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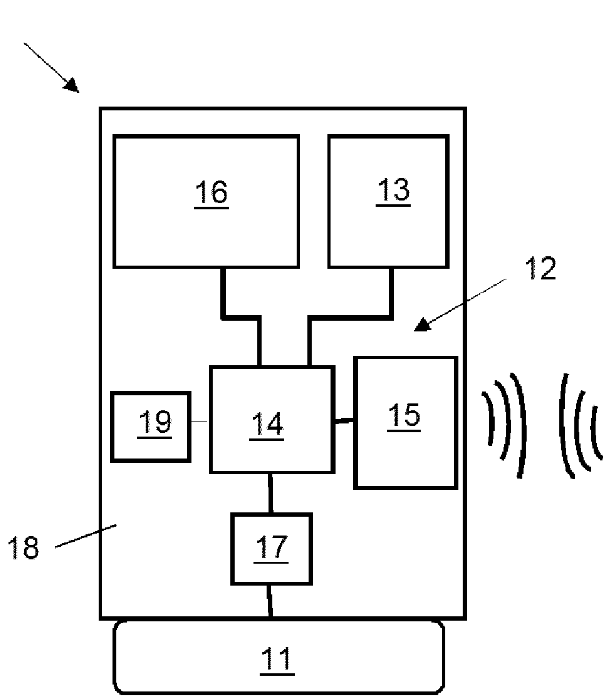
(54) METHOD, DEVICE AND SYSTEM FOR DETECTING A COLLISION IN A MOTOR VEHICLE

(57) Method for detecting a collision in a motor vehicle comprising the steps of monitoring (A2) the acceleration of the motor vehicle; and detecting (A3) whether the acceleration of the motor vehicle meets at least one predetermined collision condition; and transmitting a sequence (A4) with motor vehicle acceleration values prior and subsequent to detection. The device (1) for detecting a collision in a motor vehicle by means of said method comprises an electronic circuit (12) provided with an accelerometer (13); processing means (14) for monitoring (A2) the acceleration of the motor vehicle and detecting (A3) whether the acceleration meets at least one predetermined collision condition; and communication means (15) for transmitting (A4) a sequence with motor vehicle acceleration values prior and subsequent to detection.

Fig. 1



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Description

Technical field of the invention

[0001] The method, device and system of the present invention relate to those that enable detecting a collision in the motor vehicle in which it is loaded.

Background of the invention

[0002] Devices for detecting a collision in motor vehicles are known; however, said devices do not allow detecting collisions in a reliable way because they are usually produce false positives, since speed of detection takes precedence over reliability in this type of devices.

[0003] To improve this drawback, the devices have been endowed with greater processing power, such that the detection of the collision is more reliable, however, endowing the devices with greater processing capacity greatly increases their cost. This increase in processing also entails significant delays that could lead to detecting the collision long after it occurred or even not detecting it if the device suffers any kind of damage or breakage during the collision.

[0004] In order to prevent the device from being damaged or broken during a collision, it is common for the device or at least part of the sensors thereof to be integrated into the motor vehicle, so that a user cannot access the device easily, for example, to replace it if a malfunction is detected.

[0005] It is therefore an objective of the present invention is to disclose a device and method for detecting collisions in motor vehicles that enables quickly and reliably detecting a collision in order to reduce false positives.

[0006] It is also another objective of the present invention to disclose a system and method that, by means of the device of the present invention, enables verifying the situation of the detected collision.

[0007] Still another objective of the present invention is disclosing a method, system and device for detecting a collision in a motor vehicle alternative to those known.

Description of the invention

[0008] The method of the present invention for detecting a collision in a motor vehicle relates to those that, being computer-implemented, comprises the steps of monitoring the acceleration of the motor vehicle and detecting whether the acceleration of the motor vehicle meets at least one predetermined collision condition.

[0009] In essence, the method is characterized in that after detecting that the acceleration of the motor vehicle meets at least one predetermined collision condition, it comprises the step of transmitting a sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition, in order to thus be able to verify the collision situation externally to the device.

[0010] In a variant embodiment, a predetermined collision condition consists in that the acceleration of the vehicle exceeds a predetermined acceleration threshold. It has been observed that collisions can be detected by avoiding false positives when said predetermined acceleration threshold is 1 g.

[0011] In a variant embodiment, the method comprises the preliminary step of calibrating an accelerometer coupled to the vehicle in order to obtain a calibration vector for the acceleration, from which a horizontal plane of the vehicle as well as the acceleration of the motor vehicle can be determined.

[0012] In a variant embodiment, a predetermined collision condition is that the angle that the calibrated instantaneous acceleration vector with the calibration vector of the acceleration exceeds a predetermined inclination threshold. It has been observed that collisions can be detected by avoiding false positives when said predetermined inclination threshold is greater than or equal to 60 degrees.

[0013] It is also disclosed that in a variant embodiment, the method further comprises the steps of receiving the sequence in a computing device; modeling a pulse-shaped mathematical function starting from said sequence; and calculating verification parameters from the mathematical function and comparing them to threshold values of said verification parameters in order to verify the collision. Preferably, the mathematical function is a sinusoidal function, more specifically a haversine or squared sinusoidal function.

[0014] In a variation of interest, the step of modeling the mathematical function comprises carrying out successive approximations to the sequence.

[0015] In a variant embodiment, the verification parameters calculated from the mathematical function comprise the duration of the pulse of the function.

[0016] In a variant embodiment, the verification parameters calculated from the mathematical function comprise the average acceleration.

[0017] It is also disclosed that the verification parameters calculated from the mathematical function comprise the increase in speed obtained by means of the expression of the integral of the mathematical function.

[0018] It is also disclosed that the verification parameters calculated from the mathematical function comprise the increase in movement obtained by means of the expression of the double integral of the mathematical function.

[0019] It is also disclosed that the verification parameters calculated from the mathematical function comprise a coefficient of determination, for example, the average quadratic error, between the modeled mathematical function and the sequence that enables evaluating the similarity between the modeled mathematical function and the sequence.

[0020] In a variant embodiment, the method further comprises the steps of transmitting a warning signal after the collision has been verified; receiving the warning signal in a roadside assistance center; and the roadside assistance center establishing telephone communication with the vehicle.

[0021] It is also disclosed that before carrying out the step of transmitting the warning signal, a step for enabling means for cancelling the transmission of the warning signal during a predetermined waiting time is carried out, said means of cancellation being able to be activated by an occupant of the vehicle. Said predetermined waiting time is at least 30 seconds.

[0022] In a variant embodiment, the warning signal incorporates identification data so that the roadside assistance center can establish telephone communication with the vehicle.

[0023] A device is also disclosed for detecting a collision in a motor vehicle comprising an electronic circuit provided with an accelerometer for obtaining the acceleration of the motor vehicle; processing means for monitoring the acceleration of the motor vehicle provided by the accelerometer and detecting whether the acceleration of the motor vehicle meets at least one predetermined collision condition, derived from a collision pattern pulse; and communication means for transmitting a sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition.

[0024] In a variant embodiment, the processing means are adapted to calibrate the accelerometer and obtain a calibrating acceleration vector of said accelerometer.

[0025] Also disclosed is that the device further comprises means of coupling to the motor vehicle, said means of coupling to the motor vehicle being able to comprise a connector with the OBD port of the motor vehicle, such as OBD-II and EOBD, which further enable powering the device, being able to access other parameters of interest of the vehicle that can be transmitted either when the collision occurs, together with the sequence with acceleration values of the motor vehicle, which may be components of the instantaneous acceleration vector, prior and subsequent to detection of the predetermined collision condition, or at any time if the device receives a command to obtain an OBD parameter of the vehicle.

[0026] A system is also disclosed for detecting a collision in a motor vehicle comprising a device for detecting a collision in a motor vehicle and transmitting a sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition, as well as the calibrated vector; a telephone device adapted to receive the sequence and model a mathematical function from said sequence; calculating verification parameters from the mathematical function and comparing them to threshold values of said verification parameters extracted from a collision pattern pulse, such as those described by EURO-NCAP in order to verify the collision; and in this case, transmit a warning signal; and a roadside assistance center, which may be a telephone exchange, adapted to receive the warning signal from the computing device after verifying the collision and establishing telephone communication with the telephone device.

[0027] In a variant of interest, the telephone device is provided with means for cancelling transmission of the warning signal, said means of cancellation being able to be activated by an occupant of the vehicle and means for enabling said means of cancellation during a predetermined waiting time. The means of cancellation may be, for example, a computer program that is executed in the telephone device, the means of cancellation being a button or area of a touch screen of said telephone device that upon being actuated, would cancel transmission of the warning signal, for example, if it is a false positive.

[0028] In a variation of interest, the telephone device is provided with means for configuring both the predetermined collision condition or conditions of the device or the number of sequence samples with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition, which are transmitted after the predetermined collision condition.

Brief description of the drawings

[0029] As a complement to the description provided herein and for the purpose of helping to make the characteristics of the invention more readily understandable, said description is accompanied by a set of drawings which, by way of illustration and not limitation, represent the following:

Figure 1 shows a diagram of the device of the present invention;
Figures 2a and 2b show exterior views of the device of the present invention;
Figures 3a and 3b show a side view and a top view of a motor vehicle equipped with the device of the present

invention and a telephone device in calibration position;

Figure 4 shows the motor vehicle of Figures 3a and 3b on a slope;

Figure 5 shows the motor vehicle of Figures 3a and 3b after a collision;

Figure 6 shows an acceleration sequence sent after detecting a collision and the modeled mathematical function thereof;

Figure 7 shows the system for detecting a collision of the present invention; and

Figure 8 shows a diagram of the operating method of the system of the present invention.

Detailed description of the drawings

[0030] Figure 1 shows a process flow diagram of the device 1 for detecting a collision in a motor vehicle of the present invention. As can be seen, the device 1 comprises an electronic circuit 12 housed inside a protective casing 18, the electronic circuit comprising an accelerometer 13 for providing an instantaneous acceleration vector coupled to the vehicle through the coupling means; processing means 14 for calibrating A1 the accelerometer and obtaining a calibrating acceleration vector of said accelerometer; monitoring A2 the calibrated instantaneous acceleration vector of the accelerometer; and detecting A3 whether the calibrated instantaneous acceleration vector meets at least one predetermined collision condition; memory means 16, such as a RAM memory, in which the different calibrated instantaneous vectors are stored, for example, the Cartesian or polar three-dimensional components thereof. The electronic circuit 12 advantageously comprises communication means 15, such as a Bluetooth terminal, through which the sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition can be transmitted A4, which may be a sequence of components of the instantaneous acceleration vector, in other words, a portion of the sequence of acceleration values that the processing means 14 have been storing in the memory means 16. Naturally, it is expected that the memory means be dimensioned in such a way that sufficient previous and subsequent components can to be stored, for example, in circular fashion, by sequentially writing the memory and rewriting it from the beginning when it is filled, in a cyclical manner.

[0031] Thus, by means of the device 1 of the present invention after having calibrated the accelerometer 13 in a known way, so that the effect of the accelerations, which do not influence the trajectory of the motor vehicle, is eliminated in a known way. Preferably, in order to calibrate the accelerometer, the motor vehicle should be located on a surface as horizontal as possible, avoiding slopes that could distort the calibration and give incorrect calibrated values. By means of the calibration of the accelerometer 13, a calibrating acceleration vector is obtained from said accelerometer, which will essentially be made up of the weight of the sensor, pointing towards the center of the Earth. Naturally, the horizontal plane can be determined from said calibrating acceleration vector, which will be a normal plane to the calibrating acceleration vector, which will be parallel to said horizontal surface if the vehicle is arranged on a horizontal surface. Nevertheless, it has been found that when the motor vehicle is located on a slight slope, this does not decisively influence the calibration of the accelerometer 13, and therefore the operation of the device 1 is not sufficiently altered to prevent a collision from being safely detected and validated.

[0032] The device 1 should be coupled to the motor vehicle, so that the accelerometer 13 follows the trajectory of the motor vehicle and can obtain a calibrating acceleration vector, from which a horizontal plane of the vehicle and the acceleration of the motor vehicle can be determined. This coupling can be obtained when the accelerometer is part of an electronic circuit 12, arranged in an electronic board fastened to a casing 18 that protects it and that has an OBD connector for the fastening thereof to the OBD port of the motor vehicle, such as OBD-II or EOBD. Advantageously, the OBD port enables powering the device 1 upon being provided with a power terminal connected to the battery of the motor vehicle. In addition to powering the device 1, the OBD port enables giving access to the device 1 through other terminals of the motor and the motor vehicle parameters that can be useful to the device 1, as will be seen below, in a known way by means of a standard protocol. Naturally, it is also expected that the device 1 may be coupled to other parts of the vehicle, such as a power socket of the type usually used as a cigarette lighter or for powering devices. It is also expected that the device 1 be provided with its own power supply, such as disposable batteries or rechargeable batteries, so that it can be coupled to any part of the motor vehicle, even if it is not provided with a power socket. Nevertheless, this last embodiment requires the device 1 to be verified in order to prevent the disposable or rechargeable batteries thereof from running out.

[0033] The processing means 14 of the device 1 periodically monitor A2 the instantaneous acceleration vector of the accelerometer in order to detect A3 whether the instantaneous acceleration vector meets at least one predetermined collision condition. In addition, for further analysis, the instantaneous acceleration vectors that are monitored are stored in memory means 16, for example, by means of the same processing means 14 so as to be able to have a history of the instantaneous acceleration vectors. The memory means 16 can be a RAM memory where the components of the instantaneous acceleration vectors are written in a circular fashion, as a sequence. Preferably, the accelerometer 13 should enable providing a calibrated acceleration vector every 1 millisecond, although it has been found that this value can be increased to almost 2.5 milliseconds enabling collisions to be correctly detected and validated.

[0034] The device enables detecting a collision quickly and advantageously, by means of the evaluation of one or more predetermined collision conditions, which can be implemented in relatively simple processing means 14, such as a microcontroller or computer, the cost of which is not excessive. In order to prevent the detection of a false positive it is foreseen that, after detecting a possible collision, components of the instantaneous acceleration vectors prior and subsequent to the predetermined collision condition be sent to an external device that will carry out a more thorough processing of said components of the calibrated instantaneous acceleration vectors.

[0035] Thus, after detecting one of the predetermined collision conditions, the processing means 14 will continue to obtain instantaneous acceleration vectors from the accelerometer 13 and these, or the components thereof, will preferably be stored in the memory means 16 in order to be transmitted, by communication means 15, such as a Bluetooth terminal, to the external device that will process them to confirm the collision. The sequence with prior and subsequent acceleration values of the vehicle is expected to be about 1000 samples, of which 250 correspond to components prior to collision detection and 750 to components subsequent to collision detection, these 1000 samples corresponding to approximately 0.9 seconds. Naturally, it is expected that both the sample value of the sequence and the proportion of prior and subsequent samples be parametrizable, or can be configured during a start-up phase of the device 1, for example, through parameters sent through the communications means 15 of the device 1.

[0036] Although in the presented variation, the external device that will verify the collision is a mobile phone arranged inside the motor vehicle and connected, preferably wirelessly, for example, by means of Bluetooth, with the device 1, it is expected that the external device be a remotely located device, the communication means 15 of the device 1 being a terminal for data transmission and reception by means of wireless telephone networks.

[0037] One of the predetermined collision conditions may be that the module of a component of the instantaneous acceleration vector on the horizontal plane exceeds a predetermined acceleration threshold, for example, a threshold of 1 g, whereby an acceleration peak would be detected essentially in one of the movement directions of the motor vehicle.

[0038] Alternatively or complementarily, another triggering predetermined collision condition may be that the angle that the calibrated instantaneous acceleration vector forms with the horizontal plane exceeds a predetermined inclination threshold, such that anomalous rolling or inclination of the motor vehicle can be detected. Preferably, the inclination threshold will be 60 degrees.

[0039] In order to avoid having to incorporate an inclinometer in the device 1, which would add an additional electronic component, thereby making the device 1 more expensive and requiring a larger casing, the device 1 determines the angle that the calibrated instantaneous acceleration vector forms with the horizontal plane by calculating the angle formed by the calibrated instantaneous acceleration vector and the calibrating acceleration vector, rotated in a three-dimensional space by the angle that the calibrating vector forms with the vector $<0, 0,-1>$. In this case, as long as there are no accelerations in the Z-axis (they only occur slightly on inclined floors), the magnitude of the Z-component of the acceleration indicates the cosine of the angle that has inclined the vehicle. In order to calculate if rollover has occurred, all the monitored acceleration measurements will be analyzed. Those accelerations (not corrected with the calibrating acceleration) that exceed 1.1 or do not reach 0.9 in module are rejected. If any reading among those that are not rejected gives a Z-component value greater than '- 0.5', it is determined that a rollover has occurred. A Z-component value of '-0.5' will therefore correspond to an inclination of 60°; a Z-component value of '0' will correspond to an inclination of 90° (a quarter turn) and a Z-component value of '1' will correspond to an inclination of 180° (half turn).

[0040] As shown in Figures 2a and 2b, the device 1 has a casing 18 that seals the previously mentioned electronic components, and coupling means 11, such as a connector with an OBD port, which enables fastening the device 1 to the motor vehicle. Furthermore, in order to verify that the device 1 is correctly connected and powered by means of the OBD port, the device 1 has a light indicator 19, such as a LED, which lights up when the device 1 is powered. It is further expected that said light indicator 19 may provide additional information to the user during the operation of the device 1, for example, the light indicator 19 may light up intermittently before or during the pairing of the device 1 with a telephone device 2 by means of Bluetooth. It is also expected that the data that can be obtained from the OBD port can be transmitted when a collision is detected, so that it can be analyzed.

[0041] Figures 3a and 3b schematically show a motor vehicle provided with the device 1, which communicates wirelessly with a telephone device 2, also present inside the motor vehicle, it being, for example, the mobile phone normally used by one of the occupants of the vehicle in which a program has been installed enabling the telephone device to interact with both the device 1 and a roadside assistance center 3, as will be seen below.

[0042] After pairing the telephone device 2 with the powered device 1, it is expected that the computer program previously installed in the telephone device 2 send a set of configuration parameters to the device 1, such as number of samples to be stored per second, number of samples prior and subsequent to the predetermined collision condition. It is also expected that these configuration parameters enable activating the predetermined collision condition or conditions, as well as establishing the thresholds thereof. These configuration parameters will be stored in the computer program and both the computer program and the configuration parameters will be periodically updated by means of an update server.

[0043] If it is the first time the device 1 is paired with the telephone device 2, the computer program of the telephone device 2 will guide the user to calibrate A1 the accelerometer 13 in order to obtain the calibrating acceleration vector, from which it will be possible to determine both the horizontal plane of the motor vehicle. This calibration is necessary since the position of the accelerometer 13 after connecting the device 1 in the motor vehicle is not known in advance and accelerations that are not only due to the trajectory of the vehicle, such as weight, should be eliminated. It is also expected that the device 1 communicate motor vehicle data extracted from the parameters of the OBD port to the telephone device 2 after the pairing, such that the telephone device 2 can verify that the device 1 is not connected in a different motor vehicle than that to which it was previously calibrated, whereby the accelerometer 13 of the device 1 should be recalibrated, or the user should be alerted if the device 1 is only authorized for use in a single vehicle. Naturally, the device 1 can also make this verification by only informing the telephone device that the motor vehicle has changed since the last operation of the device 1. It is also expected that the user be able to calibrate the accelerometer 13 manually, for example, by means of an option of the telephone device 2 software. For calibration, the user will be instructed to place the vehicle on a surface as horizontal as possible, since it is expected that the trajectory of the vehicle will be mostly on said horizontal plane, such that from the components of the acceleration vector calibrated on said plane, in other words, components on the X and Y axes on said plane, it will be possible to determine the accelerations that will affect the trajectory of the vehicle. It is further expected that one of said axes, for example X, may be oriented in the longitudinal direction of the vehicle, in other words, in forward direction thereof in a straight line, while the other axis, Y, is oriented in transverse direction. After calibrating the accelerometer 13, the Z-axis thereof will remain oriented in a normal direction to the horizontal plane, such that the accelerations on this axis will serve to determine a possible rollover of the vehicle, when these are anomalous and exceed a predetermined threshold, for example, those corresponding to an inclination equal to or greater than 60°, which is highly unlikely to occur during circulation of the motor vehicle. Similarly, when the module of components in a direction in the horizontal plane, for example, the components of the acceleration vector calibrated on the X or Y-axes, exceed a predetermined threshold, such as 1 g, which is very unlikely to occur during circulation of the motor vehicle, a possible collision can be detected. Figures 3a and 3b show a schematic view of a motor vehicle with the device 1 connected to a telephone device 2 present in the motor vehicle after calibrating the accelerometer, in which the X, Y and Z-axes are indicated in Figure 3a, which shows a side view of the motor vehicle and in Figure 3b, which shows a top view of the motor vehicle; as can be seen, the X and Y-axes will determine the horizontal plane on which the components of the calibrated acceleration vector will be monitored in order to determine if a collision has occurred. Naturally, as shown in Figure 4, once the accelerometer 13 is calibrated, the direction of the X, Y, Z-axes thereof will remain fixed, whereby the horizontal plane will also be fixed in relation to the accelerometer. Advantageously, a collision can be detected after calibration regardless of the inclination of the road on which the motor vehicle is travelling.

[0044] As described previously, after calibrating A1 the accelerometer 13 of the device 1 in the motor vehicle and obtaining a calibrating acceleration vector, from which the horizontal plane will be determined, during circulation of the motor vehicle, the device 1 will begin to monitor A2 the calibrated instantaneous acceleration vector of the accelerometer in order to detect A3 whether the calibrated instantaneous acceleration vector meets at least one predetermined collision condition, for example, that the module of a component of the instantaneous acceleration vector in the horizontal plane exceeds the predetermined acceleration threshold of 1 g, such as that which occurs for example after a frontal collision as shown in Figure 5, or that the angle that the calibrated instantaneous acceleration vector forms with the horizontal plane exceeds the predetermined inclination threshold of 60 degrees, as detailed above.

[0045] In this case, a possible collision will be detected, whereby the device 1 will transmit the sequence A4 of components of the instantaneous acceleration vector prior to and subsequent to detection of the predetermined collision condition to the telephone device 2, which after receiving the sequence B1 will proceed to verify the collision by analyzing in greater detail the sequence of samples transmitted by the device 1.

[0046] To verify the collision, the telephone device 2, which could equally be any other computing device, such as an on-board computer of the vehicle, will proceed to model a pulse-shaped mathematical function B2 from the sequence, and calculate verification parameters from the mathematical function and compare them with threshold values of said verification parameters previously indicated in the computer application in order to verify the collision B3.

[0047] The modeled mathematical function can be, for example, a sinusoidal function, specifically a haversine or quadratic sinusoidal function. In this way, after modeling the parameters of the mathematical function, parameters relating to the acceleration, speed or movement of the vehicle can be quickly obtained, which, when compared with threshold values, will enable verifying the collision B3.

[0048] If the sequence of acceleration samples provided by the device 1 is modeled by way of haversine, the instantaneous acceleration will resemble the function:

$$a(t) = A sin^2 (\omega t + \varphi)$$

[0049] Therefore, the parameters of the mathematical function relative to the amplitude A, the angular frequency ω

and the phase φ must be obtained, and these will be obtained by means of the regression curve from the acceleration and time table of the sequence provided by the device 1 to the previously indicated acceleration equation. It is also expected that other pulse-shaped mathematical functions be used alternatively in order to model, for example, a square pulse, a triangle pulse or a sine-wave function from said sequence.

[0050] One option is to parametrize the values of the amplitude A, the angular frequency ω and the phase φ by means of the known Gauss-Newton algorithm. By means of this algorithm, given m data points (x_i, y_i), a regression is carried out to a function of n parameters $\vec{\beta} = (\beta_1, \ldots, \beta_n)$ by using the least squares method:

$$min_{\vec{\beta}}\ S(\vec{\beta}) \quad \text{where} \quad S(\vec{\beta}) = \sum_{i=1}^{m} r_i(\vec{\beta})^2 = (y_i - f(\vec{\beta}, x_i))^2$$

[0051] By means of this algorithm, modeling of the mathematical function is achieved by carrying out successive approximations of the sequence, thus obtaining parameters of amplitude A, angular velocity ω and phase φ. Naturally, when the mathematical function to be used is different, the parameters thereof should be obtained in a similar way. It is also expected that other known algorithms can be used to parametrize the values of amplitude A, angular frequency ω and phase φ, such as gradient descent.

[0052] Figure 6 shows a comparison between the sequence of accelerations (r1) provided by the device 1 and the mathematical function (r2) of the acceleration calculated by means of the previous method for a collision, in which it can be seen that the modeled mathematical function in fact follows the sequence of samples provided by the device 1.

[0053] Complementarily, the velocity can be obtained from the mathematical expression of the integral of the acceleration function by means of the same parameters, amplitude A, angular velocity ω and phase φ obtained previously:

$$V(t) = \int a(t)dt = \int A sin^2(\omega t + \varphi)dt$$

[0054] That by resolving and taking the initial conditions t=0, $V = V_0$

$$V(t) = \frac{A}{4\omega}\left[2(\omega t + \varphi) - \sin(2(\omega t + \varphi)) + (2\varphi - \sin(2\varphi))\right] - \frac{A}{4\omega}\left[2\varphi - \sin(2\varphi) + (2\varphi - \sin(2\varphi))\right]$$

[0055] Thus, although the initial velocity is not known, it is possible to calculate the mathematical function of the increase in velocity, which is:

$$\Delta V = \frac{A}{4\omega}\left[2(\omega t + \varphi) - \sin(2(\omega t + \varphi)) + (2\varphi - \sin(2\varphi))\right]$$

[0056] Likewise, by again integrating the mathematical formula of the velocity, the mathematical formula for calculating the movement would be obtained according to:

$$S(t) = \int v(t)dt =$$

$$\frac{A}{8\omega^2}\left(2\omega^2 t^2 + \cos(2\omega t + \varphi) + 2\omega t(4\varphi - \sin(2\varphi)) - \cos(2\varphi)\right) - \frac{A}{8\omega^2}\left(\cos(\varphi) - \cos(2\varphi)\right)$$

[0057] Thus, the verification parameters calculated from the mathematical function can comprise the duration of the pulse of the function, the average acceleration, the increase in velocity or the increase in movement. It is also expected that the verification parameters calculated from the mathematical function comprise a coefficient of determination such as the average quadratic error between the modeled mathematical function and the sequence.

[0058] Naturally, it is also expected that instead of modeling the parameters of the mathematical function of acceleration and, through said parameters by obtaining the velocities and movement from the integrals of the mathematical acceleration function, the velocities can be calculated as the summations of the acceleration samples provided by the device 1 and the movement as the summation of the calculated velocities. Although this method will be computationally more expensive, it will enable obtaining more reliable velocity and acceleration values.

[0059] As discussed above, the device 1 of the present invention and the telephone device 2 will be located in the motor vehicle, so that the device 1 can detect the collision and the telephone device 2 can verify the collision. As shown in the system in Figure 7, in addition to the device 1 and the telephone device 2, it is expected that the telephone device 2 may establish connection with a roadside assistance center 3 in order to transmit a warning signal B5 after verifying the collision. Upon receiving the warning signal C1, the roadside assistance center 3 will establish C2 telephone communication with the same telephone device of the vehicle, in order to attempt to contact the occupants.

[0060] In order to avoid false positives of detection and verification, it is expected that, prior to the step of transmitting the warning signal B5, the telephone device 2 carry out a step of enabling B4 means for cancelling the transmission of the warning signal during a predetermined waiting time, such as 30 seconds or more, such means of cancellation being able to be activated by an occupant of the vehicle, for example by displaying a warning signal. It is also expected that the warning signal incorporate identification data so that the roadside assistance center 3 can establish telephone communication with the telephone device 2 of the vehicle. It is also expected that the warning signal incorporate the position coordinates of the vehicle, which can be extracted from the telephone device 2 if it has a GPS or similar feature or even that the device 1 itself incorporates a GPS. It is also expected that the position coordinates of the vehicle be transmitted after a preset interval, so that it can be determined whether the vehicle is still moving after the collision. In this case, it can be determined that the collision has been minor or even that it is a false positive.

[0061] Figure 8 schematically shows the method of the present invention for detecting a collision in a motor vehicle. As can be seen, the method comprises the steps of calibrating A1 the accelerometer 13 that will be coupled to the vehicle and obtaining a calibrating acceleration vector in the device 1, from which a horizontal plane can be determined; and monitoring A2 the calibrated instantaneous acceleration vector of the accelerometer. The device 1 will be adapted to detect A3 whether the calibrated instantaneous acceleration vector meets at least one predetermined collision condition, and in this case transmit a sequence A4 of components of the instantaneous acceleration vector prior and subsequent to the detection of the predetermined collision condition to a telephone device which, after receiving the sequence B1, will model a pulse-shaped mathematical function B2 from said sequence, and will calculate verification parameters from the mathematical function that it will compare with threshold values of said verification parameters in order to verify the collision B3, in the above-detailed manner.

[0062] After the telephone device 2 verifies the collision and after carrying out a step of enabling B4 means for cancelling the transmission of the warning signal during a predetermined waiting time, the telephone device 2 will transmit a warning signal B5 to a roadside assistance center 3, which, after receiving the warning signal C1 will establish telephone communication with the telephone device 2 of the vehicle, in order to contact the occupants thereof and thus be able to determine whether it is necessary to send an assistance vehicle or, if they are not able to make contact or receive a distress message, alert emergency services in order to aid the occupants.

Claims

1. A method for detecting a collision in a motor vehicle comprising the steps of:

    - monitoring (A2) the acceleration of the motor vehicle; and
    - detecting whether the acceleration of the motor vehicle meets at least one predetermined collision condition;

    characterized in that after detecting that the acceleration of the motor vehicle meets at least one predetermined collision condition, it comprises the step of transmitting a sequence (A4) with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition.

2. The method according to the preceding claim, **characterized in that** a predetermined collision condition consists **in that** the acceleration of the vehicle exceeds a predetermined acceleration threshold.

3. The method according to any one of the preceding claims, **characterized in that** it further comprises the preliminary step of calibrating (A1) an accelerometer coupled to the vehicle in order to obtain a calibrating acceleration vector, and that a predetermined collision condition is that the angle that the instantaneous acceleration vector of the motor vehicle forms with the calibrating vector exceeds a predetermined inclination threshold.

4. The method according to any one of the preceding claims, **characterized in that** it further comprises the steps of:

    - receiving the sequence with vehicle acceleration values in a telephone device (B1)
    - modeling a pulse-shaped mathematical function (B2) from said sequence; and

- calculating verification parameters from said mathematical function and comparing them to threshold values of said verification parameters in order to verify the collision (B3).

5. The method according to the preceding claim, **characterized in that** the mathematical function is a sinusoidal function.

6. The method according to any one of claims 4 to 5, **characterized in that** the step of modeling the mathematical function comprises carrying out successive approximations to the sequence.

7. The method according to any one of claims 4 to 6, **characterized in that** the verification parameters calculated from the mathematical function comprise one or more from among: the duration of the pulse of the function; the average acceleration; the increase in velocity obtained by means of the expression of the integral of the mathematical function; the increase in movement obtained by means of the expression of the double integral of the mathematical function; and a coefficient of determination between the modeled mathematical function and the sequence.

8. The method according to any one of the preceding claims, **characterized in that**, after verifying the collision (B3) it further comprises the steps of:

- transmitting a warning signal (B5);
- receiving the warning signal (C1) in a roadside assistance center; and
- the roadside assistance center establishing (C2) telephone communication with the vehicle.

9. The method according to the preceding claim, **characterized in that** prior to carrying out the step of transmitting the warning signal (B5), a step for enabling (B4) means for cancelling the transmission of the warning signal during a predetermined waiting time is carried out, said means of cancellation being able to be activated by an occupant of the vehicle.

10. A device (1) for detecting a collision in a motor vehicle, **characterized in that** it comprises an electronic circuit (12) provided with

◦ an accelerometer (13) for obtaining the acceleration of the motor vehicle;
◦ processing means (14) for monitoring (A2) the acceleration of the motor vehicle provided by the accelerometer and detecting (A3) whether the acceleration of the motor vehicle meets at least one predetermined collision condition; and
◦ communication means (15) for transmitting (A4) a sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition.

11. The device (1) according to the preceding claim, **characterized in that** the processing means (14) are adapted to calibrate (A1) the accelerometer and obtain a calibrating acceleration vector of said accelerometer.

12. The device (1) according to any one of claims 10 to 11, **characterized in that** it further comprises means of coupling (11) to the motor vehicle.

13. A system (100) for detecting a collision in a motor vehicle, **characterized in that** it comprises:

- a device (1) according to any one of claims 10 to 12 for detecting a collision in a motor vehicle and transmitting a sequence with motor vehicle acceleration values prior and subsequent to detection of the predetermined collision condition;
- a telephone device (2) adapted to receive the sequence with the motor vehicle acceleration values and to model a mathematical function (B2) from said sequence; and calculate verification parameters from the mathematical function, comparing them to threshold values of said verification parameters in order to verify the collision (B3); and in such case, transmit a warning signal (B5); and
- a roadside assistance center (3) adapted for receiving the warning signal (C1) from the telephone device after verifying the collision and establishing (C2) telephone communication with the telephone device.

14. The system (100) according to the preceding claim, **characterized in that** the telephone device (2) is provided with means for cancelling the warning signal, said means of cancellation being able to be activated by an occupant of the vehicle and means for enabling (B4) said means of cancellation during a predetermined waiting time.

15. The system (100) according to any one of claims 13 to 14, **characterized in that** the telephone device (2) is provided with means for configuring the predetermined collision condition or conditions of the device.

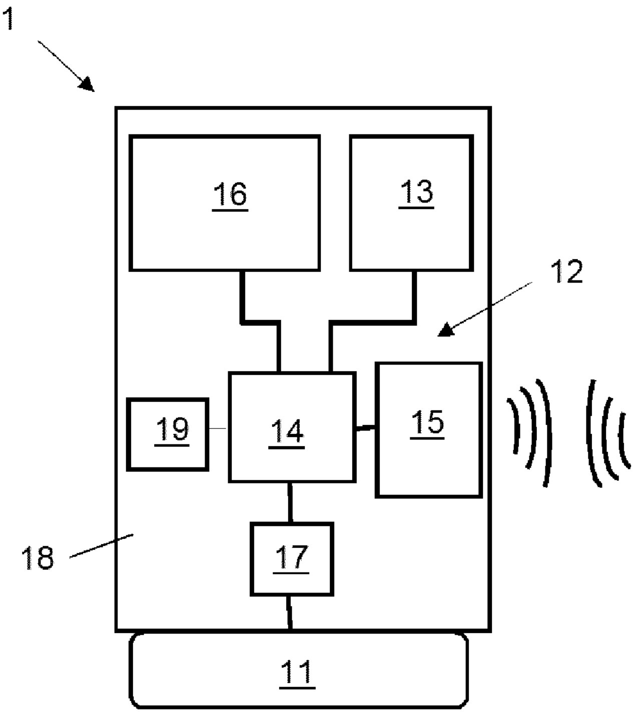

Fig. 1

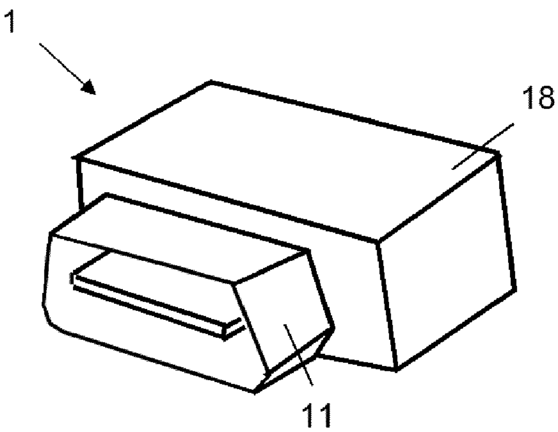

Fig. 2a

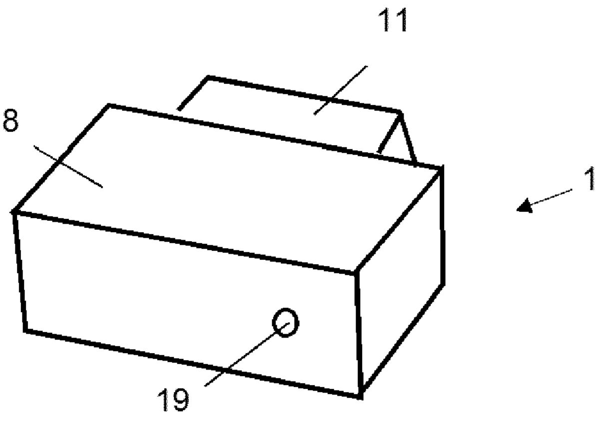

Fig. 2b

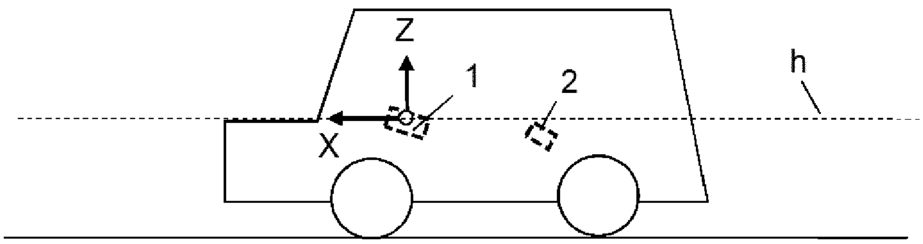

Fig. 3a

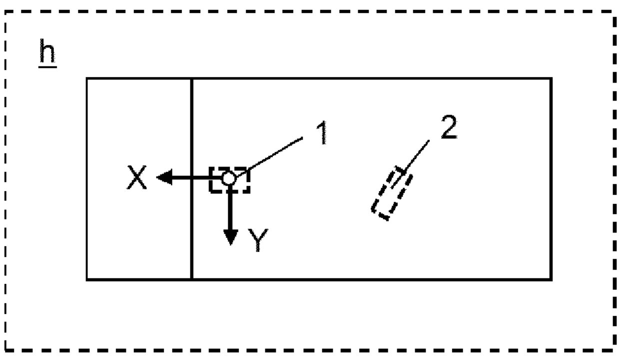

Fig. 3b

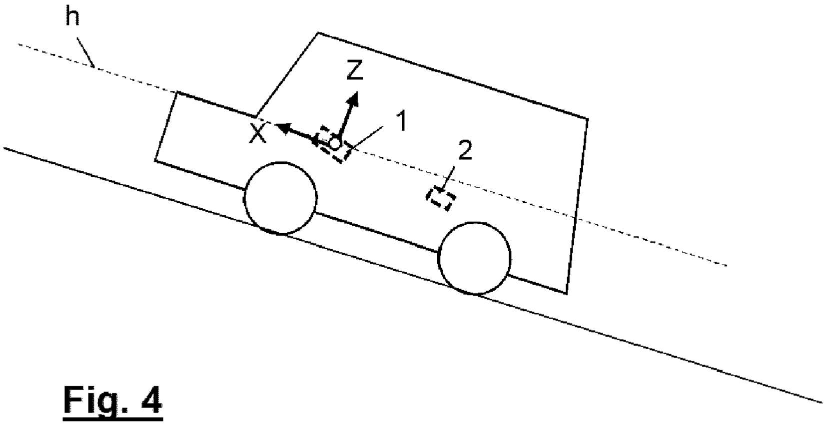

Fig. 4

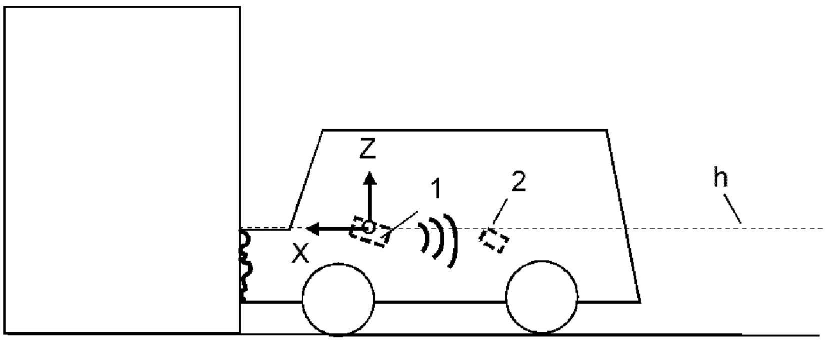

Fig. 5

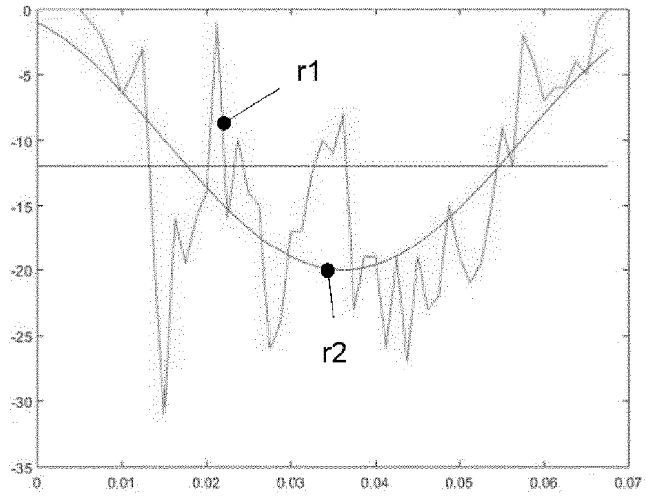

Fig. 6

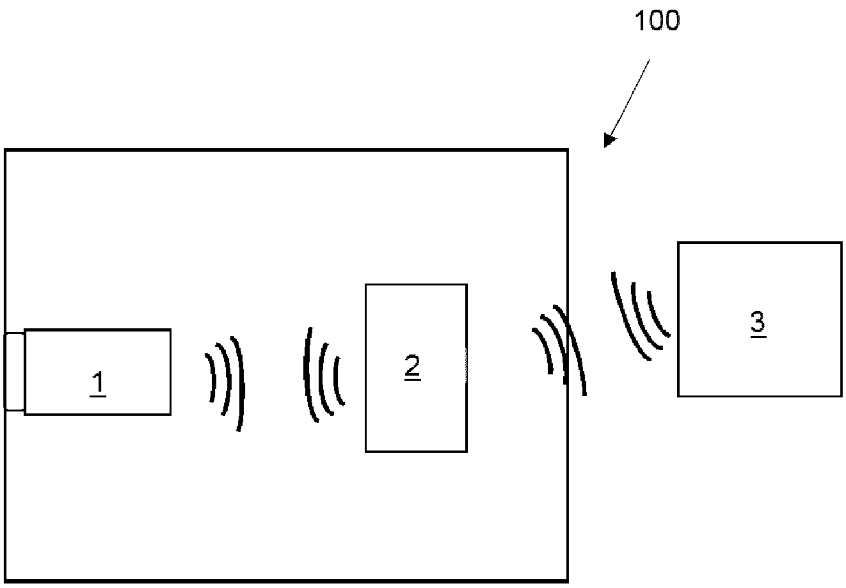

Fig. 7

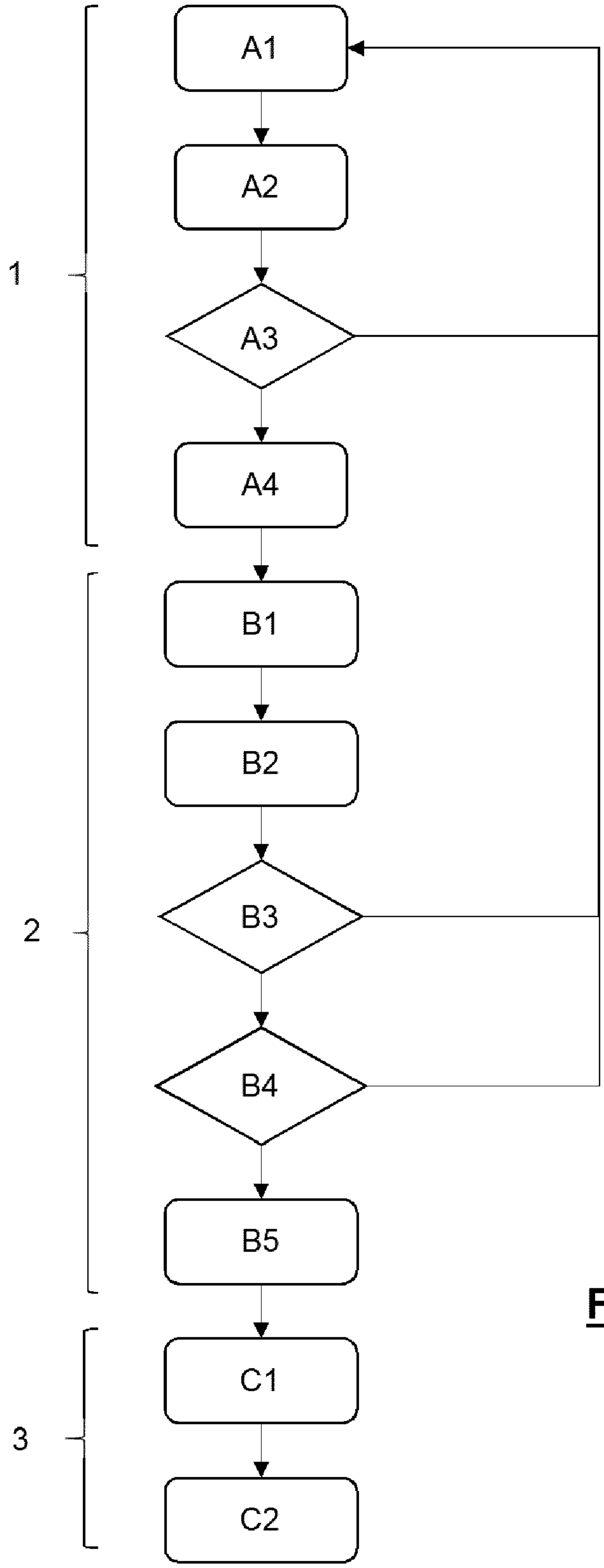

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 17 38 2611

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 2015/164611 A1 (CREATIVE INNOVATION SERVICES LLC [US]) 29 October 2015 (2015-10-29) * paragraph [0023] - paragraphs [0027], [0043] *	1,2,10	INV. G08B25/01 G08B25/00 G08G1/00 G07C5/08
X Y	US 7 574 195 B2 (QUALCOMM INC [US]) 11 August 2009 (2009-08-11) * column 11, line 26 - line 64; figures * * column 14, line 18 - line 19 *	1,3,8, 10-13 4-7,9,14	
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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	15 March 2018	Malagoli, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 38 2611

15-03-2018

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