106 that may be behind the vehicle 102 may not have a clear line of sight due to several situations. The situations may be, not limited to, weather conditions, limited visual field of a driver of the one or more vehicles 106, obstructions on path, and so on. Let's consider the situation of the limited visual field 116 of a driver of the one or more vehicles 106 as shown in fig. 1. In this situation, the one or more vehicles 106 may encounter potential hazard with the one of the plurality of objects 104. To avoid this situation, the system 108 may transmit a signal (as shown in Fig. 1) towards the plurality of objects 104, that fall within a pre-defined line of sight 118 of the vehicle 102 and receive a reflected signal (as shown in Fig. 1) from at least one of the plurality of objects 104. The pre-defined line of sight 118 may be defined by a pre-defined angle of sight of the vehicle 102. After receiving the reflected signals from at least one of the plurality of objects 104, the system 108 may provide an information to the one or more vehicles 106 related to the plurality of objects 104. The one or more vehicles 106 may use this information in order to improve safety and reduce the risk of accidents.

[0039] Moving to **FIG. 2** that illustrates a collision avoidance system 200 (same as the system 108 of Fig. 1) for vehicles, in accordance with an embodiment of the present disclosure. It must be understood to a person skilled in art that architecture may also be implemented in various environments, other than as shown in FIG. 2.

[0040] According to an embodiment of the present disclosure, the system 200 may be constituted by one or more sensor units 202 (same as the one or more sensor units 110 of Fig. 1), a controller 204 (same as the controller 112 of Fig. 1), and a communication unit 206 (same as the communication unit 114 of Fig. 1). All the constituent elements of the system 200 illustrated in FIG. 2 are essential constituent elements, but the system 200 may also be implemented by more constituent elements than the constituent elements illustrated in FIG. 2, however the same are not explained for the sake of brevity. All the constituent elements of the system 200 may communicate with each other via wireless/wired communication network.

[0041] Further, the controller 204 are constituted by an identification unit 208, a calculation unit 210, and a determination unit 212. All the constituent elements included in the controller 204 illustrated in FIG. 2 are essential constituent elements, but the controller 204 may be implemented by more constituent elements than the constituent elements illustrated in

FIG. 2. However, the same are not explained for the sake of brevity. All the constituent elements of the controller 204 may communicate with each other via wireless/wired communication network.

[0042] In a non-limiting embodiment of the present disclosure, one or more sensor units 202 may be configured to transmit a signal to a plurality of objects (such as the plurality of objects 104 of Fig. 1) ahead of a vehicle (such as the vehicle 102 of Fig. 1). The one or more sensor units 202 may be, not limited to, Radio Detection and Ranging (RADAR), Light Detection and Ranging (LIDAR), Sound Navigation and Ranging (SONAR), and so forth. The one or more sensor units 202 may be further configured to receive reflected signal from the at least one object 104 based on the signal transmitted to the at least one object 104. The frequency information is associated with a frequency of the transmitted signal and a frequency of the reflected signal. The time information is associated with a time at which the signal is transmitted and a time at which the reflected signal is received.

[0043] In particular, the one or more sensor units 202 may transmit a pulsed signal at a specific frequency, typically in a near-infrared spectrum. The signal transmitted using the one or more sensor units 202 is described below using function 1.

$$E(t)=E_0 \sin 2\pi f t \qquad (1)$$

[0044] where, E(t) may be an amplitude of the transmitted signal as a function of time, E_0 may the peak amplitude of the signal, f may be frequency of the transmitted signal, and t may be time at which the signal may be transmitted.

[0045] The signal transmitted from the one or more sensor units 202 may travel through the air until the signal may strike at least one of the plurality of objects 104 ahead of the vehicle 102. In a specific embodiment, the signals transmitted from the one or more sensor units 202 will only strike those objects among the plurality of objects 104, that fall within the pre-defined line of sight 118 of the vehicle 102. Those skilled in the art will appreciate that the line of sight of the vehicle covers an area which is required for the vehicle 102 to safely travel on a path and does not include objects that fall outside said area. As the transmitted signal may strike the plurality of objects 104 falling within the line of sight 118, the transmitted signal may get reflected from at least one of the plurality of objects 104. The one or more sensor units 202 may receive the reflected signal from the at least one of the plurality of objects 104. The reflected signal received from the at least one of plurality of objects 104 may be described below using function 2.

$$E'(t_n)=E'(n)\sin 2\pi f_n t_n \qquad (2)$$

[0046] Where, $E'(t_n)$ may be the amplitude of the received reflected signal as a function of time from the nth object corresponding to at least one of the plurality of objects 104, E'(n) may be the peak amplitude of the signal reflected from the nth object corresponding to at least one of the plurality of objects 104, f_n may be frequency of the reflected signal from the nth object corresponding to at least one of the plurality of objects 104, and t_n may be a time at which the reflected pulse signal from nth object corresponding to at least one of the plurality of objects 104 is received.

[0047] In a non-limiting embodiment of the present disclosure, the identification unit 208 may identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object.

[0048] In particular, after receiving the reflected signal pulses, in response to the transmitted signals, the identification unit 208, using the functions 1 and 2, discussed above, may determine the frequency of the transmitted signal and the frequency of the reflected signal for at least one of the plurality of objects 104. For example, f may be the frequency of the transmitted signal for at least one of the plurality of objects 104 within the line of the sight 118 of the vehicle 102 and f_n may be frequency of reflected signal from nth object corresponding to the at least one of the plurality of objects 104. The reflected signal frequency from at least one of the plurality of objects, within the line of sight 118 of the vehicle 102, may be different.

[0049] Further, the one or more sensor units 202 may determine for at least one of the plurality of objects 104 a transmitted time of the signal and a reflected time at which reflected signal may be received. For example, t may be transmitted time of the signal for at least one of the plurality of objects 104 and t_n may be reflected time at which reflected pulse signal may be received from nth object corresponding to the at least one of the plurality of objects 104. The reflected time at which the reflected pulse signal may be received from at least one of the plurality of objects 104, within the line of sight 118 of the vehicle 102, may be different.

[0050] In a non-limiting embodiment of the present disclosure, the identification unit 208 may identify a state of the at least one object based on the identified at least one of frequency information and time information, wherein the state of the at least one object indicates the at least one object as stationery or moving. The identification of the state of the at least one object may be further explained in fig. 4 in forthcoming paragraphs.

[0051] In a non-limiting embodiment of the present disclosure, the calculation unit 210 may calculate a time required by the vehicle 102 to encounter the at least one object 104 based on the identified state, the identified frequency information, and the identified time information. The calculation of the time may be further explained in fig. 5 in forthcoming paragraphs.

[0052] In a non-limiting embodiment of the present disclosure, the determination unit 212 may communicate the calculated time with the one or more other vehicles (such as the one or more vehicles 106 of Fig. 1) behind the vehicle 102. The determination unit 212 may communicate the calculated time, along with indication of direction of travel of the at least one object 104, with the one or more vehicles 106 behind the vehicle 102, if the calculated time may greater than the threshold value. The determination unit 212 may communicate, with the one or more vehicles 106 behind the vehicle 102, an indication that the at least one object 104 may travelling ahead of the vehicle 102, if the calculated time may less than the threshold value.

[0053] In particular, the determination unit 212 may receive the calculated time of the object 104 from the calculation unit 210. After the reception of the calculated time, the determination unit 212 may determine for object 104 whether the calculated time may be less than the threshold value. The threshold value may be the smallest integer.

[0054] In an exemplary embodiment of the present disclosure, if the calculated time may be less than the threshold value, then the determination unit 212 may generate an information that the object may be travelling ahead of the vehicle 102 and the travelling direction of the object may be same as the travelling direction of the vehicle 102. The determination unit 212 may provide the information to the communication unit 206. The communication unit 206 may provide an indication to the one or more vehicles 106 that the object may be travelling ahead of the vehicle 102.

[0055] The communication unit 206 may include a display, a speaker, a microphone and so on. In an embodiment, the display may be used for displaying the information that the object may be travelling ahead of the vehicle 102. In an embodiment, the speaker may be used for providing instruction to the driver relating to the object 106 may be travelling ahead of the vehicle 102. In an embodiment, the microphones may be used to provide voice commands relating to the information of the object. The communication unit 206 may be mounted on rear side of the vehicle 102. When the communication unit 206 may provide the information, the one or more vehicles 106 behind the vehicle 102 may be able to receive the information by using the communication unit 206.

[0056] In an exemplary embodiment of the present disclosure, if the calculated time maybe greater than the threshold value, then the determination unit 212 may generate information. The generated information may include the calculated time of the object and type of object.

Additionally, the generated information may include the travelling direction of the object. Additionally, the generated information may include a distance between the object and the vehicle 102. The determined information may provide the generated information to the communication unit 206.

[0057] In a non-limiting exemplary embodiment, the communication unit 206 may provide generated information to the one or more vehicles 106 by one or more means such as displaying the generated information, as shown in figure 3. Precisely Fig. 3 that illustrates the display of the generated information 300 if the calculated time may be greater than the threshold value. The generated information may include a type of vehicle such as a heavy vehicle, light vehicle, and two-wheeler. The heavy vehicle may be, not limited to, lorry, bus, truck, and so forth. The light vehicle may be, not limited to, car, auto, and so forth. Further, the generated information may include the time to encounter the vehicle (i.e., the object 104) by the vehicle 102 and the distance between the vehicle 102 and the vehicle (i.e., the object 104) to be encounter by the vehicle 102. A unit of the time may be second and a unit of the distance may be meter. Furthermore, the generated information may include a travelling direction of the vehicle (i.e., the object 104).

[0058] Moving back to Fig. 2, in order to explain further embodiment related to present disclosure in view of the system 200. In an embodiment, the determination unit 212 may identify situations where the calculated time for at least two objects may exceed a pre-determined threshold value. When such situations arise, the determination unit 212 may generate information for each of the identified objects and provide it to the communication unit 206. However, to ensure that the information is relayed in the most efficient manner possible, the determination unit 212 may assign priority levels to each of the objects based on their respective calculated times.

[0059] For instance, if the calculated time for the first object is shorter than the calculated time for the second object, then the information related to the first object may be assigned as a higher priority than the information related to the second object. This may ensure that the information related to the object with the shorter calculated time is relayed first, which may be more critical or time-sensitive than the other object.

[0060] In a non-limiting exemplary embodiment of the present disclosure, the first object may be travelling towards the vehicle 102 and the second object may be travelling in a same direction of the vehicle 102. The determination unit 212 may determine that the calculated time for both first object and the second object may exceed the threshold value. Thereafter, the determination unit 212 may generate information for both objects and prioritize the information. In order to prioritize the information, the determination unit 212 may compare the calculated times for each object. For example, the determination may determine the calculated time (corresponding to relative velocity of the first object with respect to the vehicle 102) for the first object may be 10 seconds and the calculated time (corresponding to relative velocity of the second object with respect to the vehicle 102) for the second object may be 5 seconds. Based on these calculated times, the determination unit 212 may determine that the relative velocity of the first object is less than the relative velocity of the second object. The determination of the relative velocity may imply that the second object may take less time to encounter the vehicle 102 than the first object. After the determination of the relative velocity, the determination unit 212 may assign the second object a higher priority than the first object, since the second object may be expected to reach the vehicle sooner. Therefore, the generated information related to the second object may be relayed first to the communication unit 206, followed by the information related to the first object.

[0061] The communication unit 206 may provide the generated information to the one or more vehicles 106. The communication unit 206 may provide the generated information same as mentioned in the previous paragraph. By performing the process mentioned in the description of the Fig. 2, the system 200 may reduce hazardous situation of overtaking by providing real-time information about the vehicle in front of them. Further, the system 200 may reduce the risk of accidents and improve safety on the road by providing visibility of the ongoing and oncoming traffic.

[0062] Moving on to FIG. 4 that illustrates collision avoidance system 400 (same as the system 200 of Fig. 2) for vehicles, in accordance with an embodiment of the present disclosure. As discussed in forgoing paragraphs in view of description of figure 2, the system 400 may include an identification unit 402 (same as the identification unit 208 of Fig. 2) that may be configured to identify state of the at least one object. The constituent elements of the identification unit 402 may include one or more sub-units including but not limited to a velocity identification unit 404 and a comparison unit 406. All the constituent elements of the identification unit 402 illustrated in FIG. 4 are essential constituent elements, and the identification unit 402 may be implemented by more constituent elements than the constituent elements illustrated in FIG. 4, however the same are not explained for the sake of brevity. All the constituent elements of the identification unit 402 may communicate with each other via wireless/wired communication network.

[0063] In a non-limiting embodiment of the present disclosure, the velocity identification unit 404 may identify velocity of the at least one object 104 based on the identified frequency information and time information.

[0064] In particular, after identifying the frequency and time information related to the plurality of the objects 104, the velocity identification unit 404 may determine Doppler shift by receiving the identifying frequency and time information. In order to determine the Doppler shift, the velocity identification unit 404 may determine the frequency of the transmitted signal and the frequency of the reflected signal for at least one of the plurality of objects 104, within the line of sight 118 of the vehicle 102, by using the received information. After that, the velocity identification unit 404 may determine the Doppler shift by subtracting the reflected frequency with the transmitted frequency for at least one of the plurality of objects 104. The function 3 by using functions 1 and 2 may represent the doppler shift as shown below.

$$F_d(n)=f - f_n \qquad (3)$$

[0065] Where, $F_d(n)$ is the Doppler shift for nth object corresponding to the at least one of the plurality of objects 104.

[0066] Simultaneously during the identification of the Doppler shift, the velocity identification unit 404 may determine a time difference for each of the plurality of objects 104. The time different (i.e. round-trip time) may be a difference between the time at which the signal may be transmitted and the time at which reflected signal may be received. The function 4 may represent the round-trip time as shown below.

$$T_d(n)=t-t_n \qquad (4)$$

[0067] Where, $T_d(n)$ is the round-trip time for nth object corresponding to the at least one of the plurality of objects 104.

[0068] After determining both the round-trip time and the Doppler shift, the velocity identification unit 404 may determine velocity of each of the plurality of objects 104 by using function 5 as shown below.

$$V(n) = \frac{(2 * f * c)}{T_d(n) * F_d(n)} \qquad (5)$$

[0069] Where, V(n) may be velocity of the nth object corresponding to the at least one of the plurality of objects 104, f may be frequency of the transmitted signal, and c may be speed of light.

[0070] In a non-limiting embodiment of the present disclosure, the comparison unit 406 may be configured to compare the identified velocity of at least one object 104 with velocity of the vehicle (such as the vehicle 102 of Fig. 1). The comparison unit 406 may be configured to identify the state of the at least one object 104 based on the comparison.

[0071] In particular, the comparison unit 406 may receive the velocity of at least one of the plurality of objects 104, within the line of sight 118 of the vehicle 102, from the velocity identification unit 404. After receiving the velocity of at least one of the plurality of objects 104, the comparison unit 406 may receive the velocity of the vehicle 102 from an accelerometer of the vehicle 102. The comparison unit 406 and the accelerometer of the vehicle 102 may communicate with each other via wireless/wired communication network.

[0072] Upon receiving the velocity of the vehicle 102, the comparison unit 406 may compare the velocity of at least one of the plurality of objects 104 with the velocity of the vehicle 102. The comparison unit 406, after the comparison, may identify whether the velocity of at least of the plurality of objects 104 may be equal to the velocity of the vehicle 102 or not.

[0073] In an exemplary embodiment of the present disclosure, if the velocity of the object may be not equal to the velocity of the vehicle 102, then the comparison unit 406 may determine whether the velocity of the object may be outside the deviation of the velocity of the vehicle 102. If the velocity of the object 104 may be outside the deviation, then the object may be a moving object. The deviation may be between the +10% of the velocity of the vehicle 102 and -10% of the velocity of the vehicle 102.

[0074] In an exemplary embodiment of the present disclosure, if the velocity of the object may be equal to the velocity of the vehicle 102 or within the deviation of the velocity of the vehicle 102, then the comparison unit 406 may determine that the object may be stationary object. Considering an exemplary scenario to illustrate the prediction of object either as a stationary or moving object, reference shall be made to the forthgoing paragraphs.

[0075] Let's assume there is a vehicle 102 equipped with a 77 GHz radar, traveling at a speed of 22.2 m/s. From the perspective of the vehicle 102, there are three objects located equidistantly. Doppler shift and time of flight for the first object may be 77.0000185 GHz and $2x10^{-6}$s, respectively. Doppler shift and time of flight for the second object may be 77.0000114 GHz and $2x10^{-6}$s respectively. Doppler shift and time of flight for the third object may be 76.9999972 GHz and $2x10^{-6}$s. Using the provided information and Function 5, the system 400 may identify that the first object and the third object may be moving objects and the second object may identified as a stationary object since its speed may be calculated to be 22 m/s, which is equal to the speed of the vehicle. This exemplary embodiment is only to understand a scenario of the prediction of object. However, the present invention is not limited to only this exemplary embodiment.

[0076] Moving on to FIG. 5 that illustrates a collision avoidance system 500 (same as the system 200 of Fig. 2) for vehicles, in accordance with an embodiment of the present disclosure. As discussed in forgoing paragraphs in view of description of figure 2, the system 500 may include a calculation unit 502 (same as the calculation unit 210 of Fig. 2) that may be configured to calculate a time required by the vehicle (such as the vehicle 102 of Fig. 1) to encounter the at least one object (such as the plurality of objects 104 of Fig. 1) and determination unit 504 (same as the determination unit 212 of Fig. 2) may be configured to communicate with the communication unit (such as the communication unit 206 of Fig. 2) based on the calculated time.

[0077] The calculation unit 502 may receive the identified frequency and time information of the objects 104 from the identification unit (such as the identification unit 208 of Fig. 2). Simultaneously, the calculation unit 502 may receive the identified state of the at least one of the plurality of objects 104, within the line of sight 118 of the vehicle 102, from the identification unit 208. After receiving the state information, the calculation unit 502 may calculate the time for only moving objects. The calculation unit 502 may calculate the time required by the vehicle 102 to encounter the at least one moving object. The calculation unit 502 may be calculated for the moving objects by using the received information related to moving objects. The generation of function which may describe about the time to encounter the moving object is described below:

[0078] Let us assume the time to encounter the moving objects may be mentioned in function 6 as shown below.

$$\mathrm{T(n)} = \frac{d(n)}{v(n)} \qquad (6)$$

[0079] Where, d(n) may be displacement of nth object from the vehicle 102 and v(n) may be velocity of the nth object corresponding to the at least one of the plurality of objects 104. The d(n) may be calculated as shown below.

$$\mathrm{d(n)} = \frac{c * T_d(\mathrm{n})}{2} \qquad (7)$$

[0080] Now to calculate velocity of object, Doppler function may be used. The velocity of the object from the Doppler function as shown below.

$$\mathrm{v(n)} = \frac{F_d(\mathrm{n})}{2f} \qquad (8)$$

[0081] Where, Where, $F_d(n)$ is the Doppler shift for nth object, f we would use doppler frequency shift, f may be the frequency of the transmitted pulse, and v(n) may velocity of nth object corresponding to the at least one of the plurality of objects 104.

[0082] Finally, by using the functions 6-8, the time to encounter the object may be as shown below in function 9.

$$T(n) = \frac{T_d(\mathrm{n})}{\frac{F_d(\mathrm{n})}{f}} \qquad (9)$$

[0083] Where, T(n) is time to encounter nth object. The calculation unit 502 may calculate the time for the moving objects by using function 9 and the information received from the identification unit 208. After calculating the time for the at least one of moving objects, the calculation unit 502 may transmit the calculated time for the moving objects to the determination unit 504.

[0084] In a non-limiting embodiment of the present disclosure, the determination unit 504 may compare the calculated time with a threshold value and communicate one of the calculated time and an indication information, based on the comparison of time.

[0085] In particular, the determination unit 504 may receive the calculated time of the moving objects from the calculation unit 502. The determination unit 504 may compare the calculated time for at least one the moving objects with a threshold value. The threshold value may be the smallest natural number. The determination unit 504 may compare the calculated time for at least one of the moving objects with the threshold value. After the comparison, if the calculated time may be less than the threshold value, the determination unit 504 may provide an indication information to the communication unit 206 that the at least one of the moving objects may be travelling ahead of the vehicle 102. If the calculated time may be greater than the threshold value, the determination unit 504 may calculate the distance between the at least one of the moving objects and the vehicle 102 and provide the time that may indicate a time required by the vehicle 102 to encounter the at least one of the moving objects and the distance between the at least one of the moving objects and the vehicle 102. Additionally, the determination unit 504 may provide the travelling direction of the at least one of the moving objects, if the calculated time of respective moving object may be greater than the threshold value.

[0086] FIG. 6 is a flowchart showing steps of a collision avoidance method 600 for vehicles by a system (such as a system 200 of Fig. 2). The method 600 starts at step 602, at a step 602 the method 600 may include transmitting a signal to a plurality of objects (such as the plurality of objects 104 of Fig. 1) ahead of a vehicle (such as the vehicle 102 of Fig. 1). At the step 602 the method may further include receiving reflected signal from the at least one object 104 based on the signal transmitted to the at least one object 104. In an exemplary aspect, one or more sensor units 202 of Fig. 2 of a system 200 of Fig. 2 may be configured to carry out the process steps disclosed in step 602.

[0087] At a step 604, the method 600 may include identifying at least one of frequency information and time information associated with at least one object, among the plurality of objects 104, based on the signal transmitted to the at least one object. The frequency information is associated with the frequency of the transmitted signal and the frequency of the reflected signal. The time information is associated with a time at which the signal is transmitted and a time at which the reflected signal is received. In an exemplary aspect, an identification unit 208 of Fig. 2 of the system 200 may be configured to carry out the process steps disclosed in step 604.

[0088] At a step 606, the method 600 may include identifying a state of the at least one object based on the identified at least one of frequency information and time information, wherein the state of the at least one object indicates the at least one object as stationery or moving. The identification of the state of the at least one object may include identifying velocity of the at least one object based on the identified frequency information and time information. Sequentially, the identification of the state of the at least one object may include comparing the identified velocity of the at least one object with velocity of the vehicle and identifying the state of the at least one object based on the comparison. In an exemplary embodiment of the present disclosure, if the velocity of the object may be not equal to the velocity of the vehicle 102, then the method 600 may determine whether the velocity of the object may be outside the deviation of the velocity of the vehicle 102. If the velocity of the object 104 may be outside the deviation, then the object may be a moving object. The deviation may be between the +10% of the velocity of the vehicle 102 and -10% of the velocity of the vehicle 102. In an exemplary embodiment of the present disclosure, if the velocity of the object may be equal to the velocity of the vehicle 102 or within the deviation of the velocity of the vehicle 102, then the method 600 may determine that the object may be stationary object. In an exemplary aspect, the identification unit 208 of the system 200 may be configured to carry out the process steps disclosed in step 606.

[0089] At a step 608, the method 600 may include calculating a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information. The calculation of the time may include calculating the time required by the vehicle to encounter the at least one object based on the identification that the least one object is the moving object. In an exemplary aspect, a calculation unit 210 of Fig. 2 of the system 200 may be configured to carry out the process steps disclosed in step 608.

[0090] At a step 610, the method 600 may include communicating the calculated time with one or more other vehicles behind the vehicle. The communication of the calculated time may include comparing the calculated time with a threshold value. Sequentially, communication of the calculated time may include communicating the calculated time, along with indication of direction of travel of the at least one object, with the one or more vehicles behind the vehicle, if the calculated time is greater than the threshold value. Additionally, communication of the calculated time may include communicating, with the one or more vehicles behind the vehicle, an indication that the at least one object is travelling ahead of the vehicle, if the calculated time is less than the threshold value. In an exemplary aspect, a determination unit 212 of Fig. 2 of the system 200 may be configured to carry out the process steps disclosed in step 610.

[0091] The collision avoidance method 600 for vehicles may reduce hazardous situation of overtaking by providing real-time information about the vehicle in front of them. Further, the method 600 may reduce risk of accidents and improve safety on the road by providing visibility of the ongoing and oncoming traffic.

[0092] The foregoing method descriptions and the process flow diagrams are provided merely as illustrative examples and are not intended to require or imply that the steps of the various embodiments must be performed in the order presented. As will be appreciated by one of skill in the art the order of steps in the foregoing embodiments may be performed in any order. Words such as “thereafter,” “then,” “next,” etc. are not intended to limit the order of the steps; these words are simply used to guide the reader through the description of the methods. Further, any reference to claim elements in the singular, for example, using the articles “a,” “an” or “the” is not to be construed as limiting the element to the singular.

[0093] As used herein, the term unit may be implemented in hardware and/or in software. If the unit is implemented in hardware, the unit may be configured as a device, e.g., as a computer or as a processor or as a part of a system, e.g., a computer system. If the unit is implemented in software, the unit may be configured as a computer program product, as a function, as a routine, or as a program code.

[0094] By way of example, an element, or any portion of an element, or any combination of elements may be implemented with a "controller" that includes one or more processors. Examples of processors include microprocessors, microcontrollers, digital signal processors

(DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

[0095] In one or more example embodiments, the functions described herein may be implemented by special-purpose hardware or a combination of hardware programmed by firmware or other software. In implementations relying on firmware or other software, the functions may be performed as a result of execution of one or more instructions stored on one or more non-transitory computer-readable media and/or one or more non-transitory processor-readable media. These instructions may be embodied by one or more processor-executable software modules that reside on the one or more non-transitory computer-readable or processor-readable storage media. Non-transitory computer-readable or processor-readable storage media may in this regard comprise any storage media that may be accessed by a computer or a processor. By way of example but not limitation, such non-transitory computer-readable or processor-readable media may include random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), FLASH memory, disk storage, magnetic storage devices, or the like. Disk storage, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray disc™, or other storage devices that store data magnetically or optically with lasers. Combinations of the above types of media are also included within the scope of the terms non-transitory computer-readable and processor-readable media. Additionally, any combination of instructions stored on the one or more non-transitory processor-readable or computer-readable media may be referred to herein as a computer program product.

[0096] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of teachings presented in the foregoing descriptions and the associated drawings. Although the figures only show certain components of the apparatus and systems described herein, it is understood that various other components may be used in conjunction with the supply management system. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Moreover, the steps in the method described above may not necessarily occur in the order depicted in the accompanying diagrams, and in some cases one or more of the steps depicted may occur substantially simultaneously, or additional steps may be involved. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

[0097] The various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention. Table 1 as shown below represents the list of component associated with the present disclosure along with corresponding reference numeral.

[0098] **<u>Table 1:</u>**

Reference Numeral	Component
100	Environment Architecture
102	Vehicle
104	Objects
106	Vehicles other than vehicle 102
108, 200, 400, 500	Collision Avoidance System
110, 202	Sensor Units
112, 204	Controller
114, 206	Communication Unit
116	Visual Field of Vehicles 106
118	Line of Sight of Vehicle 102
208, 402	Identification Unit
210, 502	Calculation Unit
212, 504	Determination Unit
300	Display of Generated Information
404	Velocity Identification Unit
406	Comparison Unit

WE CLAIM:

1. A collision avoidance system (200) for vehicles, comprising:

one or more sensor units (202) mounted on a vehicle and configured to transmit a signal to a plurality of objects ahead of the vehicle; and

a controller (204) operatively coupled to the one or more sensor units (202) and configured to:

identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object;

identify a state of the at least one object based on the identified at least one of frequency information and time information, wherein the state of the at least one object indicates the at least one object as stationery or moving;

calculate a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information; and

communicate the calculated time with one or more other vehicles behind the vehicle.

2. The system (200) as claimed in claim 1, wherein the one or more sensor units (202) are further configured to receive reflected signal from the at least one object based on the signal transmitted to the at least one object, wherein the frequency information is associated with a frequency of the transmitted signal and a frequency of the reflected signal, and wherein the time information is associated with a time at which the signal is transmitted and a time at which the reflected signal is received.

3. The system (200) as claimed in claim 1, wherein the controller (204) is further configured to:

identify velocity of the at least one object based on the identified frequency information and time information;

compare the identified velocity of at least one object with velocity of the vehicle; and

identify the state of the at least one object based on the comparison.

4. The system (200) as claimed in claim 3, wherein the controller (204) is further configured to:

calculate the time required by the vehicle to encounter the at least one object based on the identification that the least one object is the moving object;

compare the calculated time with a threshold value; and

communicate one of the calculated time and an indication information including direction of travel, based on the comparison of time.

5. The system (200) as claimed in claim 4, wherein the controller (204) is configured to:

communicate the calculated time, along with the indication of direction of travel of the at least one object, with the one or more vehicles behind the vehicle, if the calculated time is greater than the threshold value; and

communicate, with the one or more vehicles behind the vehicle, an indication that the at least one object is travelling ahead of the vehicle, if the calculated time is less than the threshold value.

6. A collision avoidance method (600) for vehicles, comprising:

transmitting (602) a signal to a plurality of objects ahead of a vehicle;

identifying (604) at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object;

identifying (606) a state of the at least one object based on the identified at least one of frequency information and time information, wherein the state of the at least one object indicates the at least one object as stationery or moving;

calculating (608) a time required by the vehicle to encounter the at least one object based on the identified state, the identified frequency information, and the identified time information; and

communicating (610) the calculated time with one or more other vehicles behind the vehicle.

7. The method (600) as claimed in claim 6, further comprising receiving (602) reflected signal from the at least one object based on the signal transmitted to the at least one object, wherein the frequency information is associated with a frequency of the transmitted signal and a frequency of the reflected signal, and wherein the time information is associated with a time at which the signal is transmitted and a time at which the reflected signal is received.

8. The method (600) as claimed in claim 6, wherein the identification of the state of the at least one object further comprises:

identifying (606) velocity of the at least one object based on the identified frequency information and time information;

comparing (606) the identified velocity of the at least one object with velocity of the vehicle; and

identifying (606) the state of the at least one object based on the comparison.

9. The method (600) as claimed in claim 8, further comprising:

calculating (608) the time required by the vehicle to encounter the at least one object based on the identification that the least one object is the moving object;

comparing (610) the calculated time with a threshold value; and

communicating (610) one of the calculated time and an indication information including direction of travel, based on the comparison of time.

10. The method (600) as claimed in claim 9, further comprising:

communicating (610) the calculated time, along with the indication of direction of travel of the at least one object, with the one or more vehicles behind the vehicle, if the calculated time is greater than the threshold value; and

communicating (610), with the one or more vehicles behind the vehicle, an indication that the at least one object is travelling ahead of the vehicle, if the calculated time is less than the threshold value.

Dated this 9th day of June 2023

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ABSTRACT

COLLISION AVOIDANCE SYSTEM AND METHOD FOR VEHICLES

The present invention describes a collision avoidance system (200) for vehicles. The system (200) comprises one or more sensor units (202) mounted on a vehicle and configured to transmit a signal to a plurality of objects ahead of the vehicle. The system (200) further comprises a controller (204) operatively coupled to the one or more sensor units (202) and configured to identify at least one of frequency information and time information associated with at least one object, among the plurality of objects, based on the signal transmitted to the at least one object. The controller (204) may be configured to calculate a time required by the vehicle to encounter the at least one object based on the identified frequency information, and the identified time information. Furthermore, the controller (204) may be configured to communicate the calculated time with one or more other vehicles behind the vehicle.

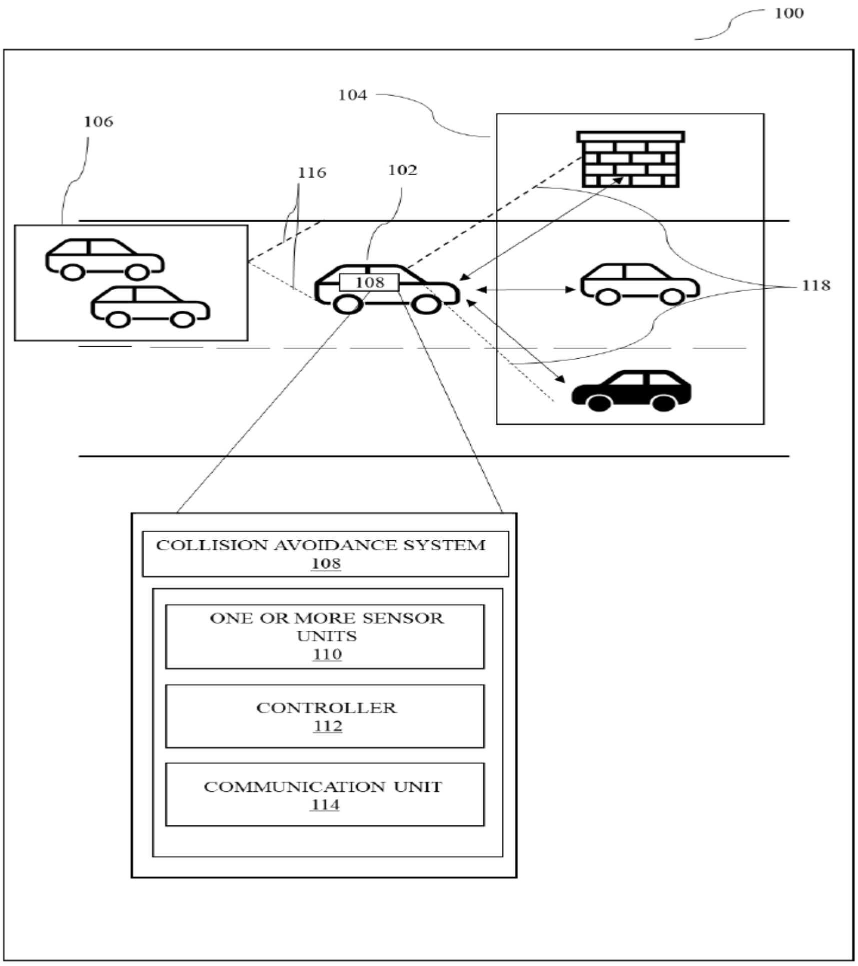

FIG. 1

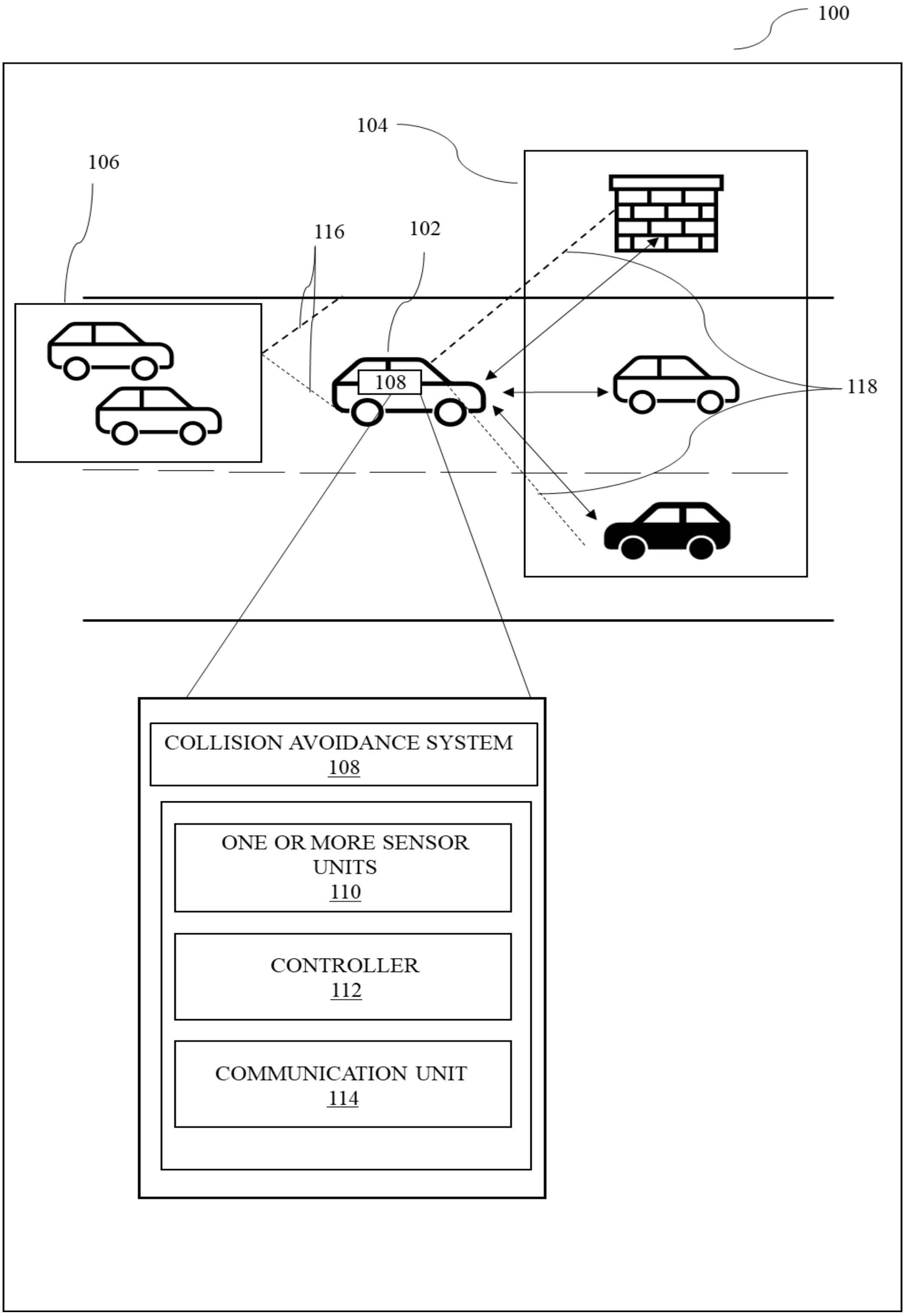

FIG. 1

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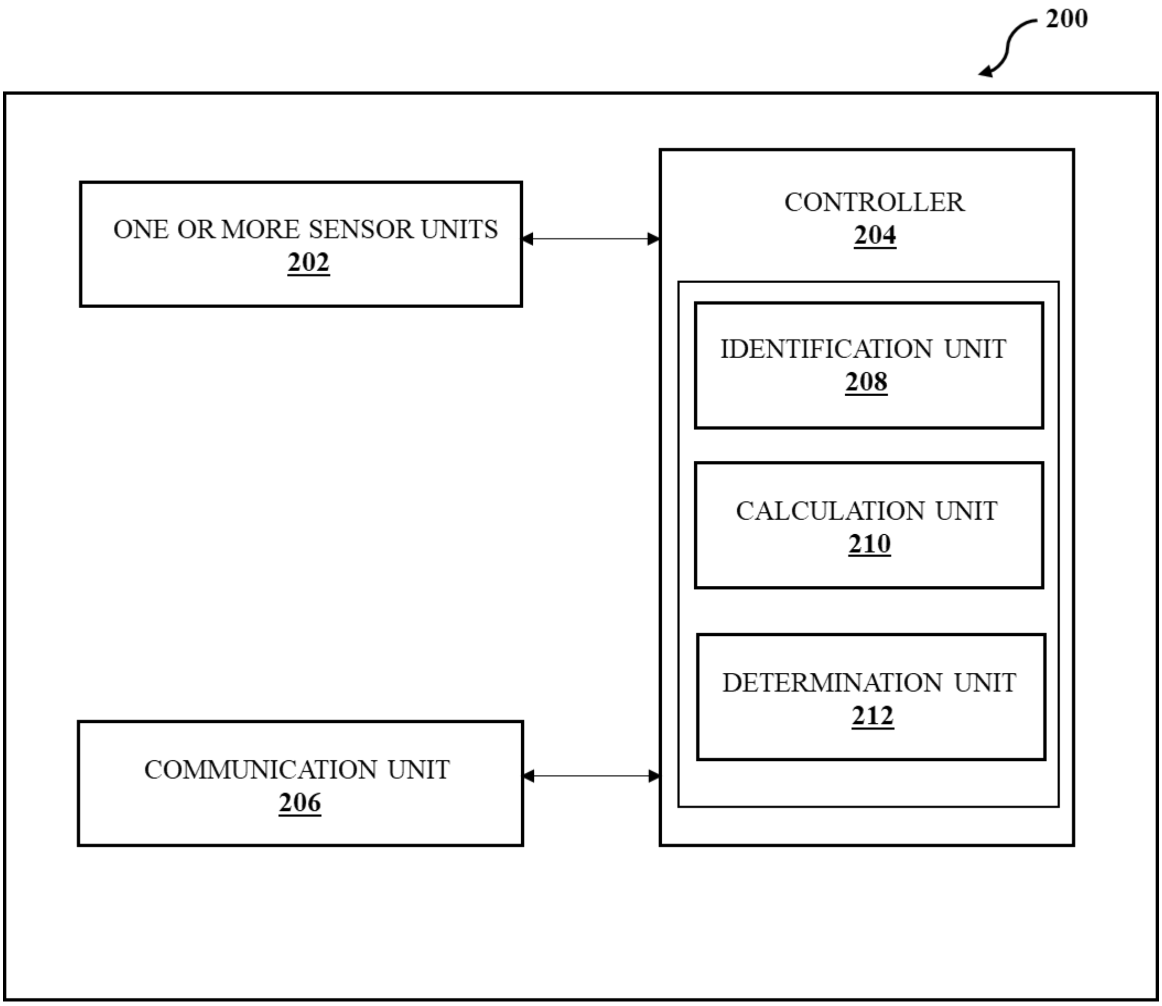

FIG. 2

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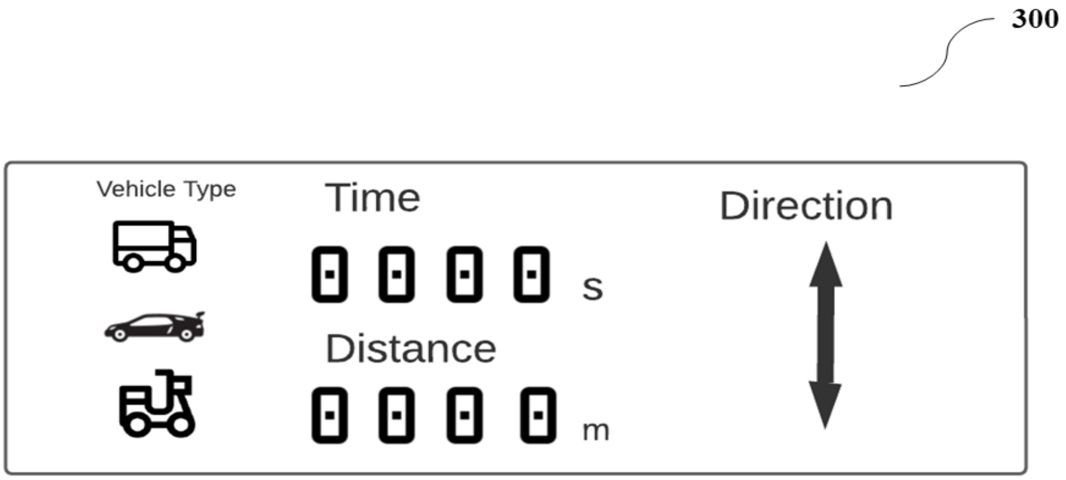

FIG. 3

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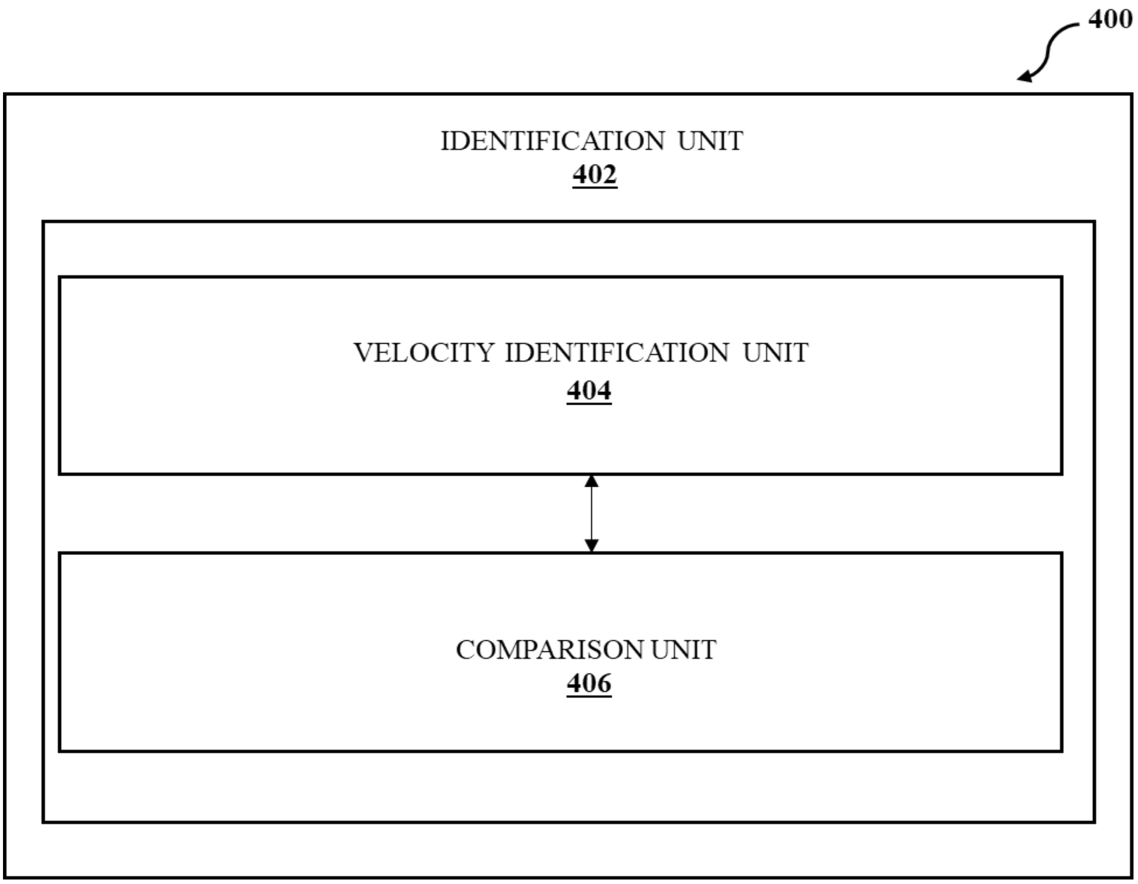

FIG. 4

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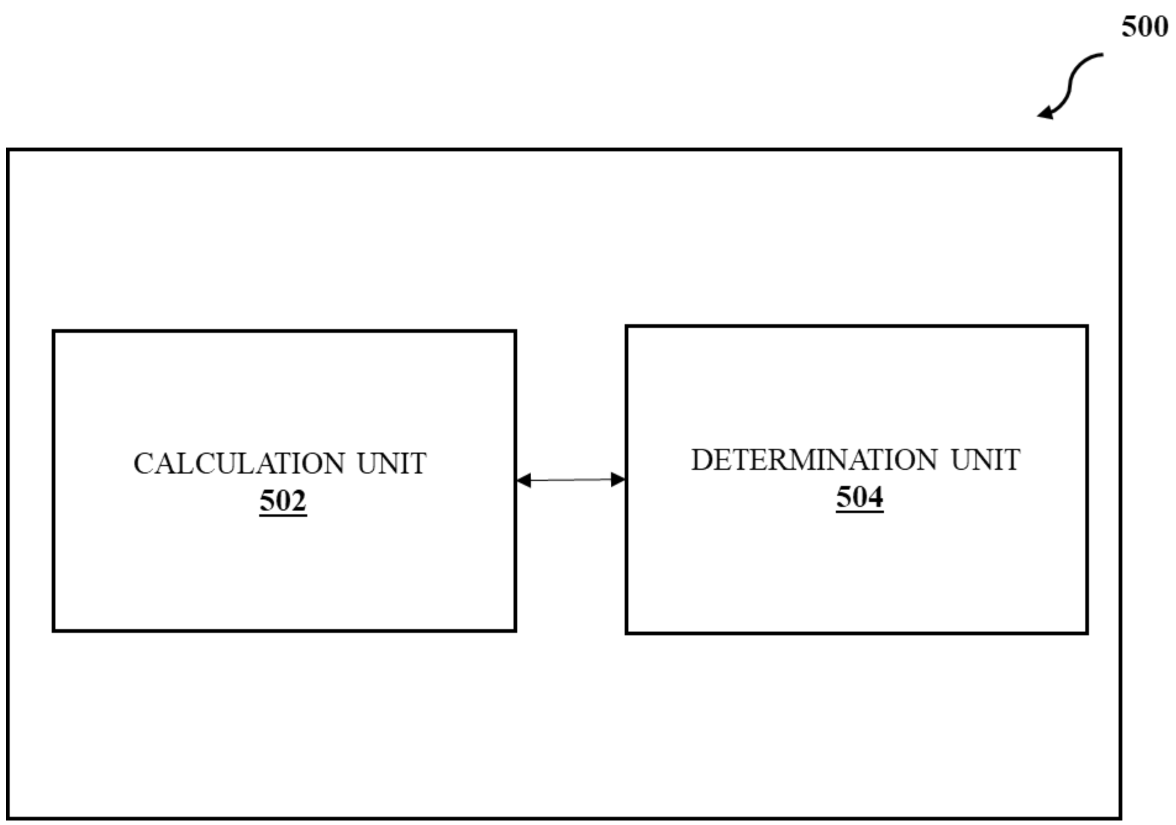

FIG. 5

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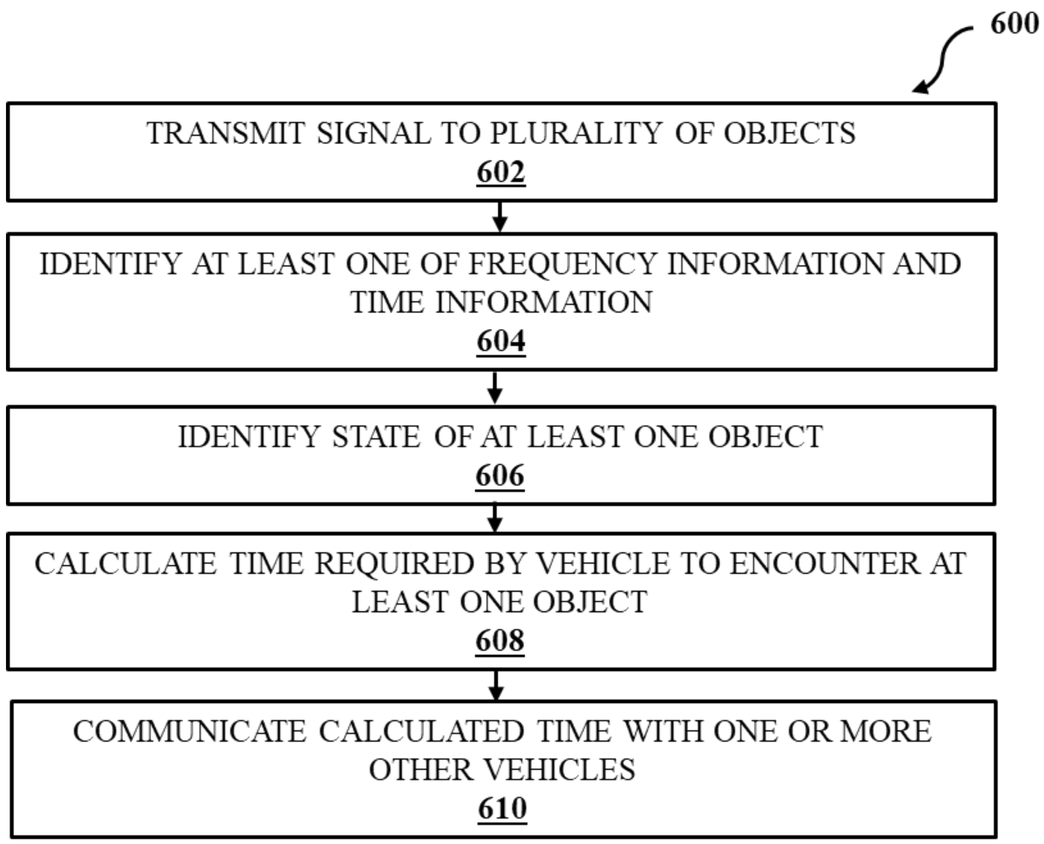

FIG. 6

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