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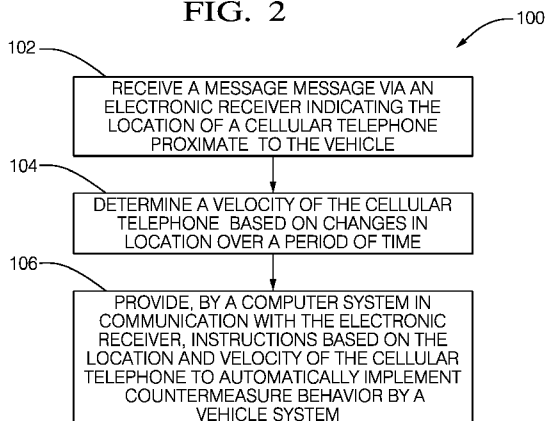
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(54) **Title:** METHOD OF AUTOMATICALLY CONTROLLING AN AUTONOMOUS VEHICLE BASED ON CELLULAR TELEPHONE LOCATION INFORMATION

FIG. 2



(57) **Abstract:** A method (100) of operating a vehicle (10), such as an autonomous vehicle, including the steps of receiving a message via an electronic receiver indicating a cellular telephone location (26) proximate to the vehicle (10) (102), determining a cellular telephone velocity (28) of the based on changes in the cellular telephone location (26) over a period of time (104), and providing, by a computer system in communication with said electronic receiver, instructions based on the cellular telephone location (26) and the cellular telephone velocity (28) to automatically implement countermeasure behavior by a vehicle system (106).



METHOD OF AUTOMATICALLY CONTROLLING AN AUTONOMOUS VEHICLE BASED ON CELLULAR TELEPHONE LOCATION INFORMATION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit under 35 U.S.C. § 119(e) of U.S.

Provisional Patent Application No. 62/112792, filed 06-Feb-2015, the entire disclosure of which is hereby incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

[0002] The invention relates to a method of automatically operating a vehicle, more particularly to a method of automatically controlling the operation of an autonomous vehicle based on cellular telephone location information received by the autonomous vehicle.

BACKGROUND OF THE INVENTION

[0003] Some vehicles are configured to operate automatically so that the vehicle navigates through an environment with little or no input from a driver. Such vehicles are often referred to as “autonomous vehicles”. These autonomous vehicles typically includes one or more forward looking sensors, such as visible light cameras, infrared cameras, radio detection and ranging (RADAR) or laser imaging, detecting and ranging (LIDAR) that are configured to sense information about the environment. The autonomous vehicle may use the information from the sensors(s) to navigate through the environment. For example, the sensor(s) may be used to determine whether pedestrians are located in the vicinity of the autonomous vehicle and to determine the speed and

direction, i.e. the velocity, in which the pedestrians are traveling. However, the pedestrians may be obscured to the sensor by weather conditions, roadside foliage, or other vehicles. Because portions of the driving environment may be obscured to environmental sensors, such as forward looking sensors, it is desirable to supplement sensor inputs.

[0004] Autonomous vehicle systems have been proposed and implemented that supplement sensors inputs from data communicated over a short range radio network, such as a Dedicated Short Range Communication (DSRC) transceiver, from other nearby vehicles. The transmissions from these nearby vehicles include information regarding the location and velocity of the nearby vehicles. As used herein, velocity refers to both the speed and direction of travel. However, not all objects of interest in the driving environment include DSRC transceivers, e.g. pedestrians, cyclists, older vehicles. Therefore, a more reliable method of determining the velocity of nearby pedestrians, cyclists, and/or older vehicles is desired.

[0005] The subject matter discussed in the background section should not be assumed to be prior art merely as a result of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may also be inventions.

BRIEF SUMMARY OF THE INVENTION

[0006] In accordance with an embodiment of the invention, a method of automatically operating a vehicle is provided. The method includes the steps of:

- receiving a message indicating the location of a cellular telephone proximate to the vehicle,
- determining a velocity of the cellular telephone based on changes in location over a period of time, and
- providing, by a computer system in communication with said electronic receiver, instructions based on the location and velocity of the cellular telephone to automatically implement countermeasure behavior by a vehicle system.

[0007] In the case wherein the vehicle system is a braking system, the method may further include the steps of:

- determining a vehicle velocity;
- comparing the vehicle velocity with the cellular telephone velocity,
- determining whether the concurrence between the vehicle location and the cellular telephone location will occur, and
- providing, by the computer system, instructions to the braking system to apply vehicle brakes to avoid the concurrence if it is determined that the concurrence between the vehicle location and the cellular telephone location will occur.

[0008] In the case wherein the vehicle system is a steering system, the method may include the steps of:

- determining a vehicle velocity,
- comparing the vehicle velocity with the cellular telephone velocity,

- determining whether the concurrence between the vehicle location and the cellular telephone location will occur,
- determining a steering angle to avoid the concurrence if it is determined that the concurrence between the vehicle location and the cellular telephone location will occur, and
- providing, by the computer system, instructions to the steering system to adjust a vehicle path based on the steering angle.

[0009] In the case wherein the vehicle system is a powertrain system, the method may further include the steps of:

- determining a vehicle velocity,
- comparing the vehicle velocity with the cellular telephone velocity,
- determining whether the concurrence between the vehicle location and the cellular telephone location will occur, and
- providing, by the computer system, instructions to the powertrain system to adjust the vehicle velocity to avoid the concurrence if it is determined that the concurrence between the vehicle location and the cellular telephone location will occur.

[0010] In the case wherein the vehicle system is a powertrain system and the cellular telephone is carried by another vehicle, the method may include the steps of:

- determining a vehicle velocity,
- comparing the vehicle velocity with the cellular telephone velocity,
- determining whether the vehicle velocity and the cellular telephone velocity are substantially parallel and in a same direction,

- determining whether a concurrence between the vehicle location and the cellular telephone location will occur, and
- providing, by the computer system, instructions to the powertrain system to adjust the vehicle velocity maintain a following distance if it is determined that the vehicle velocity and the cellular telephone velocity are substantially parallel and in the same direction.

[0011] The cellular telephone may be carried by a pedestrian or may be carried by another vehicle.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0012] The present invention will now be described, by way of example with reference to the accompanying drawings, in which:

[0013] Fig. 1 is a diagram of an operating environment for a vehicle according to one embodiment;

[0014] Fig. 2 is flowchart of a method of operating a vehicle according to one embodiment; and

[0015] Fig. 3 is flowchart of optional steps in the method of Fig. 2 according to one embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Presented herein is a method of operating an automatically controlled or “autonomous” vehicle wherein the autonomous vehicle receives electronic messages from nearby cellular telephones contain information regarding the location of the cellular

telephone. The autonomous vehicle receives this information and a computer system on-board the autonomous vehicle then determines the location and velocity of the cellular telephone and since the cellular telephone is likely carried by a pedestrian, cyclist, or another vehicle, the computer system determines the location and velocity of nearby pedestrians, cyclists, or/or other vehicles. The computer system then determines whether countermeasures are required by the autonomous vehicle to avoid a collision and sends instructions to the relevant vehicle system, e.g. the braking system, to perform the appropriate actions. Countermeasures may be used to avoid a collision with another vehicle, pedestrian, or cyclist. Countermeasures may include activating the braking system to stop or slow the autonomous vehicle,

[0017] Fig. 1 illustrates a non-limiting example of an environment in which an automatically controlled vehicle 10, hereinafter referred to as the autonomous vehicle 10, may operate. The autonomous vehicle 10 includes a computer system connected to a wireless receiver that is configured to receive electronic messages 12 containing location information from nearby cellular telephones 14. The receiver may be configured to receive the location information directly from the nearby cellular telephones 14 or the receiver may receive the location information in near-real time from a central processor and transmitter (not shown) containing a database of cellular telephone location information based on the current location 16 of the autonomous vehicle 10 reported to the central processor by an electronic message from the autonomous vehicle 10. The location information for the cellular telephones 14 may be generated by a Global Positioning Satellite (GPS) receiver (not shown) in the cellular telephone 14, may be generated by the cellular telephone network based on signal time of arrival (TOA) to

several cellular phone towers, or may be based on a hybrid method using both GPS and TOA. These and other methods of determining cellular telephone location are well known to those skilled in the art.

[0018] The computer system is interconnected to various sensors and actuators (not shown) responsible for controlling the various systems in the autonomous vehicle 10, such as the braking system, the powertrain system, and the steering system. The computer system may be a central processing unit or may be several distributed processors communication over a communication bus, such as a Controller Area Network (CAN) bus.

[0019] The autonomous vehicle 10 further includes a locating device configured to determine both the current location 16 of the autonomous vehicle 10 as well as the vehicle velocity 18. As used herein, vehicle velocity 18 indicates both vehicle speed and direction of vehicle travel. An example of such a device is a Global Positioning System (GPS) receiver. The autonomous vehicle 10 also includes a mapping system to determine the current location 16 of the autonomous vehicle 10 relative to the roadway. The design and function of these location devices and mapping systems are well known to those skilled in the art.

[0020] Receiving location information from cellular telephones 14 provides some advantages over receiving location information from a dedicated short range transceiver, such as a Dedicated Short Range Communication (DSRC) transceiver in a scheme typically referred to as Vehicle to Vehicle communication (V2V). One advantage is that cellular phone with location capabilities are currently more ubiquitous than DSRC transceivers, since most vehicle drivers and/or vehicle passenger are in possession of a

cellular telephone 14. cellular telephones 14 with location technology are also built into many vehicles, e.g. ONSTAR® communication systems in vehicles manufactured by the General Motors Company or MBRACE® communication systems in vehicles marketed by Mercedes-Benz USA, LLC. Another advantage is that cellular telephones 14 that report location information to the autonomous vehicle 10 are also carried by pedestrians 20 and cyclists 22, allowing the autonomous vehicle 10 to automatically take countermeasures based on their location. pedestrians 20 and cyclists 22 are unlikely to carry a dedicated transceiver, such as a DSRC transceiver. Location information from cellular telephones 14 may also be reported from non-roadway vehicles. For example, the location and velocity of a locomotive train (not shown) crossing the path of the autonomous vehicle 10 at a railroad crossing may be detected by the transmissions of a cellular telephone carried by the engineer or conductor on the locomotive.

[0021] As shown in Fig. 1, a cellular telephone 14 may be carried e.g. by a pedestrian 20, a cyclist 22, or another vehicle 24. This cellular telephone 14 transmits location information that may be used to infer the location 26 of the pedestrian 20, the cyclist 22, or the other vehicle 24. After receiving at least two messages from the cellular telephone 14, the computer system can calculate the velocity 28 of the cellular telephone 14 and infer the velocity of the pedestrian 20, cyclist 22, or other vehicle 24. Based on the location 26 and velocity 28 of the cellular telephone 14 and the current location 16 and velocity 18 of the autonomous vehicle 10, the computer system can send instructions to the various vehicle systems, such as the braking system, the steering system, and/or the powertrain system to take countermeasures to avoid convergence of the path of the cellular telephone 14 and the autonomous vehicle 10 that would result in a collision

between the autonomous vehicle 10 and the pedestrian 20, the cyclist 22, or the other vehicle 24.

[0022] Fig. 2 illustrates a non-limiting example of a method 100 of automatically operating an autonomous vehicle 10. The method 100 includes STEP 102, RECEIVE A MESSAGE VIA AN ELECTRONIC RECEIVER INDICATING THE LOCATION OF A CELLULAR TELEPHONE PROXIMATE TO THE VEHICLE. STEP 102 includes receiving a message indicating the current location of a cellular telephone 14 proximate to the autonomous vehicle 10 via an electronic receiver within the autonomous vehicle 10. As used herein, proximate means within a radius 500 meters or less.

[0023] STEP 104, DETERMINE A VELOCITY OF THE CELLULAR TELEPHONE BASED ON CHANGES IN LOCATION OVER A PERIOD OF TIME, includes determining a velocity 28 of the cellular telephone 14 based on changes in location 26 over a period of time.

[0024] STEP 106, PROVIDE, BY A COMPUTER SYSTEM IN COMMUNICATION WITH THE ELECTRONIC RECEIVER, INSTRUCTIONS BASED ON THE LOCATION AND VELOCITY OF THE CELLULAR TELEPHONE TO AUTOMATICALLY IMPLEMENT COUNTERMEASURE BEHAVIOR BY A VEHICLE SYSTEM, includes providing instructions to a vehicle system to automatically implement countermeasure behavior based on the location 26 and velocity 28 of the cellular telephone 14 and further based on the current location 16 and velocity 18 of the autonomous vehicle 10. The instructions are sent to the vehicle system, e.g. the braking system, by a computer system that is in communication with the electronic receiver and the instruction are based on the location 26 and velocity 28 of the cellular telephone 14

and further based on the current location 16 and velocity 18 of the autonomous vehicle 10.

[0025] Fig. 3 illustrates a non-limiting example of optional steps that may be included in the method 100. STEP 108, DETERMINE A VEHICLE VELOCITY, includes determining the velocity 18 of the autonomous vehicle 10 via the locating device. Step 110, COMPARE THE VEHICLE VELOCITY WITH THE CELLULAR TELEPHONE VELOCITY, includes comparing the vehicle velocity 18 determined in STEP 108 with the cellular telephone velocity 28 determined in STEP 104. STEP 112, DETERMINE WHETHER A CONCURRENCE BETWEEN THE VEHICLE LOCATION AND THE CELLULAR TELEPHONE LOCATION WILL OCCUR, includes determining whether the projected path of the autonomous vehicle 10 based on the current location 16 and velocity 18 and the projected path of the cellular telephone 14 based on the location 26 and velocity 28 of the cellular telephone 14 will intersect resulting in a concurrence between the current location 16 and the cellular telephone location 26 that would indicate a collision between the autonomous vehicle 10 and the carrier (20, 22, 24) of the cellular telephone 14.

[0026] STEP 114, PROVIDE, BY THE COMPUTER SYSTEM, INSTRUCTIONS TO THE BRAKING SYSTEM TO APPLY VEHICLE BRAKES, includes providing instructions to the braking system to apply the brakes to slow or stop the autonomous vehicle 10 in order to avoid a collision between the autonomous vehicle 10 and the carrier (20, 22, 24) of the cellular telephone 14 if it is determined in STEP 112 that the concurrence between the current vehicle location 16 and the cellular telephone location 26 will occur.

[0027] STEP 116, PROVIDE, BY THE COMPUTER SYSTEM, INSTRUCTIONS TO THE POWERTRAIN SYSTEM TO ADJUST THE VEHICLE VELOCITY, includes providing instructions to the powertrain system to adjust the vehicle velocity 18 by slowing or accelerating the autonomous vehicle 10 to in order to avoid a collision between the autonomous vehicle 10 and the carrier (20, 22, 24) of the cellular telephone 14 if it is determined in STEP 112 that the concurrence between the current vehicle location 16 and the cellular telephone location 26 will occur.

[0028] STEP 118, DETERMINE A STEERING ANGLE TO AVOID THE CONCURRENCE, includes determining a steering angle to avoid the concurrence if it is determined in STEP 112 that the concurrence between the current vehicle location 16 and the cellular telephone location 26 will occur. STEP 120, PROVIDE, BY THE COMPUTER SYSTEM, INSTRUCTIONS TO THE STEERING SYSTEM TO ADJUST A VEHICLE PATH BASED ON THE STEERING ANGLE, includes providing instructions to the steering system to adjust a vehicle path to avoid the concurrence based on the steering angle determined in STEP 118.

[0029] STEP 122, DETERMINE WHETHER THE VEHICLE VELOCITY AND THE CELLULAR TELEPHONE VELOCITY ARE SUBSTANTIALLY PARALLEL AND IN A SAME DIRECTION, includes determining whether the vehicle velocity 18 determined in STEP 108 and the cellular telephone velocity 28 determined in STEP 104 are substantially parallel and in a same direction indicating the autonomous vehicle 10 and the cellular telephone 14 are travelling on the same path in the same direction. As used herein, substantially parallel means within ± 15 degrees of absolutely parallel. STEP 124, PROVIDE, BY THE COMPUTER SYSTEM, INSTRUCTIONS TO THE

POWERTRAIN SYSTEM TO ADJUST THE VEHICLE VELOCITY TO MAINTAIN A FOLLOWING DISTANCE IF IT IS DETERMINED THAT THE VEHICLE VELOCITY AND THE CELLULAR TELEPHONE VELOCITY ARE SUBSTANTIALLY PARALLEL AND IN THE SAME DIRECTION, includes providing instructions to the powertrain system to adjust the vehicle velocity 18 to maintain a following distance if it is determined that the vehicle velocity 18 and the cellular telephone velocity 28 are substantially parallel and in the same direction. The following distance is based on the vehicle velocity 18 in order to allow a safe stopping distance, if required. STEP 124 may also include determining a velocity threshold for the cellular telephone velocity 28 so that the autonomous vehicle 10 does not automatically match the speed a cellular telephone 14 that is moving too slowly, e.g. a cellular telephone 14 carried by a pedestrian 20 or another vehicle 24 that is moving too quickly, e.g. a cellular telephone 14 carried by another vehicle 24 exceeding the posted speed limit.

[0030] The embodiments described herein are described in terms of an autonomous vehicle 10. However, elements of the embodiments may also be applied to warning systems that alert the driver to manually take these identified countermeasures.

[0031] Accordingly a method 100 of automatically operating an autonomous vehicle 10 is provided. The method 100 provides the benefits of allowing automatic control of the autonomous vehicle 10 when forward looking sensors are be obscured. It also provides the benefit of receiving location information from cellular telephones 14 that are nearly ubiquitous in the driving environment rather than from dedicated transceivers.

[0032] While this invention has been described in terms of the preferred embodiments thereof, it is not intended to be so limited, but rather only to the extent set forth in the claims that follow. Moreover, the use of the terms first, second, etc. does not denote any order of importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items.

WE CLAIM:

1. A method (100) of operating a vehicle (10), comprising the steps of:
 - receiving a message via an electronic receiver indicating a cellular telephone location (26) proximate to the vehicle (10) (102);
 - determining a cellular telephone velocity (28) of the based on changes in the cellular telephone location (26) over a period of time (104); and
 - providing, by a computer system in communication with said electronic receiver, instructions based on the cellular telephone location (26) and the cellular telephone velocity (28) to automatically implement countermeasure behavior by a vehicle system (106).
2. The method (100) of operating a vehicle (10) according to claim 1, wherein the vehicle system is a braking system, and wherein the method (100) further includes the steps of:
 - determining a vehicle velocity (18) (108);
 - comparing the vehicle velocity (18) with the cellular telephone velocity (28) (110);
 - determining whether a concurrence between the vehicle location (16) and the cellular telephone location (26) will occur (112); and
 - providing, by the computer system, instructions to the braking system to apply vehicle brakes to avoid the concurrence if it is determined that the concurrence between the vehicle location (16) and the cellular telephone location (26) will occur (114).

3. The method (100) of operating a vehicle (10) according to claim 1, wherein the vehicle system is a powertrain system, and wherein the method (100) further includes the steps of:

determining a vehicle velocity (18) (108);

comparing the vehicle velocity (18) with the cellular telephone velocity (28) (110);

determining whether a concurrence between the vehicle location (16) and the cellular telephone (14) will occur (112); and

providing, by the computer system, instructions to the powertrain system to adjust the vehicle velocity (18) to avoid the concurrence if it is determined that the concurrence will occur (116).

4. The method (100) of operating a vehicle (10) according to claim 1, wherein the vehicle system is a steering system, and wherein the method (100) further includes the steps of:

determining a vehicle velocity (18) (108);

comparing the vehicle velocity (18) with the cellular telephone velocity (28) (110);

determining whether a concurrence between the vehicle location (16) and the cellular telephone location (26) will occur (112);

determining a steering angle to avoid the concurrence if it is determined that the concurrence between the vehicle location (16) and the cellular telephone location (26) will occur (118); and

providing, by the computer system, instructions to the steering system to adjust a vehicle path based on the steering angle (120).

5. The method (100) of operating a vehicle (10) according to claim 1, wherein the vehicle system is a powertrain system, wherein the cellular telephone (14) is carried by another vehicle (24), and wherein the method (100) further includes the steps of:

determining a vehicle velocity (18) (108);

comparing the vehicle velocity (18) with the cellular telephone velocity (28) (110);

determining whether the vehicle velocity (18) and the cellular telephone velocity (28) are substantially parallel and in a same direction (122);

determining whether a concurrence between the vehicle location (16) and the cellular telephone location (26) will occur (112); and

providing, by the computer system, instructions to the powertrain system to adjust the vehicle velocity (18) to maintain a following distance if it is determined that the vehicle velocity (18) and the cellular telephone velocity (28) are substantially parallel and in the same direction (124).

6. The method (100) of operating a vehicle (10) according to claim 1, wherein the cellular telephone (14) is carried by a pedestrian (20).

7. The method (100) of operating a vehicle (10) according to claim 1, wherein the cellular telephone (14) is carried by another vehicle (24).

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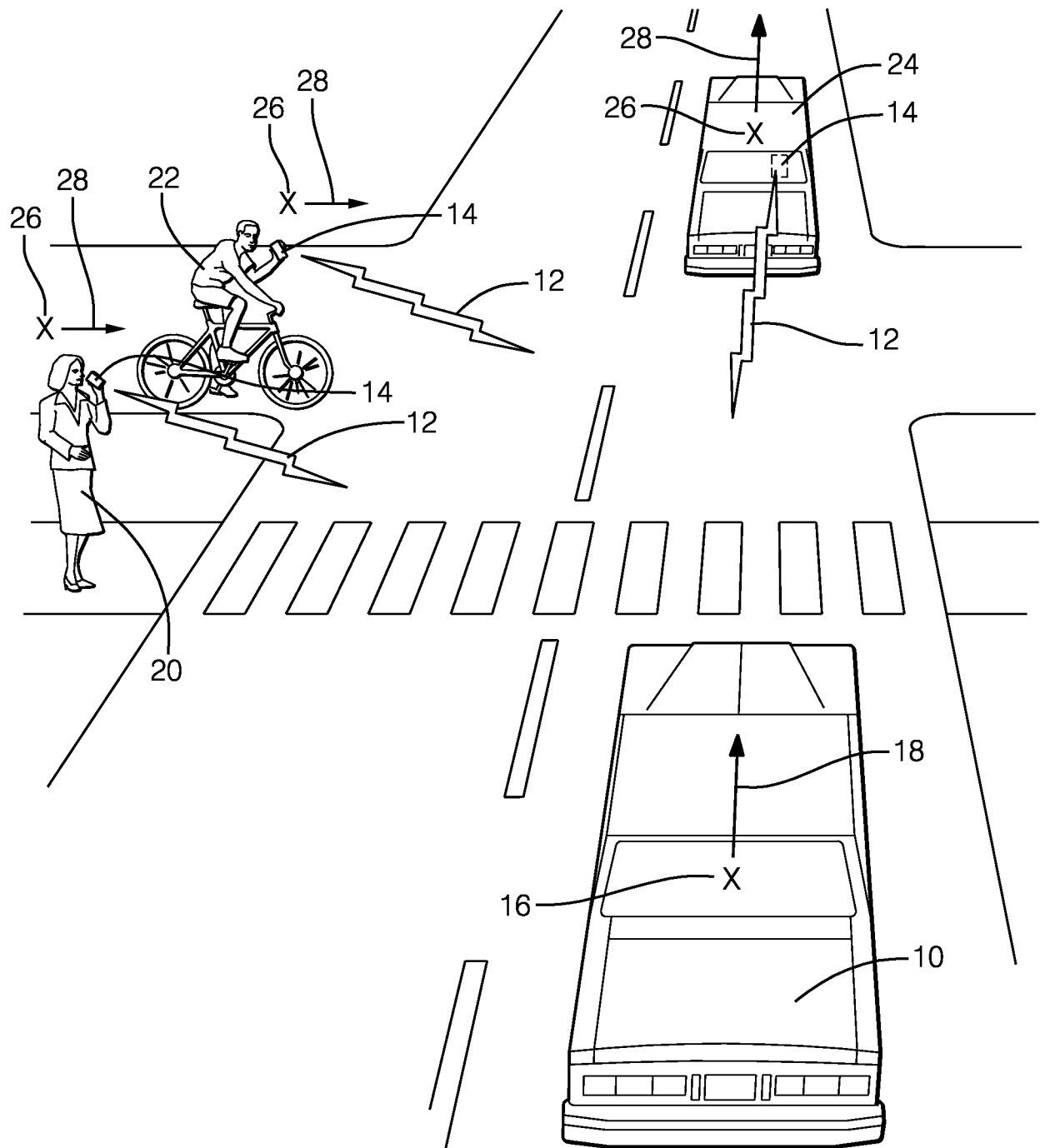


FIG. 1

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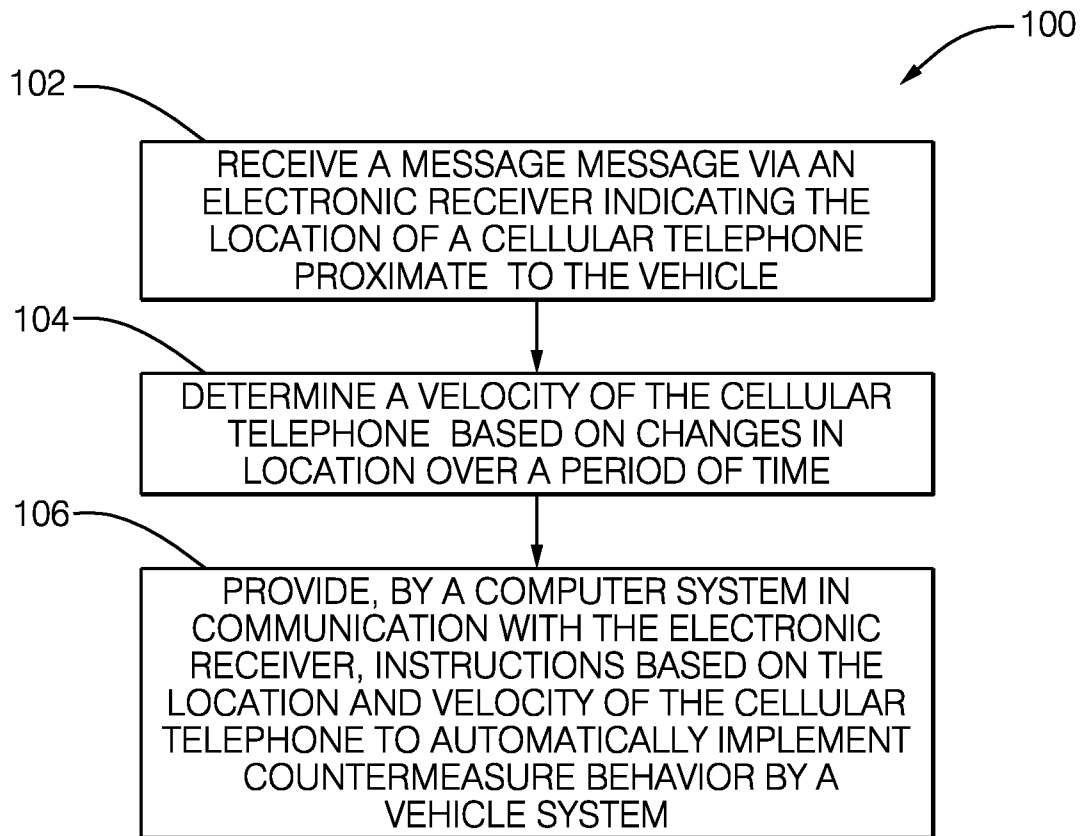
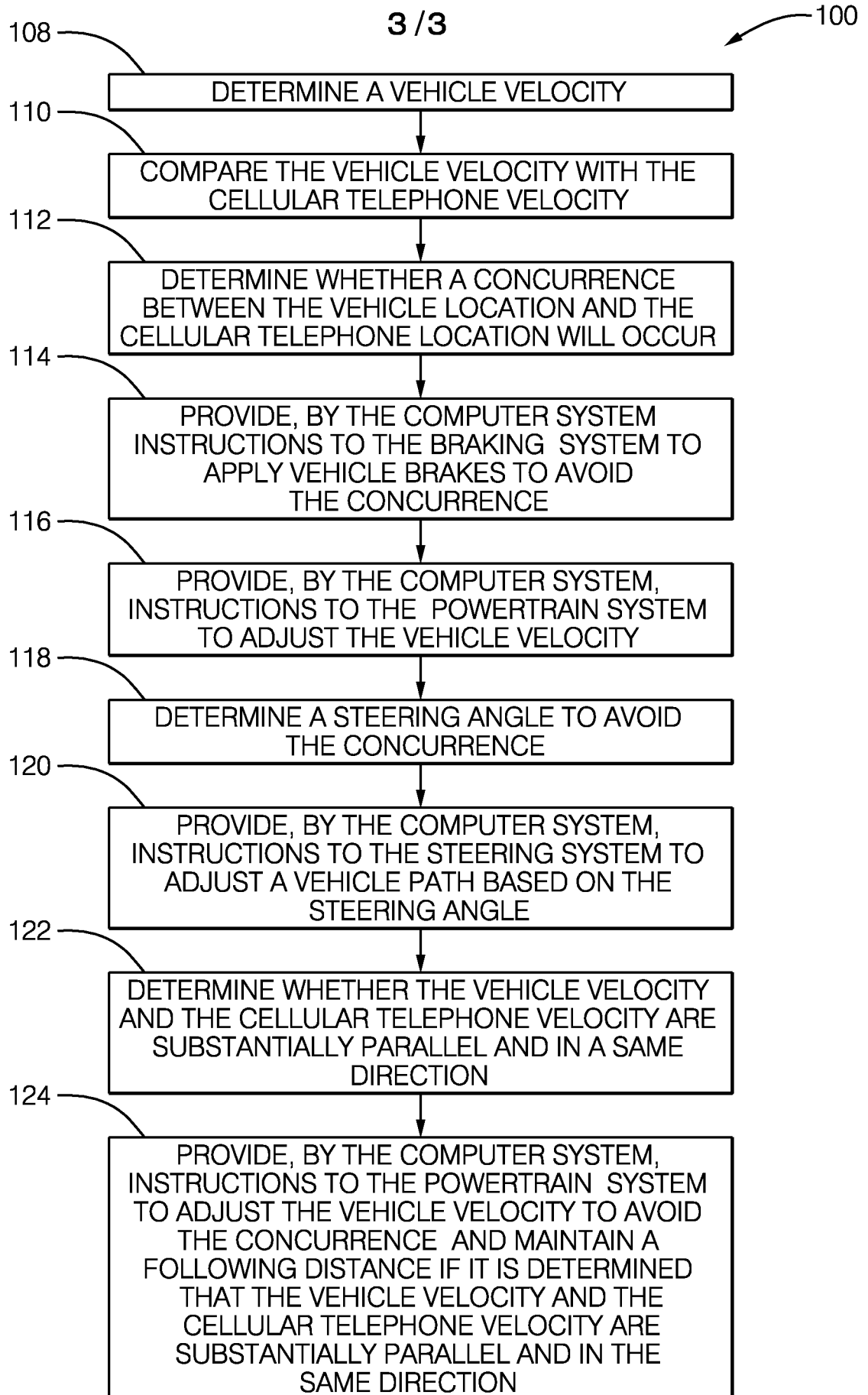


FIG. 2

**FIG. 3**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/064240**A. CLASSIFICATION OF SUBJECT MATTER****G05D 1/02(2006.01)i, H04W 4/02(2009.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
G05D 1/02; G08G 1/16; G06G 7/70; G08G 1/0965; H04W 4/02; G06F 1900; G08G 1/0968Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: autonomous vehicle, cellular phone, location, velocity, collision**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6810321 B1 (FRED S. COOK) 26 October 2004 See column 2, line 39 - column 3, line 17, claim 1 and figure 1.	1-7
Y	US 2013-0218396 A1 (NIKOLAI K. MOSHCHUK et al.) 22 August 2013 See paragraphs [0045]-[0048], claim 22 and figure 3.	1-7
Y	US 2011-0210866 A1 (KLAUS DAVID et al.) 01 September 2011 See paragraphs [0069]-[0087], claim 1 and figure 3.	6
A	US 2014-0012455 A1 (RYAN A. NEFF) 09 January 2014 See paragraphs [0038]-[0041], claim 1 and figure 1.	1-7
A	KR 10-2011-0023952 A (CHABIO & DIOSTECH CO., LTD.) 09 March 2011 See paragraphs [0025]-[0041], claim 1 and figure 1.	1-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

18 March 2016 (18.03.2016)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/064240

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6810321 B1	26/10/2004	None	
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KR 10-2011-0023952 A	09/03/2011	None	