Title: REDUCED DIMENSIONS DEVICE AND METHOD FOR DETECTING ROAD ACCIDENTS AND DRIVING STYLES

Abstract: A device (1) to be installed on board vehicles, designed for automatic detection of road accidents and of the modalities with which a vehicle is driven and for storage of the data detected, comprises: first means (3), designed to measure the six components of acceleration (ax, ay, az, qx, ay, az) of said vehicles; and second means (4), provided with absolute-time reference, for processing and storing the data supplied by said first means (3); said accidents being detected when the combination of said six components of acceleration (ax, ay, az, qx, ay, az), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicles. A method for detecting road accidents undergone by vehicles envisaged direct detection of the six components of acceleration (ax, ay, az, qx, ay, az) of said vehicles, said accidents being detected when the combination of said six components of acceleration (ax, ay, az, qx, ay, az), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicles.
REDUCED DIMENSIONS DEVICE AND METHOD FOR DETECTING ROAD
ACCIDENTS AND DRIVING STYLES
* * * * * *

The present invention relates to a device designed for automatic detection of road accidents and of the modalities with which a vehicle is driven (driving habits and style) and for storage of the data detected.

The device according to the invention is able to transmit to a second device the information stored, said second device being designed to retransmit the information stored, integrating it with the geolocation data, to a remote data-processing centre (also using the GSM, GPRS or UMTS cellular network).

The invention also regards a method, implemented by the device, which envisages direct detection of the six components of acceleration (ax, ay, az, ax, ay, az) of said vehicle, and their subsequent processing.

It is envisaged that the invention is installed on board vehicles such as cars, small four-wheeled vehicles, motorcycles, mopeds, vans, lorries, articulated vehicles, caravans, and buses.

The device is installed on board the vehicle that is to be monitored, said monitoring possibly having purely insurance purposes. The device may be considered a black box.

To save on the insurance policy for motor vehicles, there is an increasing use of a means that consists of a sort of black box, i.e., a device installed on the motor vehicle for detecting the data regarding driving of the vehicle and saving them in the event of possible accidents.
Said device basically comprises a GPS (Global Positioning System) satellite navigation system, a chronometer, and a computer.

The GPS system receives signals from satellites orbiting around the Earth, processing of which enables precise determination of the position of the vehicle on which said system is installed. By differentiating twice the position with respect to time, the device is able to calculate the speed of advance of the vehicle and its acceleration. An accident is detected if the accelerations to which the vehicle is subjected are not compatible with its technical characteristics. In this case, an alarm signal is emitted that can be sent to a remote receiver, which sends a breakdown or rescue crew.

Said device of the known art presents, however, two drawbacks.

A first drawback lies in the fact that processing of the signals is slow and imprecise. In fact, it is necessary in the first place to process the signals coming from the satellites for determining the position, and then it is necessary to perform two subsequent operations of differentiation for determining the accelerations. These operations are executed while the vehicle is moving, and the time necessary for processing markedly limits the sampling frequency of the signals, with the consequence that the precision of calculation of the accelerations may be jeopardized. In fact, an acceleration peak, due to impact against another vehicle or against a fixed obstacle might not be detected properly on account of a
sampling frequency that is not sufficiently high. In other words, if the accident is of slight intensity, it might not be detected at all, in so far as the acceleration peak could be markedly flattened owing to insufficient samplings and, hence, not be interpreted as signal of occurrence of an accident.

A second drawback lies in the fact that the GPS system supplies a point position of a vehicle that moves on a generally plane or slightly inclined surface. Processing can hence lead to the determination of just two components of acceleration, not providing any indication on the remaining four.

Paradoxically, if the vehicle were to knock down a safety barrier and end up in a ditch, a device of the known art might not detect any anomaly because the acceleration peak due to the impact against the safety barrier could be too weak to be detected, whilst the subsequent fall into the ditch, which would come about with acceleration "g" if the banks were vertical, would be totally ignored in so far as the GPS system provides approximate indications of the movements over the Earth's surface and not in a direction perpendicular thereto. The accident could be detected in so far as, according to the map, the vehicle would no longer be on the road surface, but in the ditch. However, also this detection technique would be deficient in so far as the vehicle could be removed voluntarily from the road surface. Moreover, the maps are not always sufficiently precise, or else might not be updated. Hence it would not be possible to establish with certainty where the vehicle has stopped.
The present invention overcomes the drawbacks described by proposing a device and a method for detecting accidents according to Claims 1 and 24, respectively.

The device, which is designed for automatic detection of road accidents and of the modalities with which a vehicle is driven and for storage of the data detected, is characterized in that it comprises:

- first means, designed to measure the six components of acceleration \((a_x, a_y, a_z, \alpha_x, a_y, a_z)\) referred to a cartesian system fixed with respect to the device; and
- second means for processing and storing the data supplied by said first means;

said accidents being detected when the combination of said six components of acceleration \((a_x, a_y, a_z, \alpha_x, a_y, a_z)\), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicle.

The method according to the invention is characterized in that it envisages direct detection of the six components of acceleration \((a_x, a_y, a_z, \alpha_x, a_y, a_z)\) of said vehicle, said accidents being detected when the combination of said six components of acceleration \((a_x, a_y, a_z, \alpha_x, a_y, a_z)\), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicle.

The device measures directly the six components of acceleration, describing completely, and in real time, the behaviour of the vehicle.
In other words, the device according to the invention does not detect the possible accident by processing the variation of its position, but directly by processing the six components of acceleration. In the case described of a vehicle that has fallen into a ditch, the device according to the invention would be able to detect the impact against the safety barrier, albeit very small, in so far as the acceleration peak is detected with much greater precision. The subsequent fall into the ditch would be detected in so far as there would be measured a marked variation of the vertical component \((a_z)\) of the acceleration, even though the other two components \((a_x, a_y)\) were to be compatible with the technical characteristics of the vehicle. Finally, the accident would be detected also because an anomalous variation of the three components of acceleration \((a_x, a_y, a_z)\) regarding rotation about the three axes of the reference system would be detected. This means that if the vehicle, for example, an off-road vehicle, voluntarily enters a dip or crosses a small stream, but its accelerations are compatible with its technical characteristics, the device will not issue any alarm signal, even though the device detects that the vehicle has left the road surface or is in a stream. Instead, the device according to the invention will issue an alarm signal if the vehicle were to end up in a ditch, even in the case where it was not marked on the map. In this case, the components of acceleration and their progression would be somewhat different from the ones that would be detected if the entry into the ditch were voluntary.
The device is then pre-arranged for keeping intact, in the event of an accident, the information recorded in a lapse of time of some tens of seconds before and after impact so as to provide the person responsible with a set of information useful for reconstructing the dynamics thereof.

The device according to the invention, in real time or at a subsequent instant, transmits the data to a second device, there being provided radio transmission means, with short-range or Bluetooth technology and/or a serial port and corresponding wiring.

Use of a device according to the invention renders fraud to the detriment of the insurance company far more difficult, so that it is possible to reduce the insurance premium significantly.

If it were to emerge that the driving style of the subject concerned were such as to minimize the risks of accident, the insurance company could propose a considerable reduction in the premium to the virtuous driver, with mutual advantage. In fact, the insurance company would have an edge over its competitors in so far as it would be facilitated in acquiring drivers with a low accident risk.

According to a preferred embodiment, the device according to the invention is produced so as to be contained in a case having a shape suitable for being installed within the passenger compartment or the engine compartment, possibly on the very battery from which it receives electrical supply.

The device has a shape such as to be provided on
one side with slotting elements so as to be integrated with said second device. On the same side, the serial socket is present, which enables communication of the data to said second device, in the case of integration.

The invention will now be described by way of non-limiting illustration, according to a preferred embodiment, with reference to the attached figures, in which:

- Figure 1 shows the block diagram of the device according to the invention and of the second device that integrates the function thereof;
- Figure 2 shows the device according to the invention integrated with a second device; and
- Figure 3 shows said second device separated from the device according to the invention.

With reference to Figure 1, designated by (1) is the device according to the invention, represented by a block diagram. Designated by (2) is a second device according to the invention. Said first device (1) comprises:

- means (3), designed to measure the six components of acceleration (ax, ay, az, ax, ay, az) referred to a cartesian system fixed with respect to the device (1), said means comprising an inertial system based upon accelerometric or gyroscopic sensors or gyrocompasses;
- means (4), provided with absolute-time reference, for treatment of data and their storage, designed to associate the aforesaid absolute-time reference to the events recorded, said means (4) comprising a
first microcomputer;
- transceiver means (5), designed to exchange data via radio or with other short-range wireless transmission means (also using Bluetooth technology) with said second device (2);
- means (6), comprising a serial port, for direct connection of the first device (1) to said second device (2);
- means (7) for electrical supply of its own circuits; and
- means (7a) for transfer of electrical supply to the second device (2).

The first device (1) according to the invention is built to withstand, without corruption of the internal memory, shocks with high intensity of acceleration (for example, 50 g or 60 g, g = 9.81 m/s²).

Said second device (2) comprises:
- means (8) designed to measure the spatial co-ordinates associated to the device (2) itself and defined with respect to a reference system fixed with respect to the Earth, said means (9), comprising a location system of the GPS (Global Positioning System), Glonass, or Galileo type, or a combination of a number of systems;
- means (9), for treatment of data and their storage, designed to associate the geolocation data, coming from said means (8), to the data regarding processing operations carried out by said first microcomputer (4) on the events recorded, said means (9) comprising a second microcomputer;
- transceiver means (10) designed to exchange data
via radio or with other short-range wireless transmission means (also using Bluetooth technology), with said first device (1);

- means (11), designed to transmit with radio systems (also using the GSM, GPRS, or UMTS cellular network) the data processed by said microcomputer (9) to a remote data-processing centre;

- means (6a), comprising a serial port, for direct connection of the second device (2) to said first device (1); and

- means (7b) for electrical supply of its own circuits.

The two devices (1) and (2) can be mechanically connected to one another, as illustrated in the subsequent Figures 2 and 3, or else may be separate, even though installed in one and the same vehicle.

In the first case, transfer of the data between the first device (1) and the second device (2), and vice versa, is made via the serial port (6, 6a). The electrical supply, acquired by the first device (1) via said means (7), is transferred to the device (2) via said means (7a).

In the second case, transfer of the data between the first device (1) and the second device (2), and vice versa, is made via said transceiver means (5) and (10). Electrical supply of the second device (2) is provided via said means (7b), which will be connected to the battery of the vehicle.

Said first microcomputer (4) processes the data coming from the inertial system (3), through the line (12).
The first microcomputer (4) is provided with a first algorithm for self-calibration that enables identification of the triad of the main axes of inertia of the vehicle and setting thereof in relation with the main axes of inertia of the inertial system (3). Consequently, the first device (1) can be installed in any position with respect to the vehicle.

Detection of road accidents and of the driving modalities, such as variations of speed or direction of travel, is made thanks to a continuous monitoring, carried out by the inertial system (3), of the linear and angular accelerations to which the vehicle is subjected. The monitoring is carried out with periodic readings of the accelerations (for example, with a frequency of 100 Hz or, preferably, 1000 Hz or higher).

The first microcomputer (4) is provided with a second algorithm, designed to process the accelerometric data read. An accident is detected when the combination of the six components of acceleration ($ax$, $ay$, $az$, $αx$, $ay$, $az$), or their resultant, has characteristics of value and progression that are not compatible with the technical characteristics of said vehicle.

The first microcomputer (4), through the line (13), can send the results of processing operations to said transceiver means (5) (via Bluetooth), which retransmit them to the second device (2), which receives them via said transceiver means (10) and transfers them to the second microcomputer (9) via the line (14), immediately after recording or at a subsequent instant.
In the case where the two devices (1) and (2) are connected mechanically, transfer of the data is made via the serial port (6, 6a).

The second device (2) combines the data received with the geolocation data coming from the location system (8) through the line (15), and transfers them, through the line (16), to said transmission means (11), which retransmit them to a remote data-processing centre.

At the moment when an accident event (or a crash) is detected, in a purposely provided memory of said first microcomputer (4) the information of acceleration, speed and position of the vehicle is stored for a period of time (for example, 75 s) that includes a time interval prior to the accident, the time interval in which the accident has occurred, and a time interval subsequent to the accident. Also stored are the date and time of the event.

The speed can be determined by means of integration of the accelerometric data coming from the inertial system (3). However, to prevent effects of drift, it is preferable to use the geolocation data coming from the location system (8) and processed by the second microcomputer (9), said processed data being retransmitted to the first device (1) via said transceiver means (5) and (10), or else through said serial port (6, 6a), if connected.

The microcomputer (4) is further provided with a third algorithm for processing the accelerometric data read, said third algorithm enabling identification of various driving modalities, such as, by way of non-
exhaustive example:
• positive or negative longitudinal accelerations of the vehicle;
• variation of the direction of travel of the vehicle;
• variations of the trim attitude of the vehicle (identification of the angles of pitch, roll, and yaw); and
• events that are the result of the simultaneous or sequential combination of one or more of the previous modalities.

A driving characteristic is detected when a certain number of successive samples of the six components of acceleration (ax, ay, az, qx, qa, az) or their resultant presents given characteristics of value and progression. Depending upon the values and the type of progression, the event will be classified in one of the categories of modality already described. At the moment when an event-modality is detected, the fact is recorded, and the information of acceleration of speed and position of the vehicle for the time interval in which the event-modality has occurred, as well as the date and time of the event.

Said means (7) for power supply of the first device (1) may consist of simple wiring for connection to the battery of the vehicle, or else may comprise a small battery, integrated in the device (1), which guarantees supply of its own circuits even in the absence of connection to the battery of the vehicle. In order to prevent drawing-off of energy from the battery of the vehicle, the first device (1) is pre-arranged
for going into standby when it is not being used, recharging of its battery taking place automatically when the vehicle housing the device is moving and with the control panel switched on.

5 If the first device (1) is provided with said battery of its own for power supply, it is envisaged that, in the case where it were disconnected from the battery of the vehicle, said transmission means (5) will be deactivated.

10 In this circumstance, the device will go automatically into energy-saving mode, in which it will identify turning-off of the engine or use of the vehicle through reading of the accelerations. In the energy-saving mode, the only function active during the use of the vehicle will be that of detection and recording of possible road accidents. The device is likewise able to record the event of disconnection of supply.

Illustrated in Figures 2 and 3 is a device (1) according to the invention, built so that it can be installed within the passenger compartment or the engine compartment of the vehicle.

Fixing of the device is obtained using a biadhesive or magnetic medium.

20 In Figures 2 and 3, the first device (1) is integrated with the second device (2). In this case, on the side of interfacing of the two devices, there will be present the serial ports (6, 6a) and the means for transmission of electrical supply (7a, 7b), in such a way that, by interfacing the two devices, the connections for the transfer of data and electrical
supply are simultaneously made.

According to one embodiment of the invention, the first device (1) can be used by itself, i.e., without functional integration with the second device (2). In this case, it will be possible just to record and store the events to which the vehicle is subjected, but not to transmit them. In the case of accident, it will then be possible, through the serial port (6), to download the data stored and to reconstruct the dynamics of the accident itself.

According to a preferred embodiment, in the case of the first device (1), a pushbutton is provided, by pressing which sending of the data to said second device (2) is forced, via said wireless radio connection means (5) or serial connection means (6).

The invention has been described, by way of non-limiting example, according to a preferred embodiment. The person skilled in the sector may devise numerous other embodiments, all of which fall within the sphere of protection of the annexed claims.
CLAIMS

1. A device (1) to be installed on board vehicles, designed for automatic detection of road accidents and of the modalities with which a vehicle is driven and for storage of the data detected, characterized in that it comprises:
   - first means (3), designed to measure the six components of acceleration (ax, ay, az, ax, ay, az) of said vehicles; and
   - second means (4), provided with absolute-time reference, for processing and storing the data supplied by said first means (3); said accidents being detected when the combination of said six components of acceleration (ax, ay, az, ax, ay, az), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicles.

2. The device (1) according to Claim 1, characterized in that said first means (3), designed to measure the six components of acceleration (ax, ay, az, ax, ay, az) of said vehicles, comprise an inertial system based upon accelerometric or gyroscopic sensors or gyrocompasses.

3. The device (1) according to Claim 1, characterized in that said second means (4), for processing and storing the data supplied by said first means (3), comprise a first microcomputer.

4. The device (1) according to Claim 3, characterized in that said first microcomputer (4) is provided with a first algorithm designed to process the
accelerometric data read so as to identify the triad of the main axes of inertia of the vehicle and set them in relation with the main axes of inertia of said inertial system (3).

5. The device (1) according to Claim 3, characterized in that said first microcomputer (4) is provided with a second algorithm designed to process the accelerometric data read so as to detect an accident, said accident being detected when the combination of said six components of acceleration \((ax, ay, az, ax, ay, az)\), or their resultant, present characteristics of value and progression that are not compatible with the technical characteristics of said vehicles.

6. The device (1) according to Claim 3, characterized in that said first microcomputer (4) is provided with a third algorithm designed to process the accelerometric data read so as to enable identification of various driving modalities such as:

- positive or negative longitudinal accelerations of the vehicle;
- variation of the direction of travel of the vehicle;
- variations of the trim attitude of the vehicle (identification of the angles of pitch, roll, and yaw); and
- events that are the result of the simultaneous or sequential combination of one or more of the previous modalities.

7. The device (1) according to Claims 1 to 6, characterized in that it further comprises third means
8. The device (1) according to Claim 7, characterized in that said third means, designed to transmit the results of processing operations carried out by said first microcomputer (4) comprise a short-range wireless-transmission device (5).

9. The device (1) according to Claim 7, characterized in that said third means, designed to transmit the results of processing operations carried out by said first microcomputer (4), comprise a serial port (6).

10. The device (1) according to at least one of Claims 1 to 9, characterized in that it envisages a second device (2) designed to associate the data regarding processing operations carried out by said first microcomputer (4) on the events recorded to geolocation data and to transfer them to a remote data-processing centre.

11. The device (1) according to Claim 10, characterized in that said second device (2) comprises:
   • fourth means (8) designed to measure the spatial coordinates associated to the device (2) itself;
   • fifth means (9) for treatment of data and their storage, designed to associate the geolocation data coming from said means (8) to the data regarding processing operations carried out by said first microcomputer (4) on the events recorded, said means (9) comprising a second microcomputer; and
   • sixth means designed to receive the results of processing operations carried out by said first
12. The device (1) according to Claim 11, characterized in that said sixth means designed to receive the results of processing operations carried out by said first microcomputer (4) comprise a short-range wireless-transmission device (10).

13. The device (1) according to Claim 11, characterized in that said sixth means designed to receive the results of processing operations carried out by said first microcomputer (4) comprise a serial port (6a).

14. The device (1) according to at least one of Claims 10 to 13, characterized in that said third means (5, 6), designed to transmit to said second device (2) the results of processing operations carried out by said first microcomputer (4), are designed also to receive data from said second device (2).

15. The device (1) according to at least one of Claims 11 to 14, characterized in that said sixth means (10, 6a), designed to receive from said first device (1) the results of processing operations carried out by said first microcomputer (4), are designed also to transmit data to said first device (1).

16. The device (1) according to at least one of Claims 1 to 15, characterized in that it further comprises power-supply means (7), said means (7) comprising a small battery, integrated in the first device (1), which guarantees supply of its own circuits even in the absence of connection to the battery of the vehicle.

17. The device (1) according to Claims 10 and 16,
characterized in that it is pre-arranged for de-activating automatically said third means (5), designed to transmit via radio the data acquired to said second device (2), in the case where said first device (1) were disconnected from the battery of the vehicle housing the device.

18. The device (1) according to at least one of Claims 1 to 17, characterized in that it is inserted in a case having a shape such that it can be installed within the passenger compartment or the engine compartment of the vehicle.

19. The device (1) according to Claims 10 and 18, characterized in that it envisages engagement means for connecting said second device (2) to said first device (1).

20. The device (1) according to Claim 19, characterized in that it envisages, on the side of interfacing of said two devices (1) and (2), said serial ports (6, 6a) and means for transmission of electrical supply (7a, 7b), in such a way that, by interfacing the two devices, the connections for transfer of the data and for electrical supply are simultaneously provided.

21. The device (1) according to at least one of Claims 10 to 20, characterized in that fixing of said first and second devices (1) and (2) is obtained via a biadhesive or magnetic medium.

22. The device (1) according to at least one of Claims 1 to 21, characterized in that it is pre-arranged for withstanding, without corruption of the internal memory, shocks with high intensity of
acceleration, up to 50-60g.

23. The device (1) according to at least one of Claims 10 to 22, characterized in that it envisages a pushbutton, on the outer case, by pressing which sending of the data to said second device (2) through said wireless radio connection means (5) or serial connection means (6) is forced.

24. A method for detecting road accidents undergone by vehicles, characterized in that it envisages direct detection of the six components of acceleration (ax, ay, az, αx, ay, az) of said vehicles, said accidents being detected when the combination of said six components of acceleration (ax, ay, az, ax, ay, az), or their resultant, present characteristics of a value and progression that are not compatible with the technical characteristics of said vehicles.

25. The method according to Claim 24, characterized in that the frequency of sampling of the values assumed by said six components of acceleration (ax, ay, az, ax, ay, az) is equal to or higher than 1000 Hz.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G07C5/08 G07C5/00 G01P15/14 G01P15/18

ADD.

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

**B. FIELDS SEARCHED**

 Minimum documentation searched (classification system followed by classification symbols)

G07C G01P G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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 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

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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

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Date of the actual completion of the international search: 27 June 2013

Date of mailing of the international search report: 08/07/2013

Name and mailing address of the ISA:

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel: (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer:

Mandato, Davide
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