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Airbag Deployment System Based On Pre-Crash Information

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Abstract: An airbag is a vehicle safety device. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects such as the steering wheel or a window. Airbags are directly linked to the life of the driver and passengers, as they are used as the last resort in a collision. Hence the proper functioning of the system is an important issue. Hence, to ensure the precision and reliability of airbag operation, it is necessary to design a robust system. Though many companies are working on the optimal deployment time for airbags, several problems still occurs. For example, when a vehicle operates off road or when the sensor inside the airbag control unit (ACU) receives a powerful shock, the vehicle's airbags may inadvertently deploy, although no collision has occurred, because a crash like signal is delivered to the ACU. Also, when there is actual situation which requires airbag deployment, the software designed make faulty judgement and miss the time frame for airbag deployment. To resolve these problems, we are designing a system which can generate information about the crash scenarios before collision takes place. The system is designed using ARM11.

Keywords: Advanced airbag system, airbag crash algorithm, pre-crash, sensor fusion, vehicle dynamics

I. INTRODUCTION

An airbag is a vehicle safety device. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects such as the steering wheel or a window. Airbags are directly linked to the life of the driver and passengers, as they are used as the last resort in a collision. Hence the proper functioning of the system is an important issue. Hence, to ensure the precision and reliability of airbag operation, it is necessary to design a robust system. Though many companies are working on the optimal deployment time for airbags, several problems still occurs. The reality, however, is that numerous limitations remain, to a degree that accidents have been caused by the malfunctioning of airbag systems [1]–[3]. For example, when a vehicle operates off road or when the sensor inside the airbag control unit (ACU) receives a powerful shock, the vehicle's airbags may inadvertently deploy, although no collision has occurred, because a crash like signal is delivered to the ACU. Also, when there is actual situation which requires airbag deployment, the software designed make faulty judgement and miss the time frame for airbag deployment [4]. Such situations may largely be assigned to the following two major causes.

First, by using only the data obtained through crash testing, crash algorithms are designed. However, to maintain cost effectiveness in vehicle manufacturing, crash tests are performed only in accordance with a number of standardized scenarios [5]. This condition inevitably limits the number of cases that can be used to design a crash algorithm. Consequently, if a crash scenario that is dissimilar to a crash test scenario occurs, the crash algorithm may not properly recognize the configuration and ultimately deploy the airbags in error. Second, crash algorithms use only post collision input from crash-related accelerometers. Therefore, if these sensors are broken, rotated, or moved by impact, the resulting error signals are reflected without adjustment. This factor is a key that can cause a crash algorithm to commit errors in evaluating crash scenarios and other situations [6].

To overcome these limitations, this paper proposes a system based on pre-crash information. By using this pre-crash information we are designing pre-crash algorithm that generates information about crash scenarios before a collision takes place. The purpose of the pre-crash algorithm is to make judgments about the impending collision configuration prior to impact by estimating the behaviour of frontal objects and to communicate this information to the crash algorithm to enable correct recognition of the crash scenario.

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II. SYSTEM DEVELOPMENT

A. Block Diagram

Fig. 1 shows block diagram of proposed system.

ARM 11 is heart of the system. All the sensor output are given to the ARM11. Signals obtained from various sensors are processed by ARM11 which will in turn drive the airbag deployment mechanism.

The RPM sensor is one of the most common applications for a Hall effect sensor..RPM sensor is used to sense the speed of vehicle continuously. If the speed goes above the defined value, the message will be displayed on LCD. It is a sender device used for reading the speed of a vehicle's wheel rotation. It usually consists of a toothed ring and pickup.

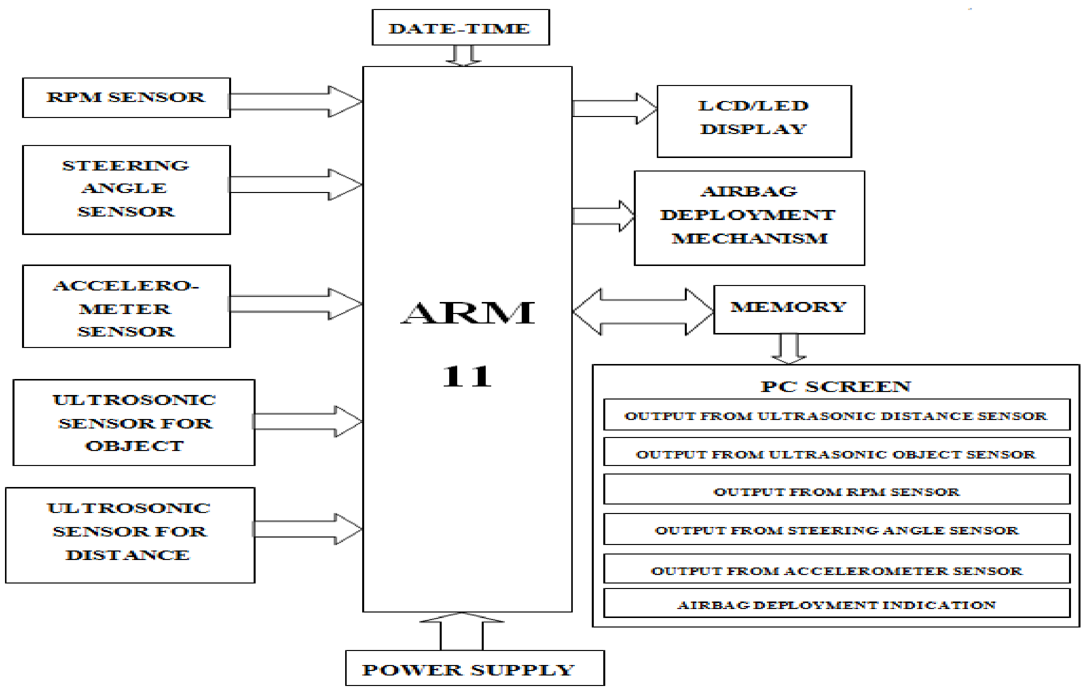

Fig. 1 Block Diagram

The steering angle speed sensor detects the angle of the steering wheel in order to which direction a user chooses. If the steering angle crosses the predefined limit, the signals are given to the processor.

Ultrasonic sensor ensures the stable detection of a variety of objects regardless of the color, transparency, or material (metallic or non-metallic) of the objects. It is used to determine the relative position of the frontal object and the relative speed of the host vehicle. Ultrasonic sensor plays vital role in pre-crash algorithm design.

Accelerometer sensor is used for host vehicle information. It is used to determine the longitudinal and lateral velocity of host vehicle.

LCD display is used for displaying various parameters from different sensors which are interfaced to ARM11.

All the parameters from various sensors are stored in a memory and the information is utilized to evaluate performance of the system on computer.

B. Algorithm Used

1. Pre-crash Algorithm

The frontal objects are estimated through simultaneous use of ultrasonic sensors and host vehicle information sensor.

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Host vehicle information estimation consists of estimating the vehicle's longitudinal and lateral velocity by using different sensors. The information thus obtained from these sensors is used to determine the position of the frontal object. For the algorithm input, accelerometer, wheel speed and steering angle sensors are used as shown in fig. 2. Ultrasonic sensors that are attached to the vehicle's ACC system are used to obtain summary information about frontal objects. Information from ultrasonic sensors has various resolutions and phase lags. Hence a sensor fusion observer is developed for the processing signals obtained from ultrasonic sensors. This improves signal reliability by utilizing the mechanical relationship between two sets of data with disparate methods of measurement.

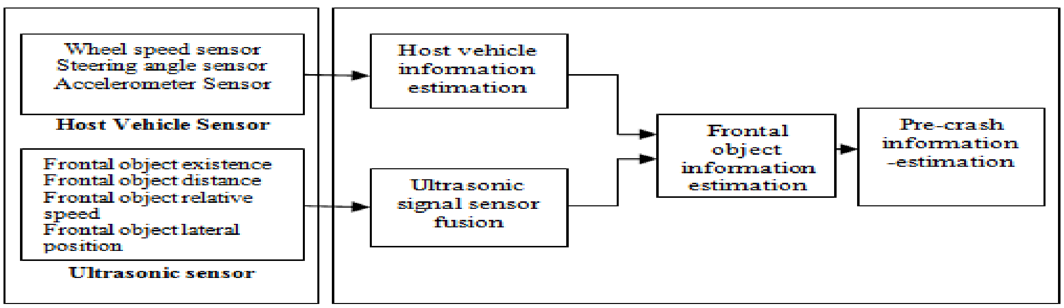

Fig. 2 Pre-crash algorithm block diagram.

Frontal-object information estimation determines the frontal object's relative position, heading angle, and position at the crash moment based on the host vehicle using the estimated information about the host vehicle and information acquired from ultrasonic sensors about the frontal object.
Pre-crash information estimation is used to generate information that improves the performance of the crash algorithm that in turn used for optimal airbag deployment.
In our system, pre-crash information is acquired by considering crash algorithms for various crash types. Crash-type-discrimination algorithms mostly use ultrasonic sensors that provide information about a frontal object's orientation, time to crash, and relative velocity. Frontal object estimation gives crash possibility. Relative speed and distance information given by ultrasonic sensor gives time to crash and frontal object's heading angle and position gives crash type.

2. Crash algorithm

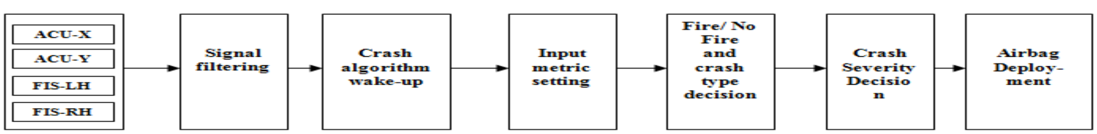

Fig. 3 Crash algorithm block diagram

The operation of the crash algorithm is illustrated in fig. 3. The signals received from various sensors are processed by the algorithm's hardware filter. If the starting conditions for the algorithm are met, the crash algorithm is triggered. The signals received from various sensors are processed so as to be used to determine the crash type, crash severity, and whether to deploy the airbag. If the results of these judgments satisfy the various thresholds assigned based on the crash test data, the vehicle's airbags are deployed. The sensors used for this process are manly accelerometer sensor.

3. Crash algorithm based on pre-crash information

In the crash algorithm based on pre-crash information, pre-crash algorithm and crash algorithm are interfaced together for optimal airbag deployment as shown in fig. 4.

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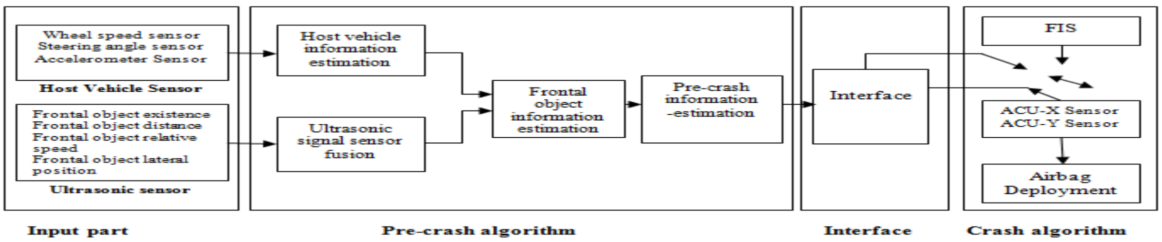

Fig. 4 New crash algorithm based on pre-crash information

The purpose of the crash algorithm based on pre-crash information is to generate crash possibility, time to crash, and crash type information using various radars and host vehicle sensors; communicate the resulting crash-type information about possible crash scenarios; and, thereby, deploy the vehicle's airbags in a manner befitting the configuration at hand.

If the pre-crash algorithm makes erroneous judgement, the overall performance may lower than when only the crash algorithm is used for airbag deployment. Hence it is necessary to design the interface between the crash and pre-crash algorithms The AND condition is used for the start and crash flags to prevent meaningless information, e.g., when crash possibility information is generated through ultrasonic sensor malfunction, even if there is no frontal object present. It is also intended to allow the crash algorithm to function as a stand-alone process when the ultrasonic sensors do not operate, by making independent decisions about a crash situation. For pre-crash information to be conveyed, the crash flag that signifies the crash possibility must be set to 1. At the same time, the crash algorithm must also detect the crash and have the start flag set to 1.

C. Hardware configuration

Fig. 5 shows the hardware configuration for the algorithm. In our system, ECU is utilized for the interfacing of the two algorithms. For the ECU, the various sensors installed for the host vehicle's ESP are given as input.The ultrasonic sensors are used as inputs for the ACC.

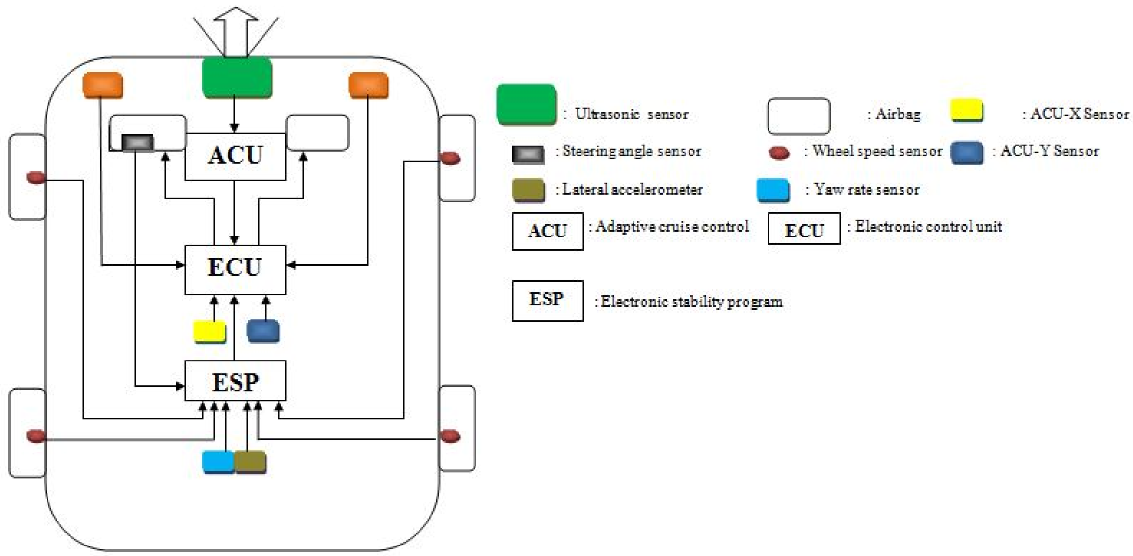

Fig. 5 Hardware configuration

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III SYSTEM IMPLEMENTATION

The system is implemented using ARM11. Various sensors are interfaced to the ARM11 provides crash related information to it which is used to design crash algorithm based on pre-crash information that provides optimal airbag deployment. For interfacing data from ARM11 to PC VB.net is used.

IV COMPARATIVE STUDY

Number of pre-crash systems has been developed to design active safety systems for vehicles. For instance, in collision mitigation system (CMS), one of the active safety system a variety of high-technology sensors are used to estimate the possibility of collision with frontal objects and sounds an alert to the driver if the possibility is substantial. Moreover, if the driver cannot avoid the collision, the impending crash is prevented by controlling the vehicle's steering or brake system. By employing high-performance sensors, these active systems can provide much information about the pre-crash situation. But once a crash has occurred, they are virtually unused. However, if an active safety system is replaced by an airbag system, it can be used to provide highly useful information.

Moritz introduced a method for applying radar sensors to a crash algorithm by using them individually or in combinations of three or four. His method defines a possible crash zone and lowers the crash algorithm threshold if a vehicle is present within that zone to trigger early functioning of the airbag system. In particular, the start threshold of the crash algorithm is lowered in advance so that the algorithm may detect an imminent crash faster. In addition, the strength of impact is defined prior to collision based on the pre-crash collision speed so that the airbag deployment threshold may accordingly be lowered [8].

The performance of the algorithm designed by Moritz is improved by Bunse. He introduced the way crash type and crash severities are estimated. Using radar sensors, the stiffness of frontal objects can be determined by the size of the ACU-X sensor signals during the time that leads up to the estimated moment of impact. His method is distinctive, because it uses only radar sensors and the ACU-X sensor, without recourse to the front impact sensor (FIS) [9]. Due to these attempts, the crash algorithm's recognition of forthcoming crashes is accelerated and allows the crash algorithm to make faster judgments about crash scenarios.

On the other hand, there is a certain threshold that has to be reached to trigger airbag. This is done by lowering the starting value which can lead to airbag misfire even if no collision has occurred or the collision impact is low. Furthermore, if crash severity is determined prior to collision based on crash velocity, airbag deployment becomes inconsistent if the stiffness of the frontal object is low despite a high collision speed, or vice versa. This condition can have the opposite of the intended effect by resulting in a failure to comply with the required time to fire (RTTF). In addition, the use of information obtained only from simple radar sensors does not allow for the estimation of the relative movement of frontal objects. This condition, in turn, makes it impossible to predict whether a frontal object will disappear from the defined crash zone or what form of crash will occur. To deal with such problems, our proposed system estimates frontal objects through the simultaneous use of ultrasonic sensors and host vehicle information sensors.

The system is designed using ARM11. Two ultrasonic sensors are used which detect the presence of frontal object and relative velocity of host vehicle. In addition, our system uses a pre-crash algorithm which enhances the airbag deployment performance of existing crash algorithms without changing their threshold was developed.

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V RESULT

TABLE I SENSOR TRIGGERING TIME

Types of crashes	Sensor Triggering Time
Head-on collision below 14 kmph, rough road, minor animal impact, breaking	No triggering
48-64 kmph Vehicle to rigid barrier	10-20 ms
48-64 kmph Vehicle to rigid angular barrier	20-30 ms
24-32 kmph Vehicle to rigid barrier	30-50 ms
24-32 kmph Vehicle to rigidangular barrier	50-70 ms
48-64 kmph Vehicle to vehivle head on collision	30-50 ms

IV CONCLUSION

This paper has proposed an airbag deployment system based on pre-crash information to overcome airbag malfunctions caused by the limitations of systems based on crash algorithm. Various sensors like wheel speed sensor, steering angle sensor, acceleration sensor, are utilized, in addition to ultrasonic sensors are used to design the system. This approach allows for the generation of more reliable pre- crash information through the addition of estimated information about the frontal-object position and behaviour to information based on the host vehicle itself.

The sensors used for the proposed system consist of combinations of various existing sensors used in commercial automotives. Hence, the proposed methods can be implemented at no extra cost.

In conclusion, the methods proposed in this paper provide several benefits in terms of cost and applicability. The applicability and performance can further be improved if the system is designed using cameras or radar sensors.

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BIOGRAPHY

Mane Archana Rajendra received the B.E. degree in electronics and telecommunication engineering in 2010 from Pune University and pursuing M.E. in VLSI and Embedded systems from VACOE, Ahmedmagar. She is working as assistant professor in PDVVPCOE, Ahmednagar.

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His area of interest includes wireless sensor network & VLSI & embedded system.