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(54) AN EXPERT SYSTEM FOR INTEGRATEDLY MANAGING VEHICLE DRIVING SAFETY AND COMPUTING AN INTERACTIVE ROAD RISK MAP

(57) An expert system for integratedly managing vehicle driving safety and computing an interactive road risk map, in which at least one operations centre (3) operates, by means of bidirectional data exchange, with intelligent control units (5) mounted on respective vehicles and able to transmit to the operations centre (3) data associated with historical events that fails to require priority transmission to the operations centre (3) and data associated with extraordinary events that requires immediate and priority transmission to the operations centre (3). The operations centre (3) aggregates the trajectories associated with different vehicles, creating a road graph, accumulating on this graph critical traffic positions and disrupted traffic positions for extraordinary events based on data coming from the electronic control units of the vehicles or possibly other information sources, such as institutional traffic authorities, weather offices or highway authorities. Thanks to the visual and audible warnings that the apparatus can transmit to the driver, these deriving from its characteristics and interaction with the expert system resident in the operations centre, the system is able to prevent accidents and reduce risk.

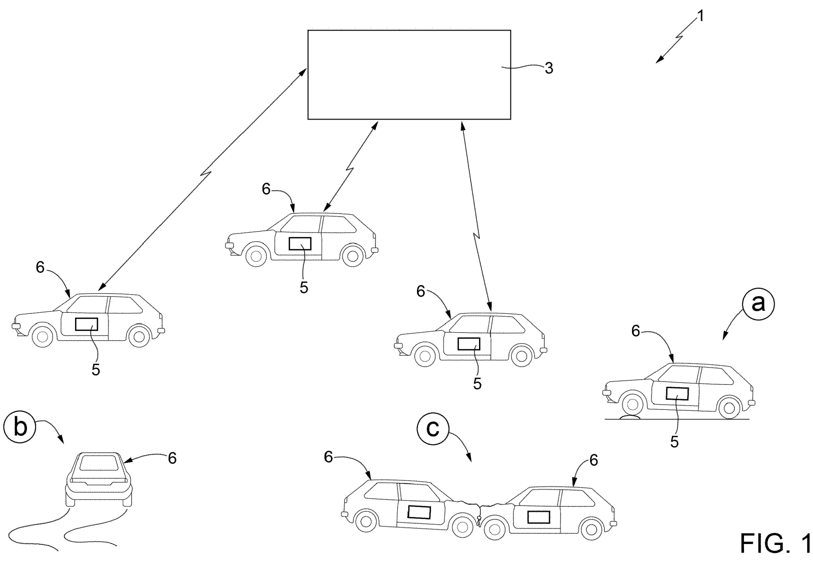

FIG. 1

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Description

[0001] The present invention relates to an expert system for integratedly managing vehicle driving safety and computing an interactive road risk map.

[0002] As is known, satellite navigators display road speed limits set by an highway authority and are designed to acoustically/visually signal hazards when a vehicle travelling along a road stretch exceeds the speed limit. The hazard warning can be set by the driver by parameterizing the threshold that triggers generation of the hazard warning.

[0003] For example, TomTom™ navigation devices can display speed limits next to the instantaneous vehicle speed. In the event of a road speed limit being exceeded, the instantaneous vehicle speed is displayed in red.

[0004] Furthermore, by now, nearly all smartphones on sale are equipped with a GPS module that, along with an Internet connection, provides extremely precise and reliable road driving indications. The smartphones may also provide indications of the road speed limits of the various road stretches.

[0005] The road speed limit shown by the navigator does not always correspond to that in force on that specific road stretch at that precise moment. Roadworks, certain weather conditions or hazardous situations in general, are the main reasons that cause the highway authorities to modify (normally reduce) the road speed limits. To this end, GPS devices (for example the device known by the brand name Coyote™) have recently been proposed that allow manually changing the road speed limit when the driver is sure of the inconsistency between the road speed limits displayed by the device and by the road signs. In addition, once the road speed limit has been changed, this information is automatically sent to a control unit that, after authenticity is verified, shares it with all owners of the device.

[0006] The object of the present invention is to provide a driver assistance system in which the road speed limit is not defined based on road signs provided by the highway authority, but on real road conditions as derived from prior travel data and events that have characterized road transit. In addition, the object of the present invention is to provide an indication of a potential hazard when vehicle speed and driving style are not consistent with the type and characteristics of the road being travelled on, independently of the road speed limit assigned to that road.

[0007] This object is achieved by the present invention, which relates to an expert system for integratedly managing vehicle driving safety and computing an interactive road risk map, wherein at least one operations centre operates, by means of bidirectional data exchange, with intelligent control units mounted on respective vehicles and adapted to real-time collect data and to continuously transmit the collected data to the operations centre; each intelligent control unit cooperates with on-vehicle sensors adapted to determine the instantaneous vehicle position and acceleration and vehicle propulsion system operation data, characterized in that each electronic control unit is configured to detect historical events that characterize the normal travel of the vehicle and store, in a non-volatile memory, data associated with the historical events and that fails to require priority transmission to the operations centre; the electronic control unit is further configured to transmit data associated with the historical events to the operations centre upon occurrence of a particular trigger event; and detect extraordinary events that characterize hazardous situations during vehicle travel and store data associated with these extraordinary events in a non-volatile memory; the electronic control unit is further configured to immediately and priorityly transmitting to the operations centre data associated with the extraordinary events and the vehicle position upon detecting these extraordinary events; the operations centre (3) is further configured to determine and store positions of each vehicle by tracking vehicle trajectory in a cartographical area of interest; the vehicle trajectory is associated with the vehicle speed, acceleration and travel direction in various successive positions; the operations centre is further configured to aggregate the vehicle trajectories of different vehicles to create a road graph that describes vehicle traffic travel direction and intensity in the cartographical area of interest, the operations centre is adapted to identify, on the road graph, critical traffic positions, in particular intense and/or slow-moving road traffic positions, by aggregating vehicle trajectories of different vehicles in the same position of the area of interest or in the same time frame; the operations centre is further adapted to identify, on the road graph, disrupted traffic positions due to extraordinary events based on the data from the electronic control units of the vehicles; the operations centre is further adapted to compute, for road sections in the road graph, a hazard index for a specific section based on a function based on a number of critical traffic and disrupted traffic positions identified in that section; the operations centre is further adapted to compute, for the road sections in the road graph, an average overall travel speed based on accumulated historical data and data relating to the road stretch; the operations centre is further adapted to transmit the hazard indexes and the average speeds of each road section examined to every intelligent control unit; each intelligent control unit is further adapted to monitor the instantaneous vehicle speed, compare it with the average overall travel speed of the section currently engaged, and send a hazard warning to the driver if the instantaneous speed fails to conform to the average speed for that road stretch; and each intelligent control unit is further adapted to monitor the instantaneous vehicle acceleration, compare it with limit accelerations modified based on the hazard index, and send a hazard warning to the driver if the accelerations fail to conform to the hazard level of that road stretch.

[0008] The invention will now be described with particular reference to the accompanying drawings, which show a preferred embodiment, in which:

Figure 1 schematically shows a system according to the present invention;

Figure 2 shows an intelligent control unit that is part of the system of the present invention;

Figure 3 shows a flowchart of the operation of the intelligent control unit;

Figure 4 shows a flowchart of the operation of an operations centre that is part of the system of the present invention; and

Figure 5 shows an operation diagram of the system of the present invention;.

[0009] In Figure 1, reference numeral 1 indicates, as a whole, an expert system for integratedly managing driving safety of a plurality of vehicles and computing an interactive road risk map.

[0010] The system 1 comprises an operations centre 3 that operates, by means of bidirectional data exchange, with intelligent control units 5 mounted on respective (schematically shown) vehicles 6 and adapted to collect data in real-time, continuously transmitting this information to the operations centre 3. As will be clarified below, each intelligent control unit 5 cooperates with sensors mounted on board the vehicle 6 and adapted to detect the instantaneous position of the vehicle, the acceleration of the vehicle and data characterizing the operation of the propulsion system of the vehicle.

[0011] Figure 2 shows the details of a possible physical implementation of the control unit 5 that comprises:

- a microprocessor control unit 7;
- a two-way communications module 8, for example a GSM 2G/3G or LTE (second/third generation GSM) module;
- a triaxial acceleration sensor 9 (for example, made using MEMS technologies) and a gyroscope;
- a satellite navigation system 10 designed to provide, amongst other things, the instantaneous position of the vehicle defined by the latitude and longitude coordinates and by the timestamp (date/time in UTC format);
- an interface 11 designed to allow communication via a serial standard with the vehicle fieldbus CAN-bus that connects a number of electronic control units (ECU) of the vehicle 6.
- a first memory 12 containing map data;
- a second memory 13 for recording data measured during travel of the vehicle 6;
- a warning device 14 (flashing LED indicator/buzzer) designed to provide an optical/acoustic hazard warning;
- a communication unit 15 equipped with microphone/speaker for voice communication with an operations centre operator and for playing recorded alert voice messages; and
- logic 16 for establishing the ignition switch status of the vehicle (on/off) via a physical signal or via opportune logic that combines the accelerometer signal, variation in vehicle battery voltage and the GNSS signal.

[0012] The control unit 5 is conveniently housed in a single casing made of an impact-resistant material that can be easily installed in the interior of the vehicle, for example, on the windscreen of the vehicle, or on top of or below the dashboard (not shown) of the vehicle.

[0013] According to the present invention, the control unit 5, under the control of the microprocessor unit 7, is capable of detecting historical events (Figure 3, block 100) that characterize normal travel/operation of the vehicle and store, in non-volatile memory 13, data associated with these historical events that does not require priority transmission to the operations centre 3.

[0014] In particular, the intelligent control unit 5 detects and stores one or more of the following historical data items that characterizes travel of the vehicle:

- the instantaneous position of the vehicle 6. This information can be conveniently detected by the system 10. The accumulation of successive instantaneous positions contributes to defining a trajectory that represents the route of the vehicle;
- the travel direction of the vehicle 6. This information can be conveniently detected by the system 10;
- the acceleration of the vehicle 6 along a longitudinal and a transverse axis of the vehicle. This information can be conveniently detected by the sensor 9;
- the acceleration of the vehicle 6 along a longitudinal and a transverse axis if this exceeds respective thresholds values. This information can be conveniently detected by the sensor 9;
- the altitude at which the vehicle 6 is located. This information can be conveniently detected by the system 10; and
- the state of the inputs of the electronic engine control system, such as, for example, ignition switch status, vehicle battery voltage, internal battery voltage, consumption and fuel level, engine speed, instantaneous speed, and fault status. This information can be conveniently detected through the interface 11.

[0015] The electronic control unit 5 is configured for transmitting, using module 8, data associated with the historical events to the operations centre 3 upon the occurrence of a particular trigger event (block 200). Among the trigger events that cause transmission of the historical data stored in memory 13, the following may be provided:

the start of a trip, by reading a physical signal (KEY - ON) or by way of self-determination upon accelerometer variation or voltage variation of the vehicle battery;

the end of a trip, by reading a physical signal (KEY - OFF) or by way of self-determination upon accelerometer variation or voltage variation of the vehicle battery;

travelling a route with a given distance in kilometres with the vehicle 6 (for example, every 10 (ten) km travelled); travelling a route with a given time frame (for example every minute or fraction of a minute); reaching a parametric threshold of the number of data items associated with historical events stored in memory 13.

[0016] The control unit 5 is also capable of continuously detecting (block 120, following block 100) extraordinary events that characterize hazardous situations during travel of the vehicle 6 and store data associated with these extraordinary events in a non-volatile memory. The electronic control unit 5 is also configured for the immediate and priority transmission of data associated with the extraordinary events and the vehicle position upon detecting these extraordinary events to the operations centre 3.

[0017] In greater detail, the control unit 5 is capable of detecting at least one of the following extraordinary events (see also Figure 1) :

a) contact between the wheels of the vehicle 6 and a hole and/or a bump of the roadway; contact is detected by monitoring the acceleration of the vehicle along a vertical axis Z to recognize the contact if the acceleration exceeds a threshold Zmax. The acceleration signal is expediently filtered with a band-pass filter to eliminate spurious interference, related to signal background noise or false signalling;

b) skidding of the vehicle 6; skidding is detected by monitoring the acceleration of the vehicle along horizontal axes X and Y in order to recognize skidding when said acceleration exceeds - along at least one axis - a respective threshold;

c) collision of the vehicle 6 with another vehicle or with a fixed structure; collision is detected by monitoring the acceleration of the vehicle along horizontal axes X and Y in order to recognize a collision when said acceleration exceeds respective second thresholds, higher than the first thresholds.

[0018] Following detection of an extraordinary event, the control unit 5 continuously transmits data related to the detected instantaneous acceleration and instantaneous vehicle position data to the operations centre for a given period of time.

[0019] In addition, after detecting extraordinary events, all the data associated with the historical events stored up to that point is transmitted.

[0020] Referring to Figure 4, the operations centre 3 is configured to detect and store the positions of every vehicle, assigning these positions to a specific stretch of road, by means of a Kalman filter, to define the trajectory T of each vehicle (block 300) in a map area of interest (see Figure 5). The trajectory T is associated with vehicle speed, acceleration and travel direction in different successive positions.

[0021] The operations centre 3 analyses the individual positions received and the quality of these positions. The quality of each position is identified by a value known as "HDOP" coming from the GNSS sensor 10 of the control unit 5. Given these samples, the operations centre 3 li aggregates them, according to tolerance parameters so as to identify a specific stretch of road characterized by one or more driving directions and average speed for different time bands of the day (for example, four bands).

[0022] In this way, the operations centre 3 can also promptly identify new stretches of road, or changes in the direction of traffic, not yet published on official maps. It should be noted that commercial and paid maps publish new releases quarterly, but a new road is not always indicated in the next release.

[0023] A road graph is thus created (block 310) that describes the travel direction and intensity of vehicle traffic in the map area of interest.

[0024] The operations centre 3 is able to detect (block 320), on the road graph, the positions of critical traffic (indicated by a triangle containing the symbol '!'), in particular the positions of intense and/or slow-moving road traffic, aggregating trajectories of different vehicles in the same position in the area of interest or in the same time frame. For example, a position of slow-moving traffic can be identified when the trajectories of vehicles build up anomalously in a certain zone and are characterized by low speed.

[0025] The operations centre 3 is able to detect (block 330), on the road graph, the positions of disrupted traffic (indicated by a circle with a bar '-' inside) corresponding to extraordinary events coming from the electronic control units of the vehicles. In this way, the positions where skidding or accidents have occurred, or where there are bumps or holes, are accumulated on the road graph.

[0026] The operations centre 3 is able to calculate (block 340), for road sections S1, S2, ... Sn of the road graph, a hazard index P1, P2, Pn for the specific section according to a function (for example, a weighted average k1*P1 + K2*P2 + ..., Kn*Pn) based on the number of positions of critical traffic (triangles with '!') and disrupted traffic (circles with '-') detected in that P^{th} section. The hazard index can be calculated on the basis of the historical positions acquired by the intelligent control units 5 and transmitted to the operations centre 3. It should be remembered that each GNSS position is supplied with instantaneous speed and instantaneous direction information. Therefore, it is possible to determine the hazard index of each road by examining the speed/direction ratio of each point of the single stretch of road.

[0027] The expert system 1 can also provide for real-time notifications regarding the weather in the geographic area in which the control unit 5 is located. This information can contribute to the calculation of the hazard index, as adverse weather conditions (driving rain, snow, ice, wind, etc.) further condition the hazard index of the road, making it worse. Thanks to the expert system's real-time communications capability, the data in the intelligent control units 5 can be updated with the current weather situation and with the forecast for the immediate future.

[0028] In the example in Figure 5, section P1, which has two triangles (!) and one circle (-), is more dangerous than section P2, which does not have positions of critical traffic (triangles) or disrupted traffic (circles).

[0029] The operations centre 3 is also able to calculate (block 350), for road sections S1, S2, ... Sn of the road graph, an average overall travel speed vm on the basis of accumulated historical data related to that stretch of road. For example, section S1 Vm1 = 100 Km/h, section S2 Vm2 = 110 Km/h, and section S3 Vm3 = 80Km/h. The operations centre 3 (block 360) can transmit the hazard indexes P1, P2, ... Pn and the average speeds of every section or the section the vehicle is currently travelling on to every intelligent control unit 5.

[0030] Preferably, a specific non-volatile memory of the intelligent control units 5 contains map "sheets" indicating the road sections of same geographic area. When it is in movement, the intelligent control unit 5 performs an operation known as "Reverse Geocoding" to identify the correct road section loaded in its memory. If this section is not found, the control unit 5 connects to the operations centre 3 to request a new map sheet and its neighbours.

[0031] Each intelligent control unit 5 (referring again to Figure 3) is able to monitor the instantaneous speed of the vehicle (block 140) to compare it (block 150) with the average overall travel speed of the currently engaged section, in order to send a hazard warning (block 160) to the driver (activation of the warning device 14) if the detected instantaneous speed does not conform to the average speed for that stretch of road. In particular, the GNSS signal communicates an instantaneous speed value to the device's microprocessor every second. Thus, this value can be easily compared with that characterizing the average speed for the stretch of road on which the device is travelling. In addition, the intelligent control unit 5 implements a hysteresis filter to notify the driver of exceeding the threshold, but only after this threshold has been continuously exceeded for a few seconds.

[0032] Each intelligent control unit 3 is able the monitor the instantaneous acceleration of the vehicle (block 170) to compare it with limit accelerations, modified as a function of the hazard index Pn related to the section currently engaged by the vehicle, to send a hazard warning to the driver (activation of the warning device 14) if the detected accelerations do not conform to the hazard level of that stretch of road.

[0033] In this way, each time that the expert system notices the speed limit for the specific section based on its current conditions has been exceeded, it emits a luminous and audible warning. Similarly, each time that the expert system notices a driving style (the driving style is characterized by the acceleration profile and by the signal coming from the gyroscope) unsuitable for the specific section, it emits a luminous and audible warning. According to the present invention, the safety threshold is not given by the "static" speed limit set by the legislator (in Italy, 130 km/h for motorways, 110 km/h for dual carriageway, 90 km/h for main and secondary roads and 50 km/h for urban roads), but is calculated by the system on the basis of the historical travel of vehicles that have engaged the stretches of road with a certain speed and takes into account the real and current road conditions. A road that is uneven, slippery or characterized by statistically dangerous curves will "collect" many extraordinary events, such as bumps/holes, sharp braking, skidding, and even accidents.

[0034] In this way, driving safety is significantly improved as the driver continually receives information in real time indicating the state of the road being driven along.

Claims

1. An expert system for integratedly managing vehicle driving safety and computing an interactive road risk map, wherein at least one operations centre (3) operates, by means of bidirectional data exchange, with intelligent control units (5) mounted on respective vehicles and adapted to real-time collect data and continuously transmit the collected data to the operations centre (3); each intelligent control unit (5) cooperates with on-vehicle sensors adapted to determine instantaneous vehicle position and acceleration and data characterising operation of a vehicle propulsion system, **characterized in that** each intelligent control unit (5) is configured to:

    - detect historical events that characterize a normal vehicle travel and store, in a non-volatile memory (13), data associated with historical events that fail to require priority transmission to the operations centre (3); said intelligent control unit being configured for transmitting data associated with historical events to the operations centre (3) upon the occurrence of a particular trigger event; and
    - detect extraordinary events that characterize hazardous situations during vehicle travel and store data associated with these extraordinary events in a non-volatile memory (13); said intelligent control unit being configured for the immediate and priority transmission of data associated with the extraordinary events and the vehicle position upon detecting these extraordinary events to the operations centre (3);

    said operations centre (3) being configured for detecting and storing the positions of each vehicle by tracking the trajectory T of the vehicle in a cartographic area of interest; the trajectory T is associated with vehicle speed, acceleration and travel direction in various successive positions;

said operations centre (3) being further configured to aggregate the position data of the trajectories in order to identify a specific road stretch belonging to a road graph that describes vehicle traffic direction and intensity in the cartographic area of interest,
said operations centre being adapted to identify, on said road graph, critical traffic positions, in particular intense and/or slow-moving road traffic positions, by aggregating trajectories of different vehicles in the same position in the area of interest or in the same time frame;
said operations centre being adapted to identify, on said road graph, disrupted traffic positions due to extraordinary events on the basis of said data coming from the intelligent control units of the vehicles;
said operations centre being adapted to compute, for road sections of the road graph, a hazard index for the specific section according to critical traffic and disrupted traffic positions detected **in that** road section;
said operations centre being adapted to compute, for said road sections of the road graph, an average overall travel speed on the basis of accumulated historical data and data relating to that road stretch;
said operations centre being adapted for transmitting the hazard indexes and the average speeds of each road section examined to every intelligent control unit;
each intelligent control unit being adapted to monitor the instantaneous vehicle speed, comparing it with the average overall travel speed of the section currently engaged, and send a hazard warning to the driver if the detected instantaneous speed fails to conform to the average speed for that road stretch; and
each intelligent control unit being adapted to monitor the instantaneous acceleration and/or signals coming from a gyroscope of the vehicle, compare it with limit accelerations modified as a function of the hazard index, and send a hazard warning to the driver if the detected accelerations fail to conform to the hazard level of that stretch of road.

2. The system according to claim 1, wherein the intelligent control unit (5) is configured to detect at least one of said trigger events:

the start of a trip, by reading a physical signal (KEY - ON) or by way of self-determination based on an accelerometer variation or on a voltage variation of the vehicle battery;
the end of a trip, by reading a physical signal (KEY - OFF) or by way of self-determination based on an accelerometer variation or on a voltage variation of the vehicle battery;
travelling a route with a given distance in kilometres;
travelling a route with a given time frame; and
reaching a parametric threshold of the number of data items associated with historical events.

3. The system according to claim 1 or 2, wherein said intelligent control unit (5) is configured to detect said historical data by detecting and storing one or more of the following data items that characterize vehicle travel:

- an instantaneous vehicle position;
- a vehicle travel direction;
- a vehicle acceleration along a longitudinal and a transverse vehicle axis;
- a vehicle acceleration along a longitudinal and a transverse axis if the vehicle acceleration exceeds threshold values;
- a vehicle acceleration along a vehicle vertical axis to determine bumps or holes;
- a vehicle altitude;
- a state of physical or logical inputs of the electronic engine control system, such as, for example, ignition switch status, vehicle battery voltage, internal battery voltage, consumption and fuel level, engine speed, instantaneous speed, and fault status.

4. The system according to any one of the preceding claims, wherein, upon detection of extraordinary events, the intelligent control unit is adapted to transmit continuously, for a given time period, data relating to the instantaneous acceleration detected and the instantaneous position data of the vehicle, to the operations centre.

5. The system according to any one of the preceding claims, wherein, upon detection of extraordinary events, all the data associated with the historical events stored up to that point is transmitted.

6. The system according to claim 1, wherein said intelligent control unit is provided with a GNSS module adapted to real time detect a vehicle position defined by latitude and longitude coordinates and by a timestamp (date/time in UTC format).

7. The system according to claim 1, wherein said operations centre is configured to filter the positions received by means of a Kalman filter, thereby filtering out noise components so as to obtain the estimate of the real instantaneous vehicle position.

8. The system according to any one of the preceding claims, wherein said intelligent control unit is adapted to detect at least one of the following extraordinary events:

contact between vehicle wheels and a roadway hole and/or bump;

said contact being detected by monitoring vehicle acceleration along a vertical axis to recognize the contact if said acceleration exceeds a threshold;
vehicle skidding; said skidding being detected by monitoring vehicle acceleration along horizontal axes X and Y in order to recognize skidding when said acceleration exceeds respective first thresholds;
vehicle collision with another vehicle or with a fixed structure; said collision being detected by monitoring vehicle acceleration along horizontal axes X and Y in order to recognize a collision when said acceleration exceeds respective second thresholds, higher than the first thresholds.

9. The system according to any one of the preceding claims, further configured to real time signal meteorological situation in the geographical area in which an intelligent control unit (5) is located; said information is used for computing the hazard index.

10. The system according to any one of the preceding claims, wherein the hazard warning is of an audible type, a luminous type or comprises recorded messages for the driver.

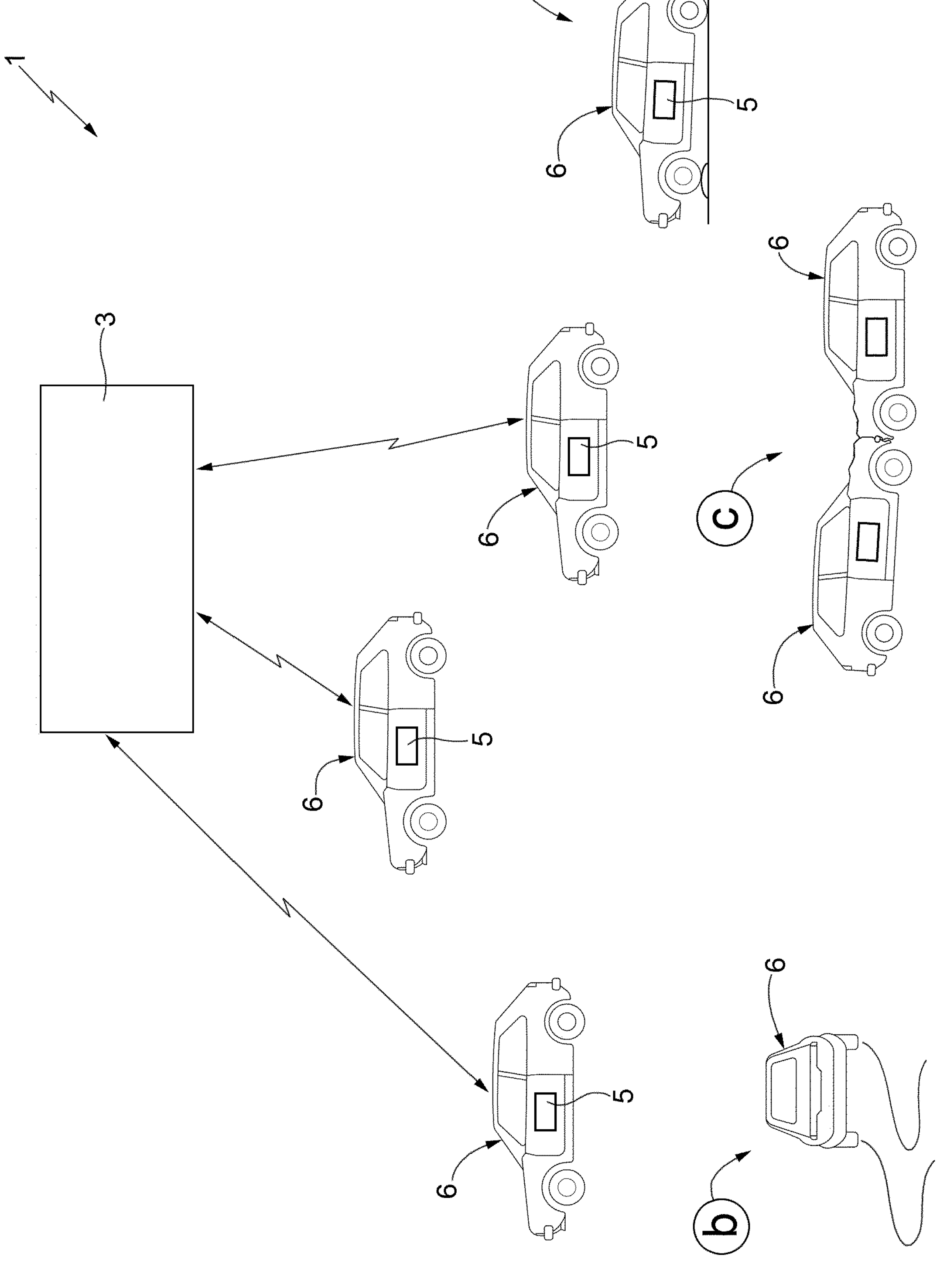

FIG. 1

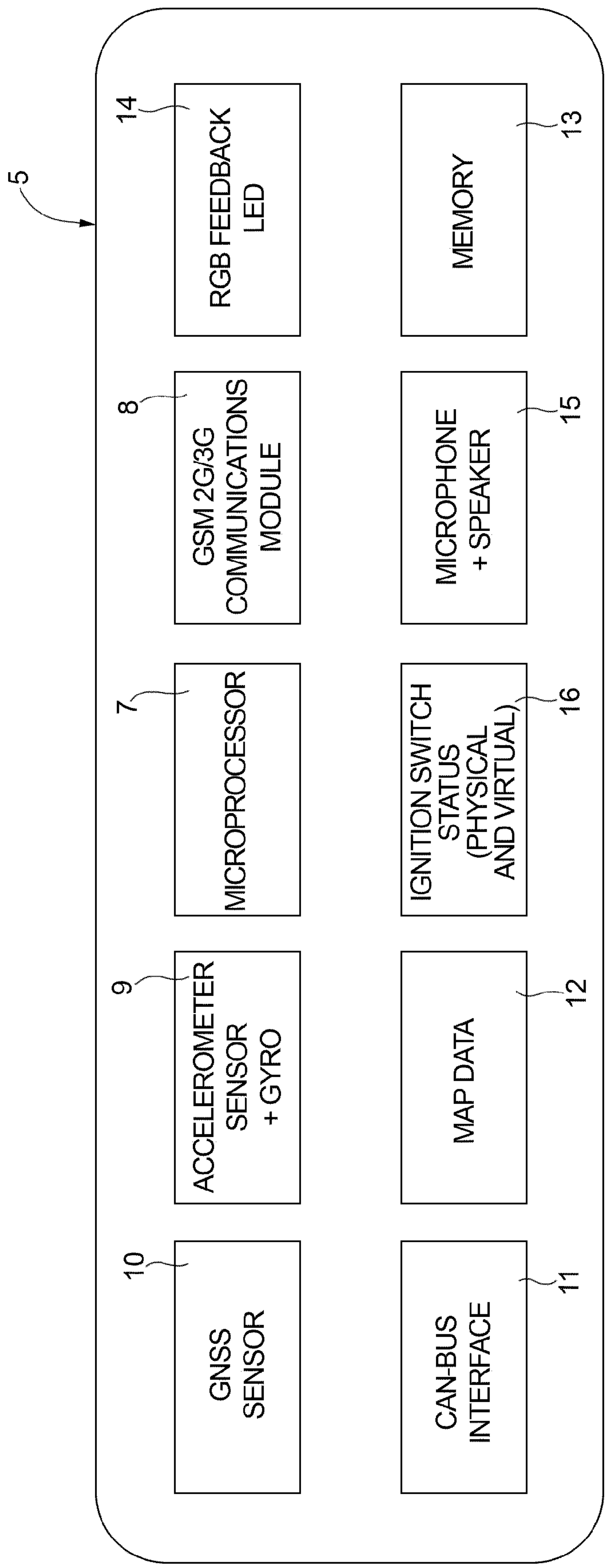
5
GNSS SENSOR
10
ACCELEROMETER SENSOR + GYRO
9
MICROPROCESSOR
7
GSM 2G/3G COMMUNICATIONS MODULE
8
RGB FEEDBACK LED
14
CAN-BUS INTERFACE
11
MAP DATA
12
IGNITION SWITCH STATUS (PHYSICAL AND VIRTUAL)
16
MICROPHONE + SPEAKER
15
MEMORY
13

FIG. 2

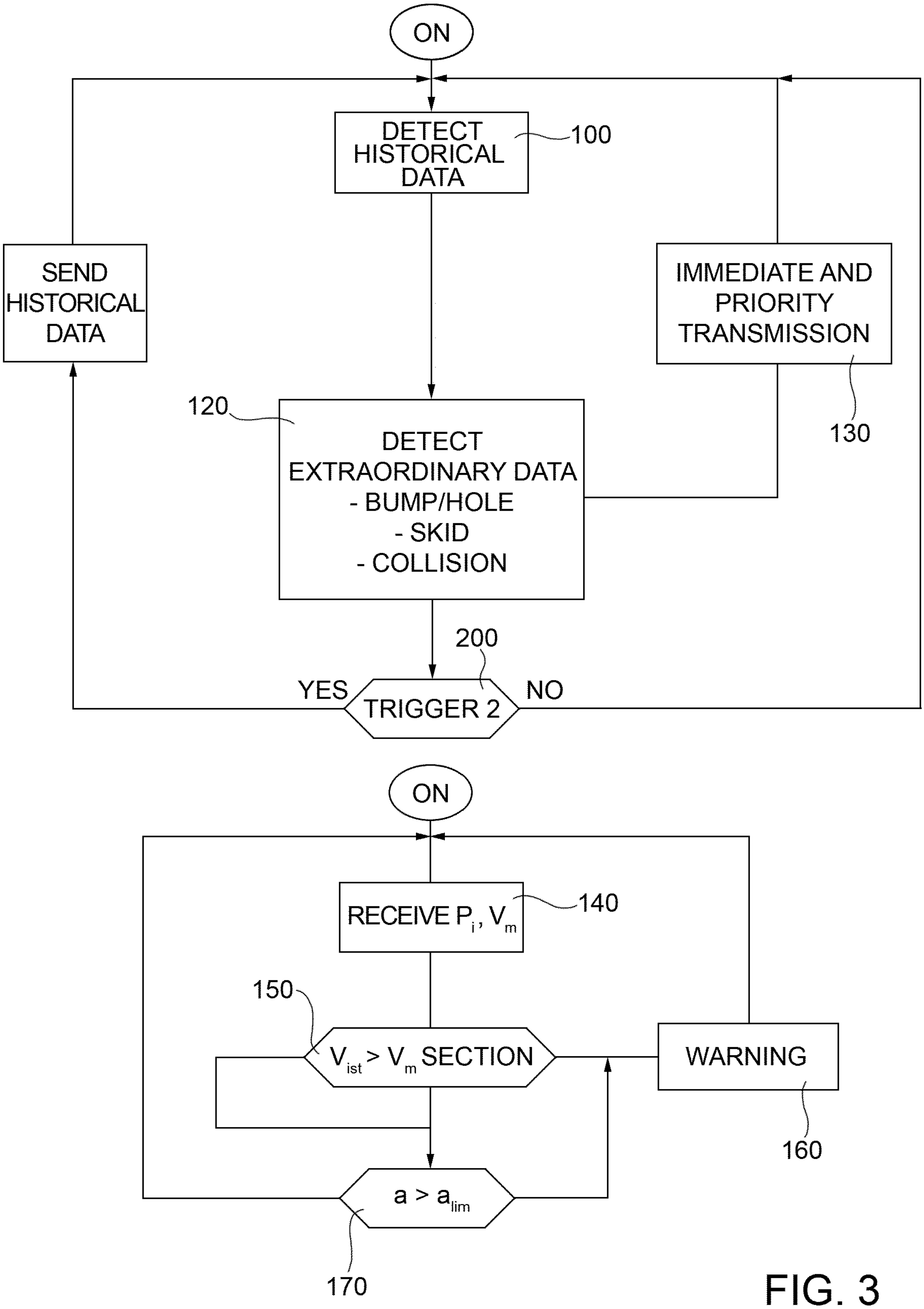
ON
DETECT HISTORICAL DATA
100
SEND HISTORICAL DATA
IMMEDIATE AND PRIORITY TRANSMISSION
130
120
DETECT EXTRAORDINARY DATA
- BUMP/HOLE
- SKID
- COLLISION
200
YES
TRIGGER 2
NO
ON
RECEIVE P_i, V_m
140
150
$V_{ist} > V_m$ SECTION
WARNING
160
$a > a_{lim}$
170

FIG. 3

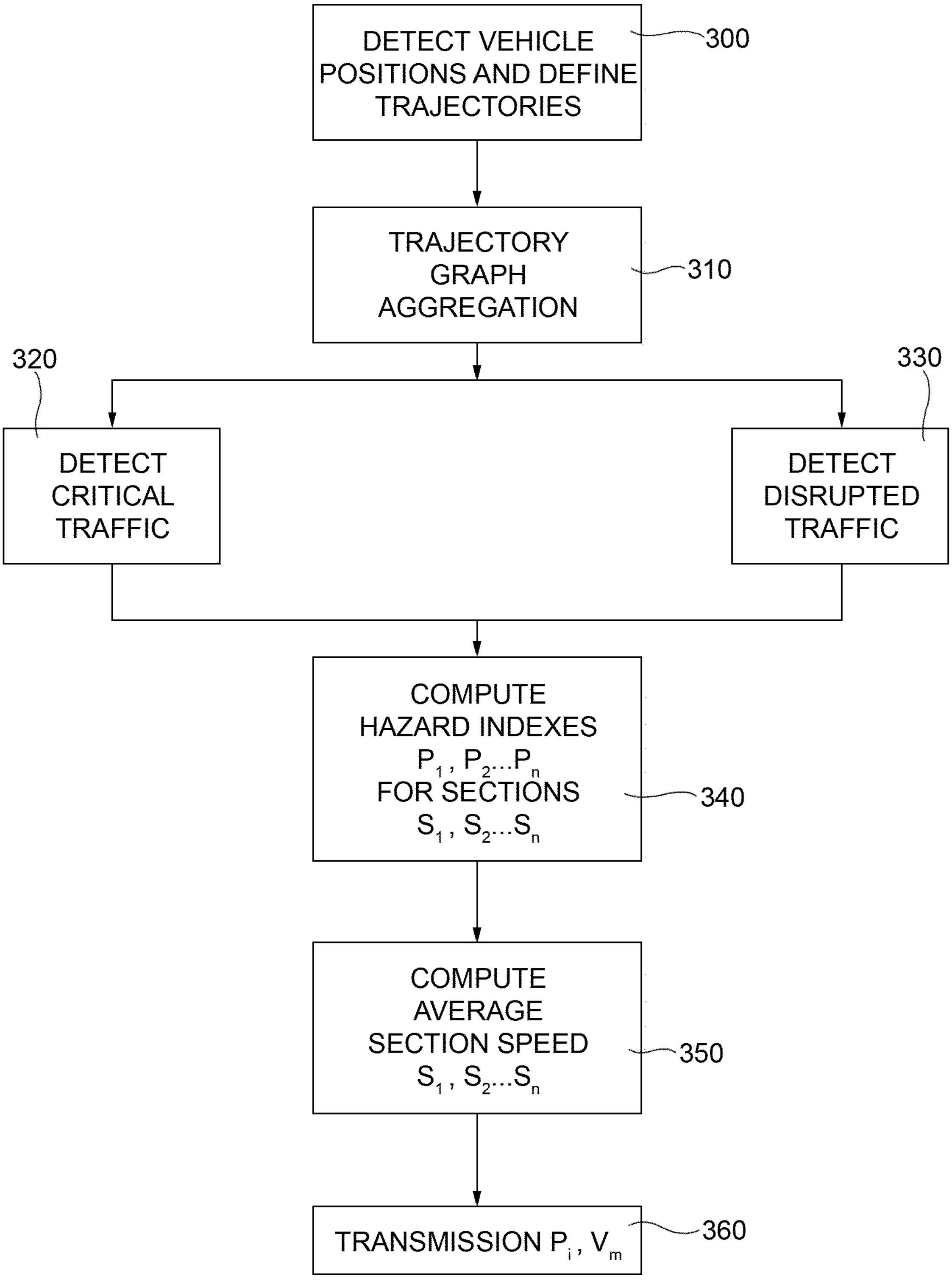
DETECT VEHICLE POSITIONS AND DEFINE TRAJECTORIES
300
TRAJECTORY GRAPH AGGREGATION
310
320
330
DETECT CRITICAL TRAFFIC
DETECT DISRUPTED TRAFFIC
COMPUTE HAZARD INDEXES $P_1, P_2 ... P_n$ FOR SECTIONS $S_1, S_2 ... S_n$
340
COMPUTE AVERAGE SECTION SPEED $S_1, S_2 ... S_n$
350
TRANSMISSION P_i, V_m
360

FIG. 4

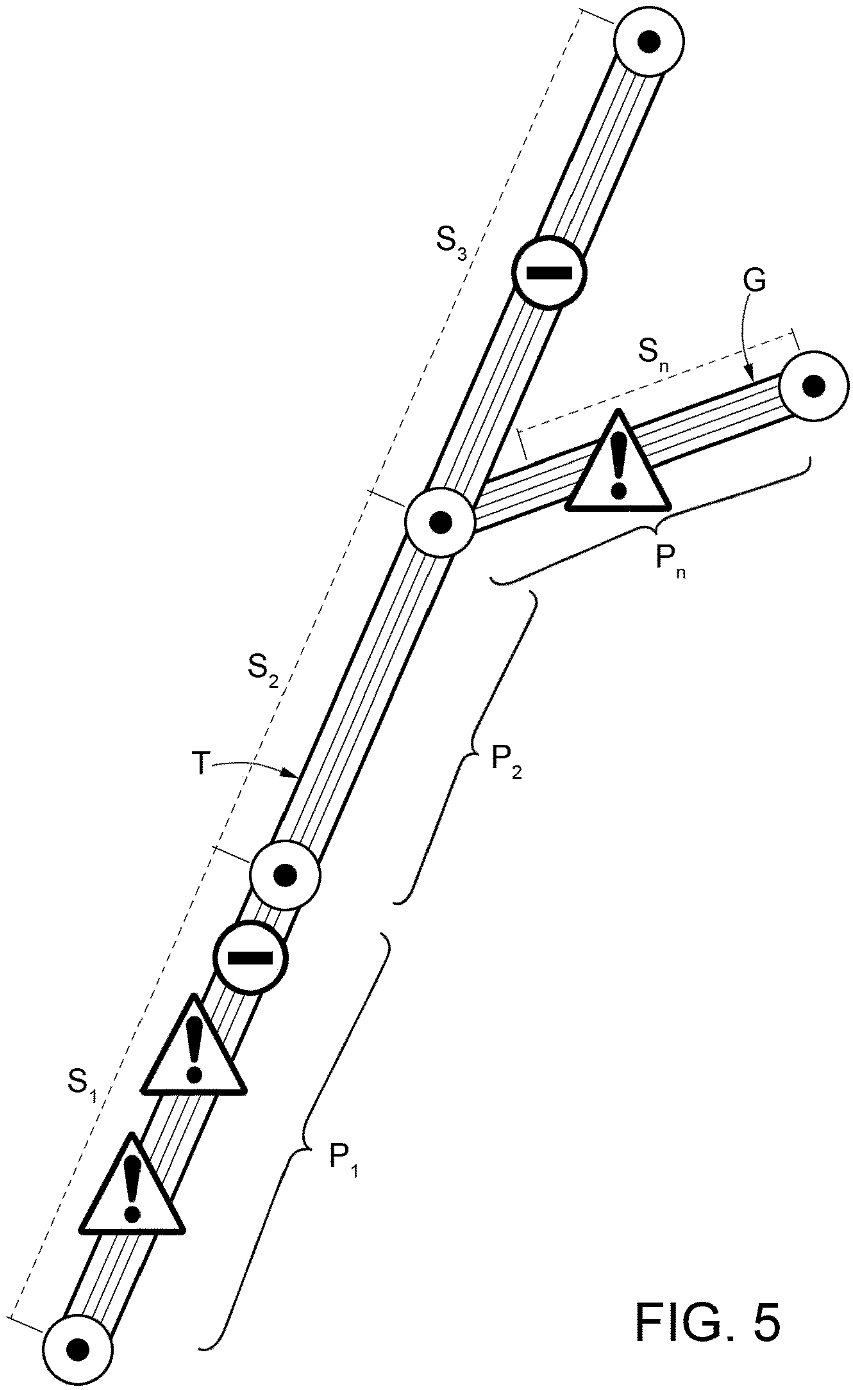

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 2922

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	WO 2015/008290 A2 (SECURE4DRIVE COMM LTD [IL]) 22 January 2015 (2015-01-22) * page 7, line 1 - line 6 * * page 8, line 2 - page 9, line 7; figure 1 * * page 17, line 1 - page 19, lines 14, 29 * * page 23, line 5 - line 6 * * page 25, line 28 - page 26, line 29 * * page 29, line 10 - line 29 * * page 31, line 1 - line 3 * -----	1-10	INV. G08G1/0967 G08G1/01
X	US 2012/158276 A1 (KIM HYUN-SUK [KR] ET AL) 21 June 2012 (2012-06-21) * paragraphs [0039], [0071] - paragraph [0104] * -----	1-3,6,9,10	
X	US 2009/140887 A1 (BREED DAVID S [US] ET AL) 4 June 2009 (2009-06-04) * paragraphs [0109], [0404] - paragraph [0629]; figures * -----	1-10	TECHNICAL FIELDS SEARCHED (IPC)
A	EP 1 591 980 A1 (FIAT RICERCHE [IT]) 2 November 2005 (2005-11-02) * paragraph [0019] - paragraph [0029]; figures * -----	1-10	G08G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	24 August 2017	Malagoli, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 16 2922

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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24-08-2017

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