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(71) Applicant: **C.R.F. SOCIETA' CONSORTILE PER AZIONI**
10043 Orbassano (Torino) (IT)

(72) Inventors:
- **Lilli, Francesco**
  10043 Orbassano (IT)
- **Capra, Luca**
  10043 Orbassano (IT)

(74) Representative: **Jorio, Paolo et al**
Studio Torta S.r.l.
Via Viotti, 9
10121 Torino (IT)

(54) **Method and apparatus for detecting a condition of danger deriving from the presence of vulnerable road users and for warning the driver of a vehicle of said condition of danger**

(57) Described herein is a method for warning the driver of a vehicle (2) of a condition of danger associated to the presence of at least one vulnerable road user (3). The method comprises the steps of: transmitting, via a user-identification device (4) carried by the vulnerable road user (3) a user-identification signal; receiving (110) the user-identification signal via a warning device (5) installed on board the vehicle (2); processing (130) the user-identification signal to determine a set of information regarding the displacement of the vulnerable road user (3); comparing (140, 150, 160) the information regarding the displacement of the vulnerable road user (3) with a set of information regarding the displacement of the vehicle (3) in order to predict, on the basis of the result of the comparison, the absence or the presence of a condition of impact between the vehicle (2) and the vulnerable road user (3); and in the case where the presence of a condition of impact is predicted, sending a warning (170) of a state of danger to the driver of the vehicle (2) through of the warning devices (11) installed on board the vehicle (2) itself.

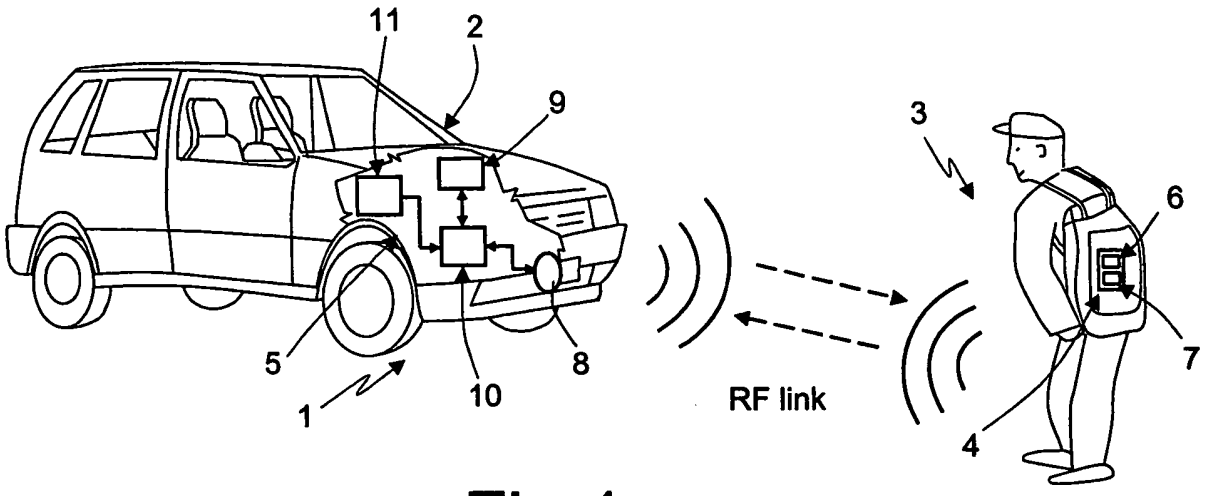


Fig.1

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Description

[0001] The present invention relates to a method and an apparatus for detecting a condition of danger deriving from the presence of vulnerable road users and for warning the driver of a vehicle, in particular a motor vehicle, of said condition of danger.

[0002] As is known, in the road-safety sector there is increasingly felt the need to provide drivers of motor vehicles with an aid that will enable them to be warned in an automatic way when a condition of potential danger arises due to the presence of the so-called vulnerable road users, who are represented by pedestrians, cyclists or motorcyclists, i.e., all those persons who travel on the road in conditions of vulnerability.

[0003] The road users mentioned above are in fact constantly exposed to a potential condition of danger in so far as, in the case where they are hit by a vehicle, they suffer particularly serious and severe consequences from the point of view of physical injury.

[0004] The aim of the present invention is hence to provide an apparatus that will enable detection and advanced warning to the driver of the vehicle of a condition of danger due to the presence of vulnerable road users.

[0005] The above aim is achieved by the present invention in so far as it regards a method designed to detect, and warn the driver of a vehicle of, a condition of danger originating from the presence of vulnerable road users, according to what is specified in Claim 1 and, preferably, in any one of the subsequent claims that depend directly or indirectly upon Claim 1.

[0006] According to the present invention an apparatus is moreover provided designed to detect ,and warn the driver of a vehicle of, a condition of danger deriving from the presence of vulnerable road users, according to what is specified in Claim 10 and, preferably, in any one of the subsequent claims that depend directly or indirectly upon Claim 10.

[0007] The present invention will now be described with reference to the annexed plate of drawings, which illustrate a non-limiting example of embodiment thereof and in which:

- Figure 1 is a schematic illustration of an apparatus for warning the driver of the vehicle of a condition of danger originating from the detection of a vulnerable road user, built in accordance with the present invention;
- Figure 2 represents a block diagram of a set of components comprised in the apparatus illustrated in Figure 1;
- Figure 3 illustrates a flowchart indicating the operations implemented by the apparatus shown in Figure 1 during its operation;
- Figure 4 shows a flowchart indicating the operations implemented by the apparatus during determination of the presence/absence of a condition of impact between the user and the vehicle; and
- Figures 5 and 6 are schematic illustrations of an example of the computation implemented by the apparatus during determination of the kinematic quantities associated to the vulnerable road user.

[0008] With reference to Figure 1, number 1 designates as a whole an apparatus having the function of detecting, and warning the driver of a vehicle 2 of, a condition of danger associated to a collision or impact that may occur between the vehicle 2 and one or more vulnerable road users 3 (only one of which, for reasons of simplicity of description, is shown in Figure 1) so as to achieve a greater road safety for the users 3. It remains, however, clear that said apparatus 1 is able to operate in the presence of any number of vulnerable road users 3.

[0009] As will be described in detail in what follows, the apparatus 1 is able to implement the following operations: detecting the presence of one or more vulnerable road users 3 in an area within which displacement of the vehicle 2 occurs; calculating a set of kinematic parameters correlated to the position and to the displacement of the vehicle 2 and of the user 3 within the area; verifying, on the basis of a set of comparisons between the displacements of the vehicle 2 and the displacements performed by the user 3, whether there exists or not a condition of potential impact between the two; and, in the case where said condition of impact is ascertained, warning the driver of the vehicle 2 of a condition of danger so as to warn him, in sufficient advance, of the possible impact between the vehicle 2 and the vulnerable road user 3.

[0010] With reference to the example illustrated in Figure 1, the apparatus 1 basically comprises: an identification device 4, which is designed to be carried or worn by a vulnerable road user 3, corresponding, for example, to a pedestrian, and/or to a cyclist, and/or to a motorcyclist, etc.; and a warning apparatus 5, which is installed on board the vehicle 2, and has the function of identifying the position and the displacement of the identification device 4 worn by the user 3, and of comparing said information with the position and the displacement of the vehicle 2, in such a way as to be able to foresee, on the basis of said comparison, a possible condition of impact between the vehicle 2 and the user 3.

[0011] The identification device 4 that can be worn by the user 3 may be, for example, a transponder (TAG), preferably, but not necessarily, of a passive type, which is activated following upon reception of an inquiry signal, and has the function of transmitting to the warning apparatus 5 a response signal to enable identification of the position of the user 3, as well as identification of the kind of user.

[0012] In the case in point, the identification device 4 can be provided with a storage module 6 containing an identification code associated preferably, but not necessarily, to the type of user (pedestrian, cyclist, motorcyclist), and a transceiver module 7, which is able to receive and/or transmit radiofrequency signals to and from the

warning apparatus 5.

[0013] With reference to Figure 1, the warning apparatus 5 comprises a transceiver device 8, constituted, for example, by a known electronic circuit that is able to transmit and receive radiofrequency signals, which is designed to transmit the inquiry signal to the identification device 4 and to receive from the latter the response signal identifying the user.

[0014] The warning apparatus 5 further comprises, preferably but not necessarily, a satellite positioning device 9, for example a GPS (Global Positioning System) module capable of determining the instantaneous position of the vehicle 2 (in terms of longitude and latitude) with respect to a pre-set reference system, and an electronic control unit 10, which implements a set of operations (described in detail hereinafter) for verification and comparison of the displacements between the vehicle and the user, on the basis of which the possible condition of danger is identified.

[0015] The electronic control unit 10 can be constituted by an electronic control unit capable of co-operating with a HMI (Human-Machine Interface) device 11 present on board the vehicle 2 so as to warn, through the latter, the driver of the vehicle 2 of the condition of danger.

[0016] In greater detail, with reference to Figure 2, the electronic control unit 10 comprises: a control module 12, which cooperates with the transceiver device 8 for managing the transmission/reception of the radiofrequency signals from and to the identification device 4; a calculation module 13, which processes the response signal received by the control module 12 to determine (with the modalities described in detail hereinafter) a set of kinematic parameters associated to the user 3, such as position, speed, and acceleration.

[0017] The electronic control unit 10 further comprises: a detection module 14, which detects a set of kinematic parameters of the vehicle 2, such as, for example, the position, speed and acceleration; and a storage module 15, which contains a geographical map of the area involved in the displacement of the vehicle 2 and of the user 3. In the case in point, the geographical map can contain a digital geographical representation (i.e., in an electronic format), in which are indicated the real elements and/or objects present in the geographical area represented.

[0018] The real elements and/or objects can comprise for instance roads, car parks, service areas, buildings, bridges, squares, green areas, cycle tracks, pavements, etc. In particular, said elements and/or objects are described within the digital geographical map on the basis of their geometrical characteristics, such as for example their position with respect to a pre-set reference system, the perimeter or the area occupied, and on the basis of other properties of an operative type, such as for example the state of accessibility of the object.

[0019] The electronic control unit 10 further comprises: a processing module 16, which is capable of determining the positions and the displacements of the user 3 and of the vehicle 2 within the geographical map contained in the storage module 15 in order to verify, as a function of the outcome of said processing, whether there exists or not a condition of danger; and a warning module 17, which sends to the HMI device 11 the signal warning of danger to be supplied to the driver of the vehicle 2.

[0020] The identification device 4 can be provided with a warning module 4a for warning the user 3 of a condition of danger detected by the warning apparatus 5. In this case, the warning module 17, in addition to activating the warning of danger to the driver of the vehicle through the HMI device 11, operates a command for transmission of a signal that encodes said condition of danger. Said signal is designed to be received by the transceiver module 7 and is converted into an acoustic and/or visual and/or vibrational message by the warning module 4a comprised in the identification device 4. The warning module 4a comprised in the identification device 4 could comprise an acoustic and/or visual and/or vibrational message device designed to warn the user of the possible condition of impact with the vehicle 2.

[0021] With reference to Figure 3 the method implemented by the apparatus 1 for detecting, and warning the driver of the vehicle 2 of, a condition of danger generated by the presence of vulnerable road users 3 will now be described.

[0022] During displacement of the vehicle 2 along the path, the electronic control unit 10 controls transmission of the inquiry signal (block 100) via the transceiver device 8, and remains in a temporary condition of waiting (block 110) for detection of a response signal by at least one identification device 4 worn by a user 3 present within an area that surrounds the path of the vehicle 2.

[0023] In this step, if the control module 12 does not receive at input any response signal transmitted by the identification device 4 (output NO from block 110), then it transmits, after a pre-set time interval (block 120), a new inquiry signal.

[0024] If, instead, the control block 12 receives a response signal transmitted by the identification device 4 (output YES from block 110), then the calculation module 13 identifies the presence of a vulnerable road user 3 and accordingly processes the radiofrequency response signal to determine a set of kinematic quantities such as for example the position, speed, and possibly acceleration of the user 3, and preferably, but not necessarily, the type of user (block 130).

[0025] At this point, the detection module 14 measures a set of vehicle parameters to supply a set of information regarding the position, speed and acceleration of the vehicle 2 to the processing module 16, which verifies whether there exists a correspondence between the positions of the vehicle and of the user and the objects indicated in the digital map. If the processing module 16 identifies said correspondence, it then represents the vehicle 2 and the user 3 on the digital geographical map stored in the storage module 15 (block 140) according to the respective positions calculated.

[0026] In this step, the processing module 16 identifies on the digital geographical map the objects or elements which the user 3 and the vehicle 2 occupy. For example, the user 3 could occupy an object corresponding to a road, or an object corresponding to a cycle track, or an object corresponding to a car park, etc., whereas the vehicle 2 could occupy an object corresponding to a road, or else an object corresponding to a bridge, or an object corresponding to a car park, etc.

[0027] At this point, the processing module 16 verifies the presence/absence of a possible situation of impact between the vehicle and the user, and hence a condition of danger.

[0028] In particular, in this step the processing module 16 makes a forecast of the paths that will be followed by the vehicle 2 and by the user 3 and, on the basis of the points of intersection of the paths and as a function of the speed of the vehicle 2 and of the user 3, determines the presence/absence of a condition of danger deriving from an impact between the user and the vehicle.

[0029] In the case where no condition of danger of impact between the vehicle and the user is identified, the processing module 16 identifies a condition of absence of danger (output NO from block 160), whilst otherwise, i.e., in the case where a condition of danger due to impact is forecast, the warning module 17 warns the driver of the vehicle 2, through the HMI device 11, of the condition of danger (block 170).

[0030] At this point, the warning module 17 transmits the danger signal to the identification device 4, which issues to the user 3 an acoustic and/or visual and/or vibrational warning of the presence of the danger of impact (block 180).

[0031] With reference to Figure 4, described hereinafter are the operations implemented by the apparatus 1 during verification of the presence/absence of the condition of danger due to a possible impact of the vehicle 2 with a user 3 (described above and indicated in Figure 2 by block 150).

[0032] In this step, the processing module 16 verifies whether there exists an effective correspondence between the positions assumed by the vehicle 2 and by the user 3 and the objects and/or elements represented within the digital geographical map (block 200). In the case where said correspondence has a negative outcome, i.e., if, on account of their positions, the vehicle 2 and/or the user 3 do not find a correspondence, i.e., they cannot be represented within the geographical map (output NO from block 200), then the processing module 16 processes the kinematic parameters of the vehicle 2 and of the user 3 in order to predict the path that will be followed by the user 3 and by the vehicle 2 starting from their respective positions previously determined (block 210).

[0033] In this step, the processing module 16 moreover determines a set of safety parameters, such as the point of intersection P_T between the path of the vehicle 2 and the path of the user 3, a safety distance r_s (described hereinafter) that must be maintained between the vehicle 2 and the user 3 to guarantee safety of the latter, and a stopping distance d_s for arrest of the vehicle 2.

[0034] In particular, the stopping distance d_s of the vehicle 2 represents the total distance along which the vehicle 2 is travelling between the initial instant, in which the driver has the perception of the presence of a user 3 on the road along which the vehicle 2 is travelling, and the final instant, in which the vehicle 2 stops following upon a stop command imparted by the driver of the vehicle 2 itself.

[0035] In particular, the stopping distance d_s can be determined through a table contained in the storage module 15 and as a function of a set of parameters such as the speed of the vehicle 2, the model of vehicle 2 (determined via a customization of the system), the driving skill of the driver (determined via a set of information associated to the driving "historic file" of the driver), the type of road along which the vehicle is travelling, and the external environmental conditions (which can be determined via a sensor for detection of the state of the road). The stopping distances d_s included in the table can be determined by measuring the stopping distances d_S as the parameters indicated above vary and by implementing on the data thus obtained a statistic calculation procedure.

[0036] As regards the safety distance r_s, this corresponds to the minimum distance required between the vehicle 2 and a user 3 along a stretch of road, below which a condition of danger for the user 3 arises.

[0037] The processing module 16 determines the safety distance r_s on the basis of the stopping distance d_s. In particular, the safety distance r_s is calculated via the following relation: $r_s = d_s * c_v$, where c_v is a coefficient preferably greater than one, which takes into account the unforeseeableness of the type of vulnerable road user 3 considered.

[0038] The coefficient c_v can also be stored in a table that represents a biunique function between the coefficients c_v and the type of road users 3. Said table can be contained in the storage module 15 in such a way as to be accessible by the processing module 16 during calculation of the safety distance r_s.

[0039] Following upon determination of the safety distance r_s, the processing module 16 verifies whether the distance measured between the vehicle 2 and the point of intersection P_T of the paths is smaller than the safety distance r_s and at the same time whether the speed of the vehicle 2 and the speed of the user 3 are such as to be able to cause an impact between the vehicle and the user in the point of intersection P_T itself (block 220).

[0040] If the verification has a negative outcome (output NO from block 220), i.e., if the distance measured between the vehicle 2 and the point of intersection P_T is greater than the safety distance r_s, and the speed of the vehicle 2 and of the user 3 along the respective paths are such as not to be able to cause an impact between the vehicle and the user in the point of intersection P_T itself, then a condition of absence of danger is determined.

[0041] If, instead, the verification has a positive outcome (output YES from block 220), i.e., if the distance measured between the vehicle 2 and the point of intersection P_T is smaller than the safety distance r_s, and at the same time the speed of the vehicle 2 and the speed of the user 3 are such as to be able to cause an impact between the vehicle 2 and the user 3 in the point of intersection P_T, then a condition of danger (block 230) is determined.

[0042] In the case where, following upon verification of the positions between the vehicle and the user on the geographical map a correspondence between the latter and the elements and/or objects is detected (output YES from block 200), then the processing module 16 verifies whether the object or element in which the user 3 is located is or is not contiguous, i.e., adjacent, to the road along which the vehicle 2 is travelling (block 240).

[0043] In particular, the geographical element of the map corresponding, for example, to a cycle track is contiguous to the road if the following two conditions arise: if the intersection between the object, i.e., the cycle track, and a corridor of width D that develops along the road is not empty, and if there does not exist any physical separation that will prevent the user travelling along the cycle track from entering the road along which the vehicle 2 is travelling.

[0044] If the object or element of the electronic map, associated to the path of the user 3, is not contiguous to the road along which the vehicle 2 is travelling (output NO from block 240) then the processing module 16 determines the safety distance r_s in the modalities described above, and the point P_s of intersection between the road along which the vehicle 2 is travelling and the path of the user 3 (block 250).

[0045] In this step, the processing module 16 verifies whether the distance between the vehicle 2 and the point of intersection P_s is smaller than the safety distance r_s.

[0046] If said verification has a negative outcome (output NO from block 250), i.e., if the distance between the vehicle 2 and the point of intersection P_s is greater than the safety distance r_s, a condition of absence of danger of impact is detected, whilst, instead, if said verification has a positive outcome (output YES from block 250), i.e., if the distance between the vehicle 2 and the point of intersection P_s is smaller than the safety distance r_s, a condition of danger of impact is detected (block 260).

[0047] If the object or element of the map associated to the path of the user 3 is contiguous to the road followed by the vehicle 2 (output YES from block 240), then the processing module 16 performs a forecast of the path followed by the vehicle 2 and of the path followed by the user 3, calculates the point of intersection P_T between the paths and determines the safety distance r_S implementing the operations described above (block 270).

[0048] At this point, the processing element 16 implements the same operations as those of block 220, i.e., it verifies whether the distance measured between the vehicle 2 and the point of intersection P_T of the paths is smaller than the safety distance r_s and, at the same time, checks whether the speed of the vehicle 2 and the speed of the user 3 are such as to be able to cause an impact between the vehicle and the user in the point of intersection P_T itself (block 280).

[0049] In the case of positive outcome (output YES from block 280), i.e., if the distance measured between the vehicle 2 and the point of intersection P_T of the paths is smaller than the safety distance r_s and the speed between the vehicle and the user 3 are such as to be able to cause an impact, then the processing module operates a warning of the condition of danger (block 260).

[0050] If, instead, the distance measured between the vehicle 2 and the point of intersection P_T of the paths is greater than the safety distance r_s and/or the speed between the vehicle and the user 3 are such as not to be able to cause an impact, the processing module 16 verifies whether the position of the user is comprised within the corridor of pre-set width D and whether the user 3 is at a distance from the vehicle smaller than the safety distance r_s (block 290).

[0051] If said verification has a positive outcome (output YES from block 290), i.e., if the position of the user is within the corridor of pre-set width D and the user 3 is at a distance from the vehicle 2 smaller than the safety distance r_S, then the processing module 16 detects a condition of danger (block 260).

[0052] Otherwise, i.e., if the position of the user is outside the corridor of pre-set width D, or the user 3 is at a distance from the vehicle 2 greater than the safety distance r_S (output NO from block 290), then the processing module 16 detects a condition of absence of danger.

[0053] As regards the operations implemented during calculation of the kinematic quantities (block 130 shown in Figure 2), i.e., the position, speed and acceleration of the user, they can be performed on the basis of a set of measurements and processing operations implemented directly by the apparatus 1.

[0054] In particular, with reference to Figures 5 and 6, the apparatus 1 is capable of measuring a set of quantities provided hereinafter.

[0055] In the case in point, should the user be moving at a speed V_c other than zero (the example shown in Figure 5), the apparatus 1 is able to determine the vectors $\underline{C\text{-}A}$ and $\underline{D\text{-}B}$, which represent both the distances C-A and D-B of the user 3 with respect to the vehicle 2 in two successive instants t_1 and t_2 and the directions along which the distances C-A and D-B are determined with respect to the direction of displacement of the vehicle 2, where C and D are the positions of the user 3 in the two instants t_1 and t_2, A is the position of the vehicle 2 at the instant t_1 and B is the position of the vehicle 2 at the instant t_2.

[0056] In this case, the processing module 16 of the apparatus 1 determines the vectors $\underline{C\text{-}A}$ and $\underline{D\text{-}B}$, processing in a known way (and consequently not described in detail) the time of flight associated to the radiofrequency signals exchanged between the warning ap-

paratus 5 and the identification device 4.

[0057] In the case where the user is stationary $V_c = 0$ (Figure 6), the apparatus 1 determines the vectors $\underline{C - A}$ and $\underline{C - B}$ that indicate both the distances C-A and C-B of the user 3 with respect to the vehicle 2 in two successive instants t_1 and t_2 and the directions along which the distances C-A and C-B are determined with respect to the direction of displacement of the vehicle 2, where C is the position of the user 3, A is the position of the vehicle 2 at the instant t_1, and B is the position of the vehicle 2 at the instant t_2. Also here the processing module 16 of the apparatus 1 determines the vectors $\underline{C - A}$ and $\underline{C - B}$, processing in a known way (and consequently not described in detail) the time of flight associated to the radiofrequency signals exchanged between the warning apparatus 5 and the identification device 4.

[0058] In the case where the apparatus 1 is provided with a satellite positioning device 9, it is then able to determine also the vector $\underline{B - A}$ indicating the distance between the positions A and B assumed by the vehicle in the two consecutive instants t_1 and t_2, its direction of displacement with respect to a pre-set reference system, and the speed V_a and V_b of the vehicle 2 in the two instants t_1 and t_2.

[0059] In addition, if the apparatus 1 co-operates with a set of directional antennas (not illustrated), such as for example a plurality of smart antennas arranged on the vehicle according to a pre-set known geometrical configuration (for example, according to a circular geometrical configuration), it is capable of detecting also the angles α_1 and α_2 that form the direction of advance of the vehicle 2 with respect to a straight line that joins the latter with the user 3 in the successive instants t_1 and t_2. Also this type of calculation is known and consequently will not be further described.

[0060] The processing module 16 of the apparatus 1, following upon detection of the information regarding the parameters $\underline{C - A}$ and $\underline{C - B}$ and/or $\underline{C - A}$ and $\underline{D - B}$ and/or V_a and V_b and/or α_1 and α_2, is capable of identifying the instantaneous positions of the vehicle 2 and of the user 3 and the relative directions and speeds of displacement. It is evident that, following upon determination of the instantaneous speeds, the processing module 16 is able to determine also the acceleration of the vehicle 2 and of the user 3.

[0061] The advantages deriving from the apparatus 1 described above are evident: the apparatus 1 gives the driver of the vehicle timely warning of the presence of a danger when a condition of potential impact between the vehicle 2 and a vulnerable road user 3 is predicted. Said warning in fact enables the driver to prepare himself with sufficient advance in a condition of particularly careful driving, which considerably reduces the risk of impact between the vehicle and the user identified, and advantageously excludes all the conditions of alarm associated to the detection of the presence of road users 3, who, albeit vulnerable, are in a condition of non-impact with respect to the vehicle itself.

[0062] Finally, it is clear that modifications and variations can be made to the apparatus 1 described and illustrated herein, without thereby departing from the scope of the present invention as defined by the annexed claims.

Claims

1. A method for warning the driver of a vehicle (2) of a condition of danger deriving from the presence of at least one vulnerable road user (3); said method being **characterized in that** it comprises the following steps:

   - transmitting via a user-identification device (4) carried by said vulnerable road user (3) a user-identification signal;
   - receiving (110) said user-identification signal via a warning device (5) installed on board the vehicle (2);
   - processing (130) said user-identification signal to determine a set of information regarding the displacement of said vulnerable road user (3);
   - comparing (140, 150, 160) the information regarding the displacement of said vulnerable road user (3) with a set of information regarding the displacement of the vehicle (3) in order to predict, on the basis of the results of said comparison, the presence or the absence of a condition of impact between the vehicle (2) and the vulnerable road user (3); and
   - in the case where said condition of impact is predicted, sending a warning (170) of a condition of danger to the driver of the vehicle (2) through warning means (11) installed on board the vehicle (2) itself.

2. The method according to Claim 1, **characterized in that** it comprises the step of:

   - transmitting (100) by means of said warning device (5) an inquiry signal outside the vehicle (2),

   the command for transmission of said identification signal via the user-identification device (4) being controlled following upon reception of said inquiry signal by said identification device (4).

3. The method according to Claim 1 or Claim 2, **characterized in that** said step of comparing (140, 150, 160) said information regarding the displacement of said vulnerable road user (3) with a set of information regarding the displacement of the vehicle (2) comprises the step of verifying (140) whether the position of the vehicle (2) and the position of the user (3) can be represented within an electronic map contained

in storage means (15) of said warning device (5).

4. The method according to Claim 3, **characterized in that** it comprises the step of:

- in the case where the position of the vehicle (2) and the position of the user (3) can be represented within said electronic map, verifying (240) whether the object of the electronic map which the user (3) occupies is or not contiguous to the road along which the vehicle (2) is travelling indicated in said electronic map.

5. The method according to Claim 4, **characterized in that** it comprises the step of:

- in the case where the object of the electronic map which the user (3) occupies is contiguous to the road along which the vehicle (2) is travelling implementing the following steps:
- verifying (280) whether the distance measured between the vehicle (2) and a point of intersection (P_T) of the paths of the vehicle (2) and of the user (3) satisfies a first relation with a pre-set safety distance (r_s) and checking whether the speed of the vehicle (2) and the speed of the user (3) are such as to be able to cause an impact between the vehicle and the user at said point of intersection (P_T); and
- in the case where said first relation is satisfied and if the speed of the vehicle (2) and the speed of the user (3) are such as to be able to cause an impact between the vehicle and the user at said point of intersection (P_T), sending a warning (170, 260) of a condition of danger to the driver of the vehicle (2).

6. The method according to Claim 4, **characterized in that** it comprises the step of:

- in the case where the object of the electronic map which the user (3) occupies is not contiguous to the road along which the vehicle (2) is travelling, implementing the following steps:
- determining (250) a point of intersection (P_s) between the road along which the vehicle (2) is travelling and the path of the user (3) on the electronic map;
- verifying (250) whether the distance between the vehicle (2) and the point of intersection (P_s) satisfies a second relation with a pre-set safety distance (r_s); and
- in the case where said second relation is satisfied, sending a warning (170, 260) of a condition of danger to the driver of the vehicle (2).

7. The method according to Claim 6, **characterized in that** it comprises the following steps: in the case where the distance measured between the vehicle (2) and the point of intersection (P_T) of the paths does not satisfy said second relation, and/or the speed of the vehicle (2) and of the user (3) are such as not to be able to cause an impact, verifying (290) whether the position of the user (2) in said electronic map is comprised within a corridor which has a pre-set width (D) and extends along the road on which the vehicle (2) is travelling, and whether the user (3) is at a distance from the vehicle (2) smaller than a pre-set safety distance (r_s).

8. The method according to Claim 3, **characterized in that** it comprises the following steps:

- in the case where the position of the vehicle (2) and the position of the user (3) cannot be represented within said electronic map, determining the path of the vehicle (2) and the path of the user (3) as a function of the information regarding the displacement of the vehicle (2) and of the user (3) ;
- verifying (220) whether the distance measured between the vehicle (2) and a point of intersection (P_T) of the paths of the vehicle and of the user satisfies a third relation with a pre-set safety distance (r_s) and checking whether the speed of the vehicle (2) and the speed of the user (3) are such as to be able to cause an impact between the vehicle and the user at said point of intersection (P_T);
- in the case where said third relation is satisfied and, if the speed of the vehicle (2) and the speed of the user (3) are such as to be able to cause an impact between the vehicle and the user at said point of intersection (P_T), sending a warning (170) of a condition of danger to the driver of the vehicle (2).

9. The method according to any one of the preceding claims, **characterized in that** said step of sending a warning (170) of a condition of danger to the driver of the vehicle (2) comprises the step of transmitting (180, 190) a signal indicating said condition of danger to said identification device (4) so as to send an acoustic and/or visual and/or vibrational warning of said condition of danger to the user (3).

10. An apparatus (1) for warning the driver of a vehicle (2) of a condition of danger deriving from the presence of at least one vulnerable road user (3); said apparatus being **characterized in that** it comprises:

- an identification device (4), which is designed to be carried by said vulnerable road user (3) and is able to transmit a user-identification signal;
- a warning device (5), which is installed on board

the vehicle (2) and is designed to receive and process the user-identification signal in order to verify the presence of a condition of impact between the vehicle (2) and the user (3) so as to warn the driver of the vehicle (2) of a condition of danger; said warning device (5) comprising:
- transceiver means (8,12) designed to receive said user-identification signal;
- processing means (16) designed to process said user-identification signal to determine a set of information regarding the displacement of said vulnerable road user (3);
- comparison means (140, 150, 160) designed to compare the information regarding the displacement of said vulnerable road user (3) with a set of information regarding the displacement of the vehicle (2) in order to predict, on the basis of the result of the comparison, the absence or the presence of a condition of impact between the vehicle (2) and the vulnerable road user (3) ; and
- warning means (17) designed to warn the driver of the vehicle (2) of a condition of danger when said condition of impact is predicted.

11. The apparatus according to Claim 10, **characterized in that** said transceiver means (8, 12) of said warning device (5) are designed to transmit an inquiry signal, and **in that** said identification device (5) comprises transceiver means (6) designed to transmit said identification signal following upon reception of said inquiry signal.

12. The apparatus according to Claim 11, **characterized in that** said warning means (17) are designed for transmitting a signal encoding said condition of danger to said identification device (4), said identification device (4) comprising a warning module (4a) designed to warn the user of said condition of danger encoded in said transmitted signal.

13. The apparatus according to any one of Claims 10 to 12, **characterized in that** said warning device (5) comprises storage means (15) containing an electronic geographical map; said comparison means (140, 150, 160) comprising first control means (200) designed to verify whether the position of the vehicle (2) and the position of the user (3) calculated can be represented within the electronic geographical map.

14. The apparatus according to Claim 13, **characterized in that** said comparison means (150) comprise second control means (240) designed to verify whether the object of the electronic map which the user (3) occupies is or not in a position adjacent to the road along which the vehicle (2) is travelling indicated in said electronic geographical map.

15. The apparatus according to any one of Claims 10 to 14, **characterized in that** said comparison means (150) comprise third control means (220, 280) designed to verify whether the distance measured between the vehicle (2) and a point of intersection (P_T) on said map of the paths of the vehicle (2) and of the user (3) satisfies a first relation with a pre-set safety distance (r_s), and check whether the speed of the vehicle (2) and the speed of the user (3) are such as to be able to cause an impact between the vehicle and the user at said point of intersection (P_T).

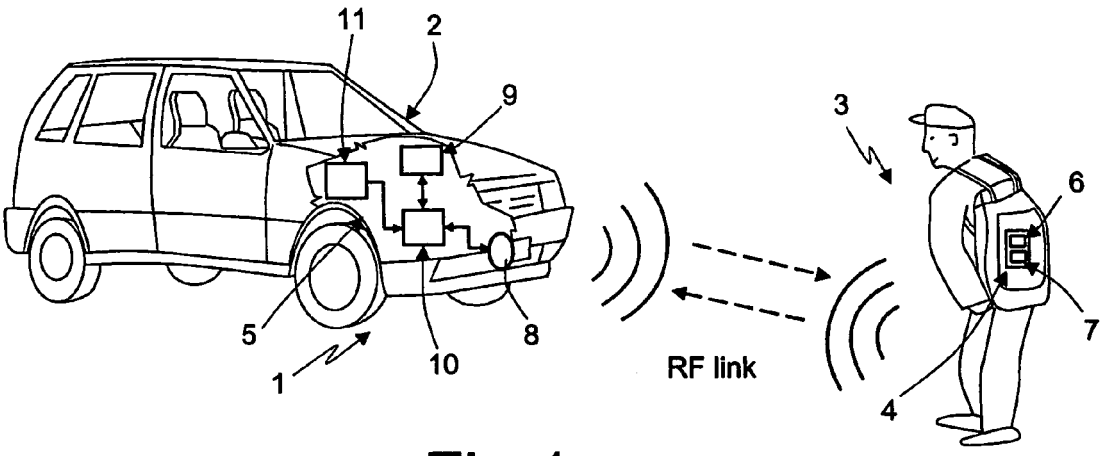

11
2
9
3
6
7
5
8
10
1
RF link
4

Fig.1

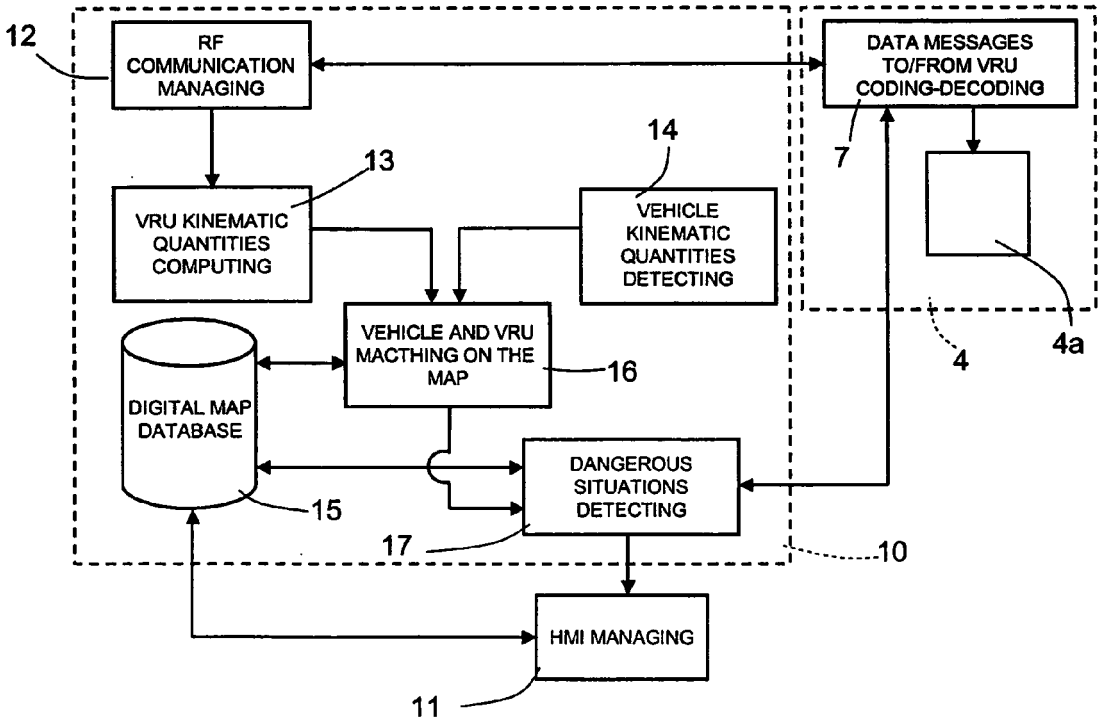

12
RF COMMUNICATION MANAGING
DATA MESSAGES TO/FROM VRU CODING-DECODING
7
14
13
VRU KINEMATIC QUANTITIES COMPUTING
VEHICLE KINEMATIC QUANTITIES DETECTING
4a
4
VEHICLE AND VRU MACTHING ON THE MAP
16
DIGITAL MAP DATABASE
DANGEROUS SITUATIONS DETECTING
15
17
10
HMI MANAGING
11

Fig.2

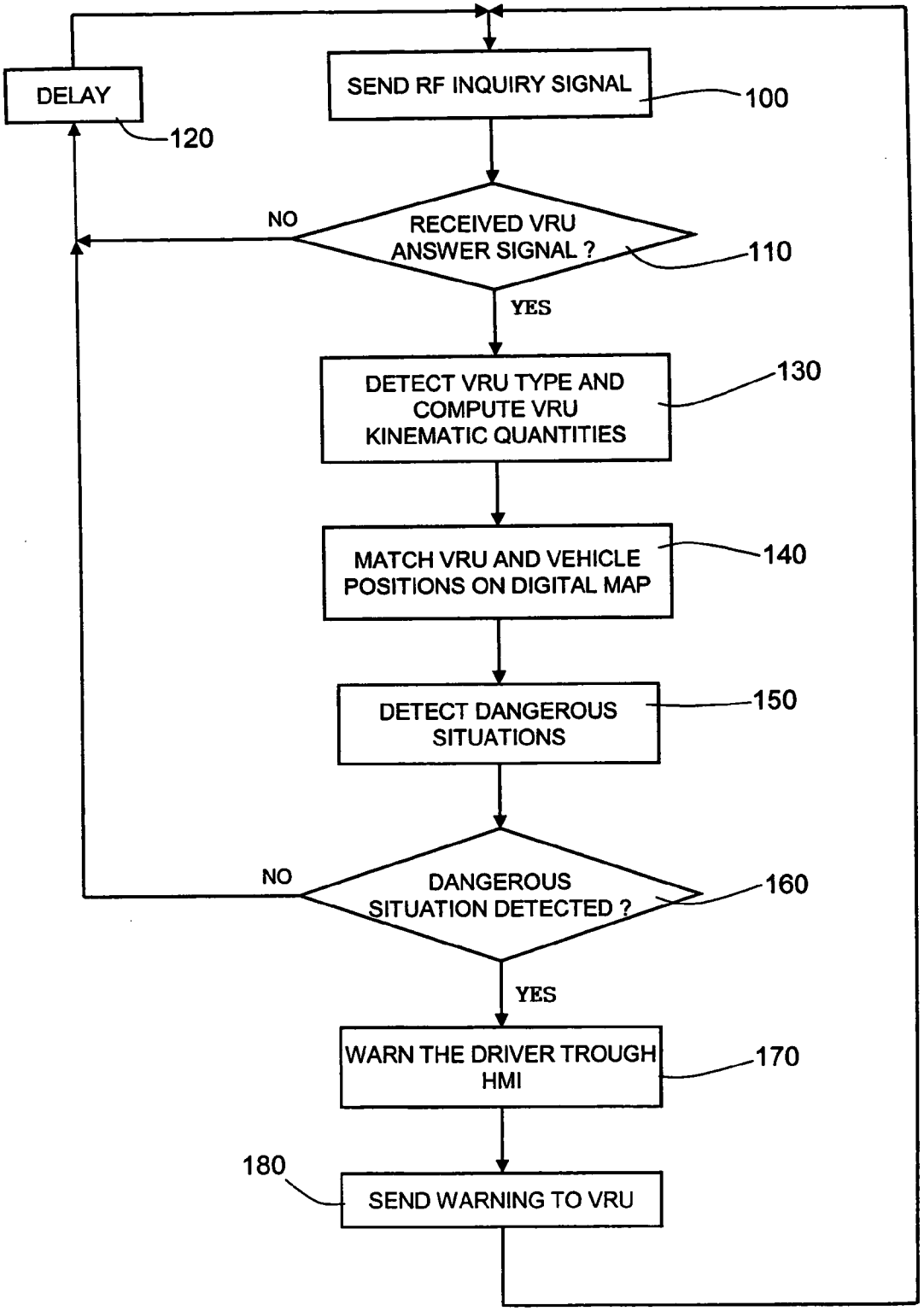

SEND RF INQUIRY SIGNAL
100
DELAY
120
NO
RECEIVED VRU ANSWER SIGNAL ?
110
YES
DETECT VRU TYPE AND COMPUTE VRU KINEMATIC QUANTITIES
130
MATCH VRU AND VEHICLE POSITIONS ON DIGITAL MAP
140
DETECT DANGEROUS SITUATIONS
150
NO
DANGEROUS SITUATION DETECTED ?
160
YES
WARN THE DRIVER TROUGH HMI
170
180
SEND WARNING TO VRU

Fig.3

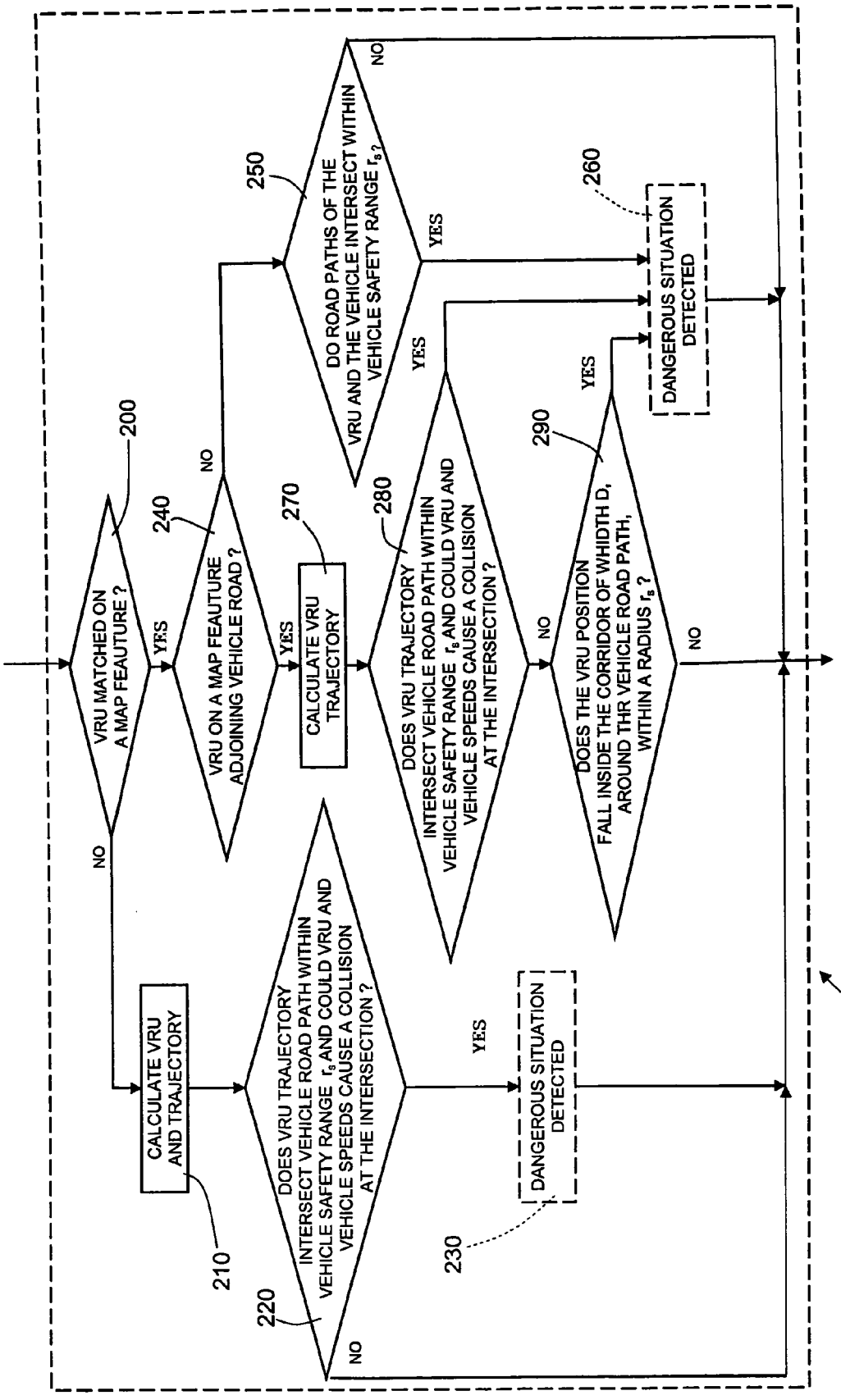

VRU MATCHED ON A MAP FEAUTURE ?
200
YES
NO
VRU ON A MAP FEAUTURE ADJOINING VEHICLE ROAD ?
240
YES
NO
CALCULATE VRU TRAJECTORY
270
DO ROAD PATHS OF THE VRU AND THE VEHICLE INTERSECT WITHIN VEHICLE SAFETY RANGE r_s ?
250
YES
NO
DANGEROUS SITUATION DETECTED
260
DOES VRU TRAJECTORY INTERSECT VEHICLE ROAD PATH WITHIN VEHICLE SAFETY RANGE r_s AND COULD VRU AND VEHICLE SPEEDS CAUSE A COLLISION AT THE INTERSECTION ?
280
YES
NO
DOES THE VRU POSITION FALL INSIDE THE CORRIDOR OF WHIDTH D, AROUND THR VEHICLE ROAD PATH, WITHIN A RADIUS r_s ?
290
YES
NO
CALCULATE VRU AND TRAJECTORY
210
DOES VRU TRAJECTORY INTERSECT VEHICLE ROAD PATH WITHIN VEHICLE SAFETY RANGE r_s AND COULD VRU AND VEHICLE SPEEDS CAUSE A COLLISION AT THE INTERSECTION ?
220
YES
NO
DANGEROUS SITUATION DETECTED
230
150

Fig.4

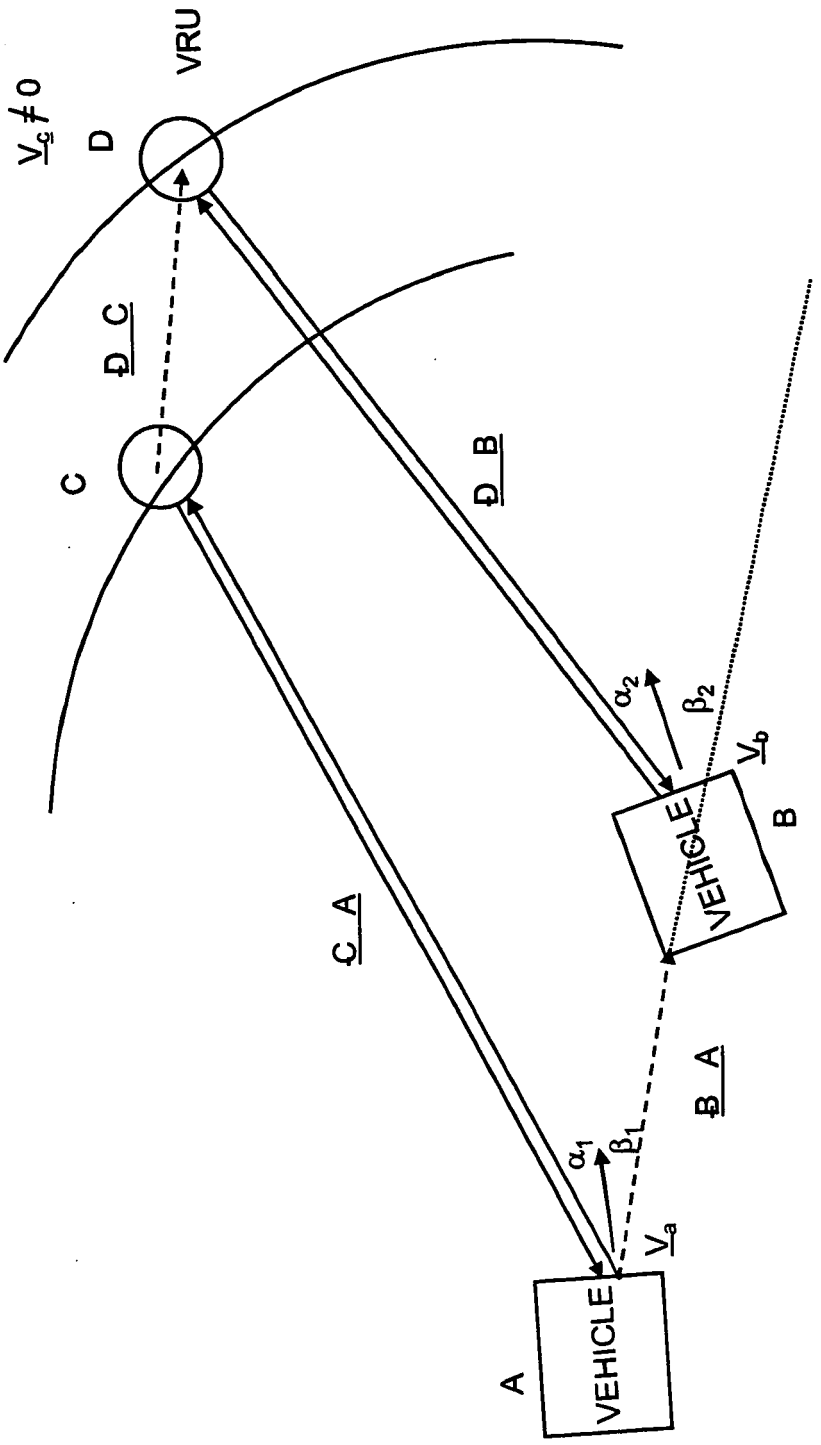

VRU
D
$\underline{V_c} \neq 0$
C
D C
D B
C A
B A
α_2
β_2
$\underline{V_b}$
B
VEHICLE
α_1
β_1
$\underline{V_a}$
A
VEHICLE

Fig.5

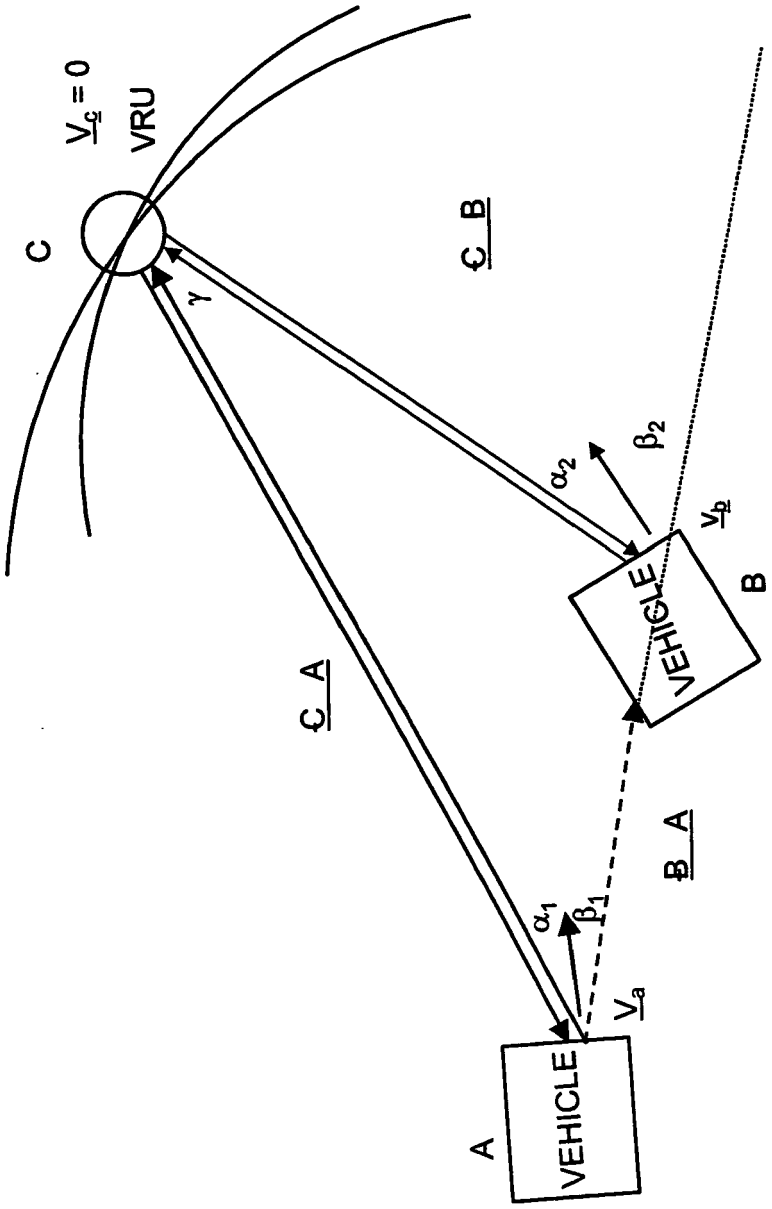

C
$\underline{V_c} = 0$
VRU
$\underline{c}$ B
γ
α_2
β_2
$\underline{v_b}$
VEHICLE
B
$\underline{c}$ A
$\underline{B}$ A
α_1
β_1
$\underline{V_a}$
A
VEHICLE

Fig.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5841

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 102 53 192 A1 (PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH) 27 May 2004 (2004-05-27) * page 2, paragraph 7 * * page 3, paragraphs 11,12 * * page 5, paragraph 32 * -----	1-15	INV. G08G1/16
X	WO 00/48158 A (JAFFE, SHAI) 17 August 2000 (2000-08-17) * figures 1,2 * * page 3, lines 1-18 * * page 4, lines 1-20 * -----	1-15	
X	DE 202 08 643 U1 (HAGENBRUCH, OLAF) 12 September 2002 (2002-09-12) * page 2, paragraphs 3,4 * * page 6, paragraph 1 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC) G08G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 April 2006	Coffa, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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26-04-2006

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82