Study of Sensors for Automobile Safety with Automated Road Transport: A Review

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ABSTRACT

Road accidents involving two-wheeled vehicles are numerous indeed, and can cause the riders severe injuries. Therefore, developing automatic features that are able to detect the fall of the vehicle and autonomously issue first-aid calls is of particular interest for this type of vehicles. To solve the problem in a low-cost and portable way, this paper proposes to use the GPS and the acceleration sensors with automotive MEMS, capacitive sensors, acoustic sensors, SONAR data, pressure sensors that are on board of any modern smartphone. In recent years, self-driving cars have generated significant attention and discussion. Conditions are explored in the broader transportation system under which self-driving vehicles may be either harmful or beneficial and how autonomous operation could affect the attractiveness of traveling by car, how this in turn could affect mode choice. The concept aims for partially automated driving where the driver is still responsible for the driving task and in charge of monitoring the automation system of his vehicle in relation to traffic and transportation control systems. On the other hand using an OBD scan-tool that sends its data using Bluetooth to a smartphone through Wifi or Bluetooth that already processes the data into detection events, forwarding only these to central server, road surface distress detection processed.The automotive industry is increasingly using electrical control systems in order to assist the driver of a vehicle or to automate certain maneuvers. The setup of the low-level controller and actuators is discussed. The systems used to convert the vehicle to safe vehicle in acceleration, braking and steering are documented along with details of the low-level controller and safety systems.

Keywords*:OBD, Accelerometer, Self Driving Car, Driver in the loop, Intelligent Vehicle Initiative*

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1. INTRODUCTION

Road accidents are one of the leading causes of casualties which involve two-wheeled vehicles mostly. Automatic accident detection systems can save lives by decreasing the time required to issue emergency calls that alert first-aid response [1]. In four-wheeled vehicles, safety systems such as the airbag can automatically detect a crash and trigger appropriate actions to enhance passengers' safety. Also in two-wheeled vehicles is possible to detect dangerous situations with in-built sensors. But such detection is more difficult to achieve, due to their dynamic characteristics and to the available sensors. Recent advances in smart-phone technology are making it possible to detect road accidents in a more portable and cost effective manner than conventional in-vehicle solutions, and smartphone-based approaches for accident detection in cars have been proposed. In the two-wheeled vehicle context, an early detection of a crash and/or of a fall is even more important, as a rather large part of the accidents that involve two-wheeled vehicles causes significant injuries to the rider, who may not be capable of autonomously call for help. Until technological challenges in terms of sensor performance, situation interpretation and functional safety as well as legal questions are solved, the driver will still be necessary for monitoring and as backup for automated driving systems [2]. Especially taking over the driving task from an automated car at a system boundary can take several seconds if the driver is out of the loop. In consequence, one research goal is to find ways to keep the driver in the loop during an automated drive and support him in monitoring the automation system of his car. This article describes a concept that addresses those goals by creating a transparent system behavior and using the driver's perception of the vehicle motion to feedback information about the system's state and safety. To prevent accidents and increase vehicle safety, manysafety control systems, such as anti-lock braking system(ABS) and electronic stabilizing program (ESP), have beendeveloped and introduced into modern automobiles inthe past decades. Generally, these control systems requireaccurate and 'up-to-date' vehicle state information as criticalpart of the control logic [3].

2.NEED OF SENSORS

The performanceand reliability of such systems are heavily dependent on the accurate measurement/estimation of vehicle state information. Especially, the vehicle sideslip angle is essential state information for a commercial viable safety control system [3]. In general, to measure the slide slip angle two methods.

A. *Direct measurement method.*

In this method, sideslip angle is measured directly through the use of speed-over-ground sensors or the high-performance multiple-antenna Global Positioning System (GPS)[4]. Although these sensors can provide accurate information, they are very expensive and unsuitable for large-scale commercial applications. Moreover, such sensors are very sensitive to external environments.

A. *Kinematics-based method*.

Generally, it utilizes low cost in-car sensors such as inertial sensors including gyro and accelerometers. It mainly involves numerical integration from these sensors or establishes a kinematic estimator according to their configuration relationship [5]. This method only considers the kinematic features of vehicle body and can rapidly detect transient change in vehicle behaviour. Thus, it can achieve good robustness against vehicle unmodeled dynamics and parameters, changes in driving manoeuvres, and variations in tire-road conditions. Besides, it is economical due to large-scale commercial application of low-cost inertial sensors based on microelectromechanical system (MEMS) technology in modern vehicles. However, for numerical integration processing, it suffers from serious accumulative integration errors due to inertial sensor drift/bias [6], while for the kinematic estimator discussed in the literature, it becomes unobservable and can cause large estimation errors in the near-zero yaw rate driving condition [7]. Vehicles need to be sensed in front for adaptive cruise control and forward collision warning; on the sides, for blind spot and lane change / merge warning; and behind, for backup warning and for lane change / merge warning of overtaking vehicles.Sensing has to work in all weather, and at a variety of ranges.Each vehicle can broadcast its current location, derived from GPS or other positioning systems.Vehicles can also broadcast other information, such as speeds, intent to change lanes, or onset of emergency braking. This is crucial in decreasing inter-vehicle spacing to increase throughput, while maintaining safety.This kind of scheme is most appropriate for high-end systems, such as automated highways.Obstacle detection is much more difficult than vehicle detection: obstacles can be small, non-metallic, and much harder to see.Obstacle detection is one of the most challenging tasks for an intelligent vehicle.

3. SENSORSINTERFACE

3.1 MEMS in vehicle dynamic control

A typical MEMS gyro uses a quartz tuning fork. The vibration of the tuning fork, along with applied angular rotation (yaw rate of the car), creates Coriolis acceleration on the tuning fork. An accelerometer or strain gauge attached to the tuning fork measures the minute Coriolis force. Signal output is proportional to tuning-fork size. To generate a strong enough output signal, the tuning fork must vibrate forcefully. You can best accomplish this with a high Q structure. Manufacturers often place the tuning fork in a vacuum to minimize mechanical damping by air around the tuning fork. High Q structures can be fairly fragile .Because the gyro must be rigidly connected to the car to accurately measure yaw rate, the gyro often experiences shock and vibration. This mechanical noise can introduceý signal to the Coriolis pick-off accelerometer that is several orders of magnitude higher than the tuning fork generated Coriolis signal. Separating the signal from the noise isn't easy. Often, the shock or vibration saturates the circuitry and makes the gyro output unreliable for a short time (this explains why your VDC warning light may occasionally come on for no apparent reason). New MEMS devices avoid these shortcomings, though. For example, Analog Devices' iMEMS gyro (which is in development) is 7 by 7 by 3 mm (0.15 cm^3). Rather than quartz, it uses a resonating polysilicon beam structure, which creates the velocity element that produces the Coriolis force when angular rate is presented to it. At the outer edges of the polysilicon beam, orthogonal to the resonating motion, a capacitive accelerometer measures the Coriolis force. The gyro has two sets of beams in antiphase that are placed next to each other, and their outputs are read differentially, attenuating external vibration sensitivity.

3.2 Rollover Sensor

Rollover detection systems sensor particularly true for vans, pickup trucks, and sport utility vehicles, which are more likely to roll over because of their higher centre of gravity. These systems read the roll angle and roll rate of the vehicle to determine if it is tipping over. If it is, the system fires the side curtain air bags to protect the occupants.

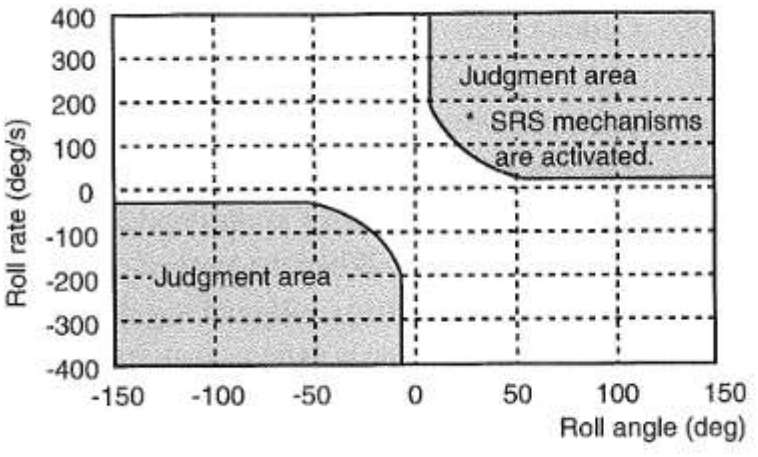

Fig.2 Judgment map

The roll rate is integrated to determine the roll angle of the vehicle, but roll rate data alone are not enough to predict if a vehicle is (or will be) rolling over. An accelerometer reading vertical acceleration (Z axis) is also required because large roll angles can be encountered in banked curves with no possibility of rollover. Many rollover detection systems use a second accelerometer to measure lateral acceleration (Y axis). If a car is sliding sideways, it's less likely to roll over if unobstructed. But if it hits a curb or another object, the chances of a rollover increase significantly. The side crash detection accelerometer generally can't perform this task because the magnitude of acceleration when sliding sideways is close to the noise floor of the typical >100 g range used for side impact detection [6] A low g range, dual-axis accelerometer is best suited to reading the Y and Z axes' acceleration. Roll rates are almost half an order of magnitude greater, but they must have excellent rejection of external shock and vibration. It's not unusual for a car to roll over immediately after striking another vehicle or stationary object. A gyro whose output is unreliable for a short time after a shock event is next to useless.

3.3 Crash and interior safety sensor

Crash sensing for air bag control represents the largest automotive use of Capacitive accelerometer inertial sensors. In this application, an accelerometer continuously measures the acceleration of the car. When this parameter goes beyond a predetermined threshold, a microcontroller computes the integral of the acceleration (i.e., the area under the curve) to determine if a large net change in velocity has occurred. If it has, the air bag is fired. The decision to fire front air bags has to be made in dozens of millisecond?; the decision to fire side air bags must be made even more quickly because the car door is closer to the occupant than the steering wheel or dashboard. Because the capacitive accelerometer reads a continuous (analog) measurement, you can replace the g switches with one device in the centre console. The resulting increase in reliability (e.g., Analog Devices' highly integrated accelerometers achieve single-digit defect rates) and reduction in price of the air bag system helped bring about its near universal inclusion in cars.

3.4 Acoustic sensors

Acoustic sensors can monitor traffic and be able to detect a crash using the high amplitude noise generated in a crash, if these events happen inside the detection radius of the sensor. Even though acoustic sensors are very useful and have advantages over other sensors, the cost and maintenance of these sensors is significant (though not as high as a video image processor). The limited number of acoustic sensors available need judicious placement to maximize detection capability of future crashes. In this work, we use past crash location. Acoustic sensors can also aid in assessing the severity of a crash. Acoustic sensors can detect if there are multiple impacts in a crash. Multiple impacts from a crash have significant influence of the passenger’s safety. Multiple impact crashes increase the chance of serious injury to vehicle occupants making the information on multiple impacts a higher priority for emergency service providers. Similarly, acoustic sensors are also capable of detecting a rollover during a crash .Thus acoustic sensors not only aid in crash detection but also aid in crash characterization. Acoustic sensors also differentiate themselves from the other sensors by their capabilities in bad weather conditions.

3.5 Vehicle Navigation Systems

3.5Navigation

Vehicle navigation systems are rapidly becoming a standard feature in American luxury automobiles. In Japan, more than half the cars sold in 2001 were equipped with navigation systems. A global positioning system (GPS) is a fundamental part of a navigation system, but GPS information alone is insufficient for navigation. The GPS can tell you where you are (position and altitude), but not what direction you are facing. Magnetometers (electronic compasses) are not reliable because they're confused by large ferrous metal objects close by (e.g., a truck full of scrap metal in the next lane). Navigation systems rely on compass and GPS information when the system is first started. The direction of travel is matched up with map data to give the system more certainty regarding direction. Once initial direction is established, gyroscope information is used to determine when and how much the car has turned, until directional data can be verified by map matching. In urban settings, it's not unusual for the GPS signal to be obscured by tall buildings or tunnels for short periods. At these times, the navigation system relies on the gyroscope for heading information and a low-g accelerometer for position information. The acceleration signal is integrated twice to derive position (this technique is called dead reckoning).

4. CLUSTER AND INTEGRATION

In some cases, there are as many as 15 axes of inertial sensors (accelerometer and gyro) per vehicle. But why don't manufacturers use each sensor for multiple functions? The main reason is that to date no one has had the expertise or interest to integrate all the functions in a single system. Manufacturers often deem inertial sensor signals of safety systems off limits to external functions for fear they'll lose the crash sensor signal because another subsystem (e.g., the navigation system) takes the bus down. Nevertheless, many automotive OEMs are adopting the concept of using a cluster of inertial sensors to send information to whatever system needs it .In this configuration, a six-degree-of-freedom inertial measurement unit (IMU) is located in the centre of the automobile. All the inertial accessory systems (e.g., antitheft, VDC, electronic parking brake, and navigation systems) use the IMU signals, and the unit can also pass information to the air bag control unit. Separate stand-alone accelerometers are still placed at locations around the car for crash sensing. This is necessitated by the proximity-to-crash-zone demand of some of the applications. A side benefit of the inertial sensor cluster concept is that new features can be developed at little additional cost because the inertial information isavailable for free. All the designer has to do is add some intelligence.

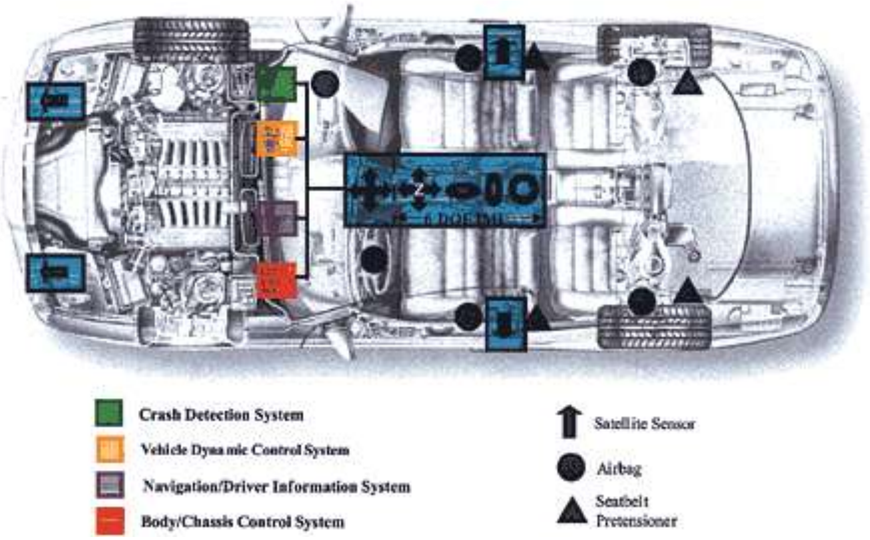

Fig 5.1.1 Cluster position

The increasingly electronic nature of modern cars means that there are more automatic safety systems than ever before. These systems require accurate input about the car’s movement to determine when the car is moving (or will move) in a potentially unsafe way, in order to trigger the appropriate response, be it deploying the airbags or applying the handbrake. Modern sensors use a micro-electromechanical system (MEMS), which can be mass-produced at low cost and enable very small form factors. In this post I'll look at two types of MEMS sensors; accelerometers and gyroscopes, and explain how these parts work and how they are used in today’s vehicle safety systems.

5. CONCLUSION

There are many different technologies available that can assist in creating autonomous vehicle systems. Items such as GPS, automated cruise control, and lane keeping assistance are available to consumers on some luxury vehicles. In this work, the problem of designing an automatic alert system for issuing first-aid calls in the case of riders’ falls in two-wheeled vehicles was considered. To solve the problem, the inertial sensors and the GPS system present on modern smartphones were used. The project showed that this information can be used for rapid communication to road users who can then adapt their driving style. The product will not be accepted instantly, but over time as the systems become more widely used people will realize the benefits of it. The implementation of autonomous vehicles will bring up the problem of replacing humans with computers that can do the work for them. There will not be an instant change in society, but it will become more apparent over time as they are integrated into society. As more and more vehicles on the road become autonomous, the effects on everyday life will be shown.

ACKNOWLEDGEMENT

I would like to express my sincere thanks for the assistance and support of a number of people who made this seminar a success.I am very thankful to my guide Prof.P.D.Menghani ,for his valuable guidance and suggestions throughout the seminar work. I am also thankful to Dr.A.P.Pandhare Head of Mechanical Engg. Dept. and all other staff members for their valuable suggestions.

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