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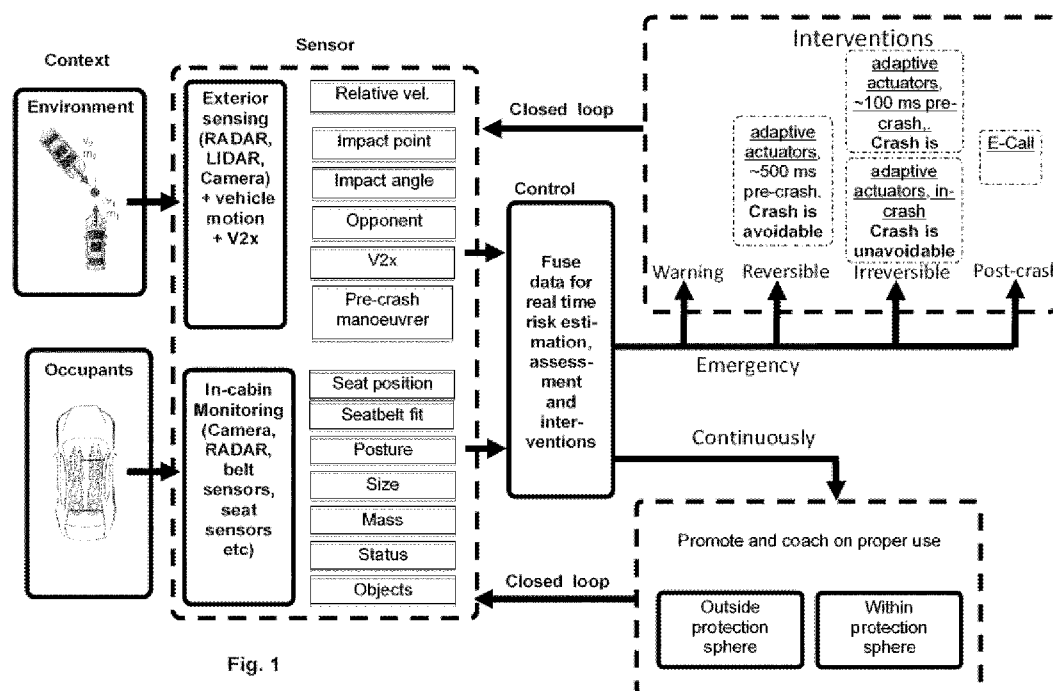


Fig. 1

(57) Abstract: A system for vehicle occupant protection is described. This system comprises at least a first sensor to sense the exterior environment of the vehicle and at least a second sensor to sense the interior vehicle cabin. The system further comprises a control unit for fusing the sensor signals of the first and the second sensors and for evaluating a risk estimation based on the sensor signals. The control unit is adapted to give an output of the risk estimation assessment that may be a feedback message to the occupants in case of a risk estimation below a threshold level or may be an active intervention of the system by triggering at least one safety equipment in case of the risk estimation is above the threshold level. The system continuously repeats the risk estimation.

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System and method of continuously estimating risk situation for vehicle occupants

Description

The invention relates to a risk estimation system according to claim 1, to a method for protecting the occupants(s) in a vehicle according to claim 4, and to a vehicle comprising such a system according to claim 11.

Modern motor vehicles, especially passenger cars, are equipped with a variety of sensors, and active safety equipment to warn and/ or protect the occupant(s) in case of an accident or a likely occurring accident which is most often a collision. All of those are part of the safety system of the vehicle.

The sensors can be sub-divided into two groups, namely sensors sensing (monitoring) the exterior environment (including the motion of the vehicle relative to the external environment) - in the following also referred to as “first sensors” - and sensors sensing (monitoring) the interior of the cabin - in the following also referred to as “second sensors” - . The first sensors can especially comprise speed- and acceleration-meters, radars, lidars, cameras and so-called V2x sensors that communicate with other vehicles or road infrastructure. The second sensors can especially comprise belt sensors, seat occupancy sensors, seat position/ inclination sensors, cameras, and radars,

The active safety equipment can be sub-divided into three groups, namely warning features, reversibly working safety equipment - each having at least one reversibly working element - and irreversibly working safety equipment - each having at least one irreversibly working element - . The warning features can especially comprise light-, sound-, and vibration signals. The reversibly working safety equipment can for example comprise electric belt pre-tensioners and automatic seat position/ inclination

actuators. The irreversibly working safety equipment can for example comprise pyrotechnic belt tensioners and airbags.

The warning features as well as the active safety equipment are triggered at least indirectly by the signal of at least a first and/ or at least a second sensor.

Starting from that prior art, it is an object to improve the invention to improve the safety system for a vehicle in such a way that at least statistically the number and/ or severity of injuries and/ or repair costs are reduced while the occupants remain undisturbed as far as possible.

According to the invention, the safety system comprises a joint control unit to which the signals of the at least one first sensor and the at least second sensor are fed and fused and which continuously evaluates those signals and performs a risk estimation assessment based on the sensor signals. The control unit is adapted to give an output of the risk estimation assessment that may be a feedback message to the occupants in case of a risk estimation below a threshold level or may be an active intervention of the system by triggering at least one safety equipment or an element of the same in case of the risk estimation is above the threshold level.

In other words: The signals of various sensors – with at least one sensor sensing the exterior of the cabin and at least one sensor sensing the interior of the cabin – are jointly evaluated by the control unit such that it can perform a risk estimation assessment based on data being related to both, the environment (including speed and acceleration of the vehicle) and the interior of the cabin such that also the actions taken by the control unit has its basis in those “mixed” data. This fusing makes a real risk estimation assessment possible, especially in such way that interventions of different intensity can be taken by the control unit according to a defined scheme. This scheme comprises at least one threshold level. As long as the estimation of the risk level is below this threshold value, no action is taken at all, a pure information/ advice to the occupants is given (for example by a spoken message or information on a monitor) and/ or the maximum speed of the vehicle is limited. When the estimation of the risk level is above the threshold value, a real warning (not only an advice) and/ or an active intervention is executed. Permanently assessing the risk level and advising

the occupants to react on that (if necessary), helps to lower the risks for the occupants in case of an accident and to potentially lower the level of intervention in case of an accident or a likely occurring accident.

Preferably, the actions taken by the control unit above the threshold level have different levels of intensity based on different levels of the estimated risk, such that even above the threshold level, an adapted reaction of the control unit is provided. Preferably there are at least two levels, even more preferably three levels of intensity as follows: In a first level, a potentially dangerous situation with a high degree that an accident can clearly be avoided (for example by the driver in a case of a manually driven vehicle) is estimated. A typical example is that the speed of the vehicle is too high and/ or the distance to an object (for example another vehicle) in front of the vehicle is too low. As a reaction, a warning signal to the driver (acoustically and/ or optically) could be triggered. In a second level, there is a risk that an accident occurs higher than in the first level, but is still estimated as being avoidable. As a reaction, at least one reversibly working element of the safety equipment could be triggered, for example electric belt pre-tensioners can be activated and/ or an automatic braking operation could be triggered. In a third level, an accident is estimated as being un-avoidable. In this case, at least one non-reversibly working safety equipment can be triggered, for example pyrotechnic belt tensioners and airbags. The activation of non-reversibly working equipment (or elements of the same) can continue to take place during the crash. Finally, the system can continue to work after the crash, for example by making an automatic emergency telephone call. Because the system continuously monitors the cabin, the control unit has detailed and useful information to provide in the emergency call, for example the number of persons. Further, the system may also provide detailed information about the accident and may also estimate the severity of injuries of the occupants.

Because the system continuously collects data related to the outside (outside the cabin) and data related to the inside of the cabin and interconnects those data, the system can better react to critical situations because it can take its “collected knowledge” into account. To give an example: If the system knows that all passengers are in ideal sitting position and belted with the belts being in a correct position, an

action (reversible or irreversible) might be taken later than in a case that at least one occupant is not in a good sitting position or not perfectly belted.

The just described has another advantage: The data of the first sensors (external sensors) might in a critical situation be such that the control unit does not only estimate an un-avoidable accident, but an accident with at least two subsequent collisions, including a roll-over after a first collision (multi-crash scenario). Of course, a non-reversible action can only be taken once at an element of the safety equipment and with the knowledge of the overall-situation, the point in time of triggering a certain element (for example the inflator of an airbag or an active vent of an airbag) can be optimized for this multi-crash scenario.

The system is useful for manually driven cars but especially for vehicles having an autonomous drive mode in which it is more likely that occupants are in “unusual” sitting positions.

The invention will now be described in more detail in view of Figure 1.

The risk estimation system for vehicle occupants as shown in Figure 1 comprises a plurality of sensors (also referred to as “first sensors”) that sense the exterior of the vehicle like radar sensor, camera sensor, lidar sensor and so called V2x sensors that communicate with other vehicles or road infrastructure. The speed- and acceleration sensors also belong to the first type of sensors. Those first sensors give input about the environment of the vehicle like other vehicles and their relative velocity, a potential impact point or angle or maneuvers of that vehicle which may be added-up with the own vehicle movement data like speed and acceleration.

Further there is at least one sensor for monitoring the interior compartment of the vehicle and give input about the vehicle occupants and their masses, sizes and postures and how they are currently using the safety devices like seatbelts or in what seat position they are in. Those sensors can be camera sensors, radar sensors, seatbelt usage and seat occupation sensors. Those sensors are also referred to as “second sensors”.

The system further comprises a control unit with a risk estimation algorithm that evaluates the input signals from the sensors (meaning the first sensors and the second sensors) by fusing them and estimates a corresponding risk for the vehicle occupants in real time.

Based on the risk assessment, the system gives feedback to the vehicle occupants that the situation is safe, all the occupants are within the protection sphere and no further action is necessary, if the risk assessment is very low and below a threshold level. If at least one of the occupants is in a non-preferred seating position which is outside the protection sphere, the system may alert and propose to move into a safer seating position in order to move back into the protection sphere. Another example is wearing of the seatbelt in correct way. The in-cabin sensors are able to detect, if the seatbelt is worn in correct way.

There might be more drastic interventions, for example that the vehicle only allows a limited driving speed under this current outside protection sphere condition. It may ask the occupant to move into the preferred seating condition in order to allow the vehicle to go with the desired speed.

If the risk assessment is concluding a higher risk scale above a threshold level, it will start to intervene the vehicle. On the lower scale there may be still a warning that alerts a potential emergency situation and requires an action by at least one of the occupants.

With increasing risk estimation the system may start an intervention by triggering reversible safety equipment. That can happen in so-called pre-crash situations at around 500 milliseconds before a crash could happen, when the car goes with 50km/h and could impact in a fully frontal crash situation. The reversible safety equipment could be electrical pre-tensioners of the seatbelts or seat actuators that reposition the seatback or the full seat in longitudinal direction. In this scenario the crash is typically still avoidable and it might not come to an impact at all.

With further increasing risk the system may also trigger non-reversible safety equipment like pyrotechnic actuators in airbag systems or seatbelt tensioners. This

could happen at a timing of around 100 milliseconds before a crash could happen. At this timing an impact is typically not avoidable anymore. Further the system may trigger adaptive actuators and select the right level for the current situation that has been sensed. This might be done for a seatbelt load limiter with multiple levels.

If the systems estimates an unavoidable accident with a multi-crash scenario, the system may delay the triggering at least one non-reversibly working element, as for example an active vent of an airbag.

After a crash situation happened the system may generate an emergency call (E-call) and specify the level of severity based on the sensor data input.

As long as the risk assessment is at a reasonable level below a threshold there is always a continuous closed loop of sensing, risk evaluation and feedback to the vehicle occupants. The system may be able to allow an occupant to use a safety equipment like the seatbelt in not preferred way, if the overall risk situation is at a low scale. However, if the environmental situation would change and the risk would increase to a level above a threshold this occupant would be reminded to act and wear the seatbelt in most preferred way.

Claims

1. System for vehicle occupant protection comprising at least a first sensor to sense the exterior environment of the vehicle and at least a second sensor to sense the interior vehicle cabin, the system further comprising a control unit for fusing the sensor signals of the first and the second sensors and for evaluating a risk estimation based on the sensor signals,
wherein the control unit is adapted to give an output of the risk estimation assessment that may be a feedback message to the occupants in case of a risk estimation below a threshold level or may be an active intervention of the system by triggering at least one safety equipment in case of the risk estimation is above the threshold level and
wherein the system continuously repeats the risk estimation.
2. The system of claim 1, wherein the first sensor is at least one of a radar, a lidar, a camera, a speed meter, an acceleration sensor, and a V2x sensor.
3. The system of claim 1 or claim 2, wherein the second sensor is at least one of a camera, a belt sensor, a radar, a seat position sensor and a seatback inclination sensor.
4. Method for vehicle occupant protection comprising the steps of
sensing the exterior environment of the vehicle with at least a first sensor,
sensing the interior vehicle cabin with at least a second sensor,
evaluating a risk estimation in the control unit and giving an output that may be a feedback message to the occupants in case of a risk estimation below a threshold level or may be an active intervention of the system by triggering at least one safety equipment in case of the risk estimation is above the threshold level,
wherein the method continuously repeats the risk estimation.

5. The method of claim 4, wherein the output of the control unit comprises, when the risk estimation evaluation results in a possible collision, an actuation of at least one reversibly working element of the safety equipment.
6. The method of claim 4 or claim 5, wherein the output of the control unit comprises, when the risk estimation evaluation results in certainly happening collision, an actuation of at least one irreversibly working element of the safety equipment.
7. The method of claim 6, wherein the control unit evaluates the probability of at least a second collision after a first collision and takes the result of this into account when actuating the at least one irreversibly working element of the safety equipment.
8. The method of any one of claims 5 to 7, wherein the control unit takes the situation of the interior provided by the at least one second sensor before the threshold level is exceeded into account when actuating at least one element of the safety equipment.
9. The method of any one of claims 5 to 8, wherein the control unit generates an automated emergency call when an accident occurred.
10. The method of any one of claims 4 to 9 using the system of any one of claims 1 to 3.
11. Vehicle comprising a system of any one of claims 1 to 3.
12. The vehicle of claim 11, wherein the vehicle comprises an autonomous drive mode.

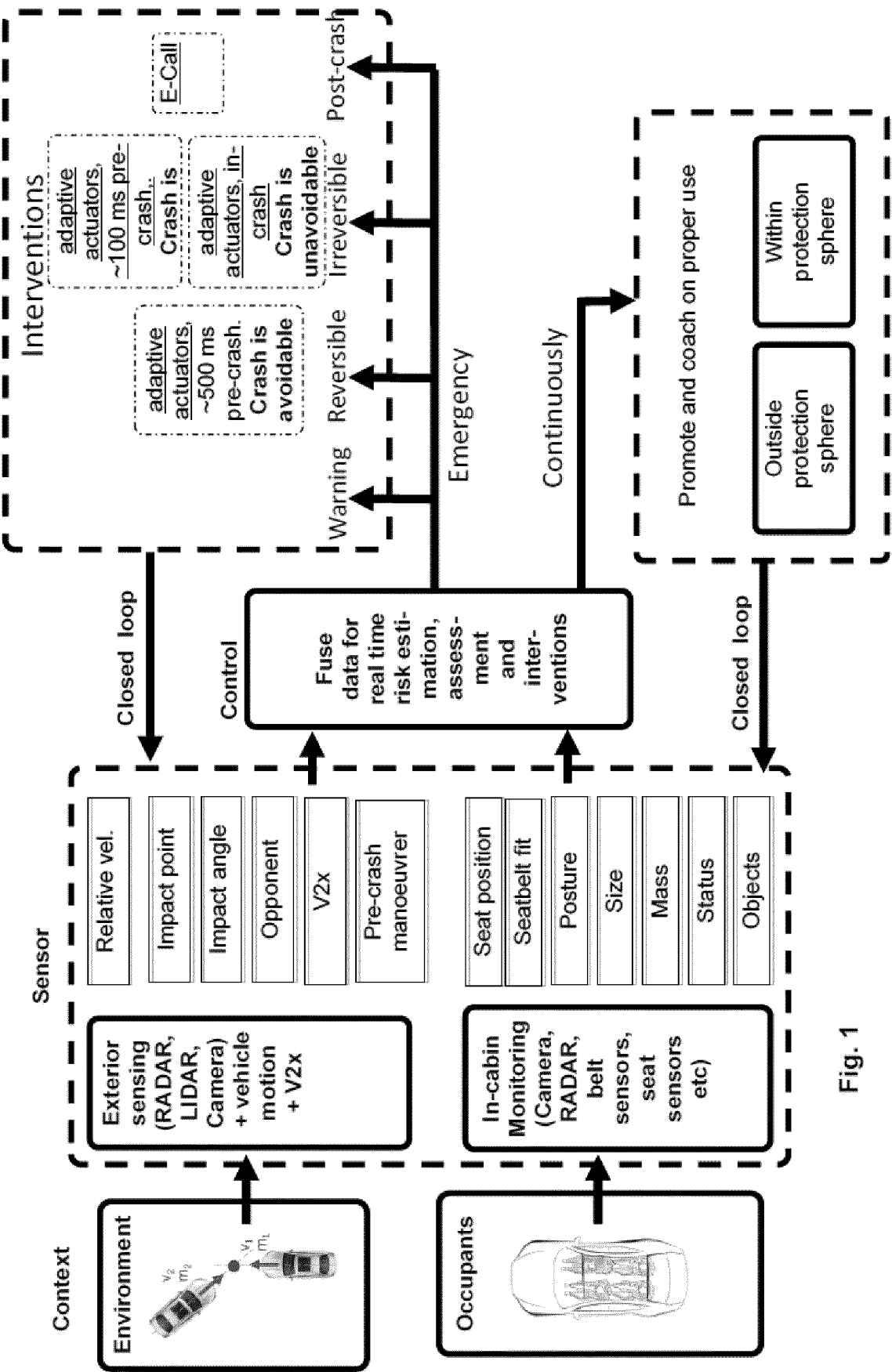


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No

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A. CLASSIFICATION OF SUBJECT MATTER

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ADD.

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60R

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/195231 A1 (DIEBOLD JURGEN [DE] ET AL) 31 August 2006 (2006-08-31) abstract; figure 1 paragraphs [0026] - [0040] paragraphs [0114] - [0119] -----	1-12
X	US 2007/228704 A1 (CUDDIHY MARK [US] ET AL) 4 October 2007 (2007-10-04) abstract; figures 1-5, 13A, 13B paragraph [0040] paragraphs [0050] - [0055] paragraphs [0068] - [0072] -----	1-12
A	US 2020/307481 A1 (YEZERSKY GRIGORY [US] ET AL) 1 October 2020 (2020-10-01) abstract paragraph [0048] -----	9



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INTERNATIONAL SEARCH REPORT

Information on patent family members

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