Intelligent Safety Warning and Alert System for Car Driving

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Intelligent Safety Warning and Alert System for Car Driving

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Abstract

The new vehicle performance has been continuously improved and the study results relating to the safety of car driving have also been continuously reported and demonstrated, it is trying to find a balance point between the development of vehicle speed limit and the protection of driver's safety. In the current study and development of various products, no matter it is in the enforcement of vision system, radar detection or the tracing and control it is always asking the driver to watch or handle the possible issues after the occurrence of accidents. In this paper we try to develop a system to provide the prior to accident information to the vehicle control unit so that it enables the vehicle to prevent the happening of accident. During the vehicle movements the system will continuously record the vehicle's moving status and conditions so that the record will provide the decision basis in the accident investigation if it unfortunately happens the fatal accident.

Key Words: Intelligent Safety, Vehicle Control Unit, Warning and Alert System, Automation, Car Driving

1. Introduction

When it turned into twentieth century various kinds of vehicles have been introduced to provide convenience in human daily life and due to the developments of new technologies it makes the vehicle running fast and accelerating easily. It on the contrary brings in some problems such as the happenings of accidents due to driver's fatigue after a long journey of travel, the shortage of parking spaces, the bad visibility in night or the driving in heavy rain days etc. The accidents sometimes bring in the fatality of human lives and loss of properties, therefore many measures to enforce the safety driving and the development of models to monitor driver's behaviors have been proposed and brought in many promising results. From a study conducted by Mercedes Benz it reports that if it can get an extra 0.5 seconds in the warning period it will avoid 60% of the overrun accidents and it will reach 90% if 1.5 seconds is added into the warning period. We introduce in the following some safety warning systems [1–6] that are currently available in the market and they are technically matured:

1.1 Sleepiness Warning System

It reports in statistics that the fatality rate increases by four times when the driver is sleepiness in driving therefore many researches are focused on finding the relationship between the sleepiness with the driver's eyelids width, the visibility of the pupil, the motion of the head etc. Industrial Technology Research Institute (ITRE) has even used the ultra wide bandwidth (UWB) technique to integrate low power pulsed electromagnetic (EM) waves to precisely measure the driver's physiological signals such as his heartbeat and respiration etc. It is also through the development of various system algorithms to detect driver's psychic status. In all these technology developments its main purpose is trying to emit warning signal to awake the driver before his falling into

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sleepiness and to avoid any possible accidents.

1.2 Low-Speed Following Mode (LSM) System

The LSM exploits mini-meter wave radar to detect the acceleration, deceleration and stopping of the front car to estimate the distance away from the front car, meanwhile he also controls the brake and the fuel systems to maintain his car within the safety range. If the front car experiences abnormal condition the system will blow alarm sound to warn the driver.

1.3 Lane Keeping Assist System (LKA)

The LKA uses camera to monitor the passing or dividing lane in the front and the system will give warning signal if the driver crosses the passing lane or enters into the opposite direction passing lane without giving or giving improper direction signal.

1.4 Intelligent Night Vision System (INVS)

In driving at night or in heavy rain the driver's visible range will be restricted and also the light illuminating range will be limited to prevent the driver from clearly noticing any pedestrian along the roadside or the person is in repairing his out of condition car the INVS will display the front road condition on the LCD screen of the car audio system by using infrared camera to monitor the road condition to present to the driver a complete knowledge of the front road condition to greatly reduce the possible occurrences of accidents.

1.5 Adaptive Front-Lighting System (AFS)

The AFS catches the car's moving direction by using the direction sensor implemented in the wheel and then using the unit's control motor to rotate the headlight and with the installation of High Intensity Discharge (HID) Xenon light to extend the light illuminating range so as to enable the pedestrians and the obstructions in the vehicle direction to be visible to the driver.

1.6 Video Parking Assist System

This system uses camera system to extract the images of the car in the back and side directions and in its coordinating with the collision avoidance radar system and the dynamic auxiliary linear system to inform the driver of the wheel rotation direction and angle to assist the driver to complete the reversing or parking action. Currently it has a new system, in coordinating with the wheel rotating mechanism, without requiring the direct involvement of the driver to automatically assist the driver to reverse the car into the garage or to park the car along the road side.

It has other systems, just mention here for reference, such as Adaptive Cruise Control (ACC), Electronic Stability Control (ESC), Emergency Brake Assist (EBA), Blind Spot Warning etc. each system has its own specific functions and will not discuss them further [7,8].

In the design of safety vehicle driving system, it needs to consider and include the following four processes:

(1) Normal condition - to assist the driver to lower his driving burden and to provide him with visual and driving assistances.
(2) Prior to accidence - to prevent the occurrence of accident and to possibly provide the actions of collision avoidance and warning.
(3) During the accidence - to reduce the damage and the collection of accident data and information.
(4) After accidence - to report the accidence and to provide emergency treatment.

In the above-mentioned research themes, they usually emphasize and confine in the normal and prior to accidence processes it seldom covers the information and data collections and the emergency treatment during the accidence and the accident report after the accidence.

The main theme we will consider in this paper is the monitoring of the vehicle behavior model prior to the happen of accidence, to warn the driver when abnormal and dangerous condition might happen and meanwhile it will record the vehicle acceleration, deceleration and its moving direction and finally to provide sufficient information or data for the investigator when he is in the investigation of the accident case.

The organization of this paper is in the following. We will introduce the current development of vehicle safety system in section 1. In the second section we will briefly introduce the most commonly implemented information transmission system in the current vehicles. We will then introduce the design concept and the test platform of our proposed vehicle monitoring system in section 3. In section 4 it will present, discuss the data we collect and the results of analyzing these collected data.

2. Introduction of Vehicle Transmission System

It currently has more than few tens of electronic instruments installed in the vehicle, but at the initial design stage almost every instrument is just designed to independently perform its own function without coordinating and accommodating with others so that the vehicle instruments are just providing the 'base layer' data of the vehicle condition such as the vehicle speed, engine's torque, the remaining in the gas tank and the radiator's temperature etc. The vehicle's audio-video system just provides the audio or video amusement and could not display or provide other conditions of the vehicle. This independent situation has quickly been drawn attention and every world car manufacture has proposed its own ideas of how to inter-connect instruments, basically they possess the characteristics of separating the high speed instrument from the slow speed instrument, serial bus structure and the capability to resist the high random noise. We give a brief description of each instrument in the following:

2.1 MOST bus (Media Oriented Systems Transport)

The MOST bus system was agreed upon and set up by some giant car manufactures and cars equipments providers in 1997 it uses the structure of Ring, Star or Daisy-chain to build up a point-to-point optical network system with data rate of 22.5 Mb/s that it is high enough to convey the compressed videos. Plastic optical fiber is the main transmission media for the optical network to provide a wide bandwidth, low interference data transmission network. The Germany car manufacture BMW integrates this optical network with its own developed ByteFlight system to form the Intelligent Safety Integration System (ISIS). This ISIS system has been implemented in its 7 series sedans to provide a safety monitoring function for the whole vehicle.

Due to the high transmission speed of the MOST bus, the low radiation interference to its surroundings, the lightweight of the transmission material (it is estimated that its weight is around 1/20 of the current copper wire), the price dropping of the optical material and the easier installation and connection of the optical network etc., it is anticipated that the MOST bus system will become the dominant system in the vehicle bus system [9−11].

2.2 J1850 bus

J1850 bus was designed in 1994, its purpose was to apply the functions of self-diagnosis and information sharing etc. within the transportation vehicle (such as car, airplane etc.) In J18050 bus it basically has two information transmission modes, the first mode is a 41.6 Kbps dual-line differential PWM transmission mode, the other is a 10.4 Kbps single line VPM transmission mode. Currently the majority of cars uses the single line transmission mode its transmission distance can reach 35 meters [11,12].

2.3 CAN bus (Controller Area Network)

Within the transportation vehicle it can install one set or many sets of CAN buses. Low speed CAN bus can be used in the regular information transmission and control while the high speed CAN bus can be used in the handling and management of engine condition and in the control of vehicle brake system. The CAN bus is the most popular bus system used in all vehicles, almost all information within each vehicle can be communicated and conveyed through this bus system, but each car manufacture has different definition for its information content, it is not easy to understand the content of the information transmitted in the bus of other vehicles if the information definitions in the bus system are not transparent between car manufactures [11,13,14].

2.4 LIN bus (Local Interconnect Network)

This bus system is used within the transportation vehicle itself, it is a series bus to communicate between each detecting/monitoring instrument and electronic switch, its highest transmission rate is 19200 bauds for a maximum transmission distance of 40 meters [11].

In addition to above discussed bus structures that are frequently implemented in the vehicles they are many other designs and structures of bus systems such as MI, DSI, OBDII, Flex Ray, D2B, SMART wire X, IDB-1394, IE bus, Intelli Bus, BST bus, MM bus and J1708 bus etc.

3. Design Concept and the Composition of the Design Platform

3.1 The Composition of the Design Platform

This design platform consists of a microprocessor and an acceleration sensor as shown in Figure 1 is a test board of an acceleration sensor. The analog signal output from the acceleration sensor is amplified by a two-stage amplifier and is sent to the design platform, the system is completed by connecting this platform with a computer. This test board is also integrating with an optical receiver and many sets of analog/digital converters for use with other applications.

3.2 Procedures in Data Extraction and Data Analysis

It uses vibrator to test the acceleration of the design platform, the design platform is vertically fixed at the vibrator platform due to the vibrator is repeatedly vibrating in the up/down directions. We made four random tests and in each test we applied 1G ~ 4G vibrating force test in four directions of the design platform. As shown in Figures 2 and 3 are a series of resulting vibrating waveforms in the tests. The vibrator delivers its sensed output in each dimension of the 2D test, but we just select one set of data from the x-axis and from the y-axis for analysis. In the test driving condition when it happens to have acceleration impulse effect it will happen only in the x-direction (forward-backward) with an abrupt and high-slope data changes while in actual driving situation it will also happen with data variation in the y-axis (left-right). The data obtained from these four random tests are almost the same therefore we can conclude that the data obtained from the design platform are reproducible and we can use any set of data in the analysis.

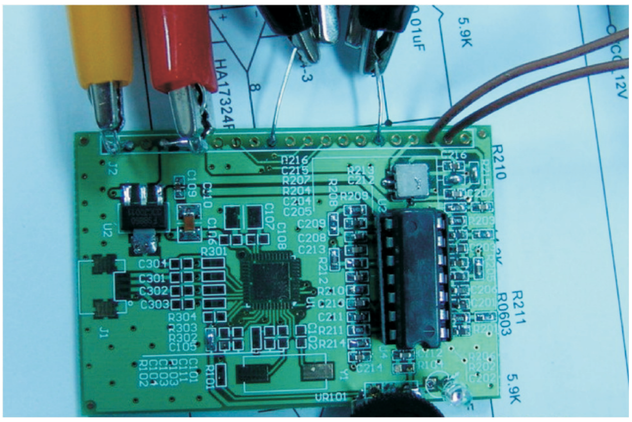


Figure 1. Test board of acceleration sensor.

After analyzing the test data, obtained from the design platform, we have the data distributions for the 1G~5G vibrating force tests as shown in Figure 4.

3.3 The Design of Acceleration Impulse Pre-Warning System and Its System Flow Chart

When a vehicle is supposed to be in slow motion or in stopping situation but due to the malfunction of the fuel supply system or due to the human mistake the vehicle engine is accelerating to a high speed in a very short duration and resulting in the vehicle damage and the fatalities of the driver and passengers. It intends to design a pre-warning system to prevent the happening of the acceleration impulse in its early forming stage and to inform or to warn on time to the fuel supply system, the electric system or the brake system to perform appropriate action to prevent the occurrence of this kind of accidence.

The acceleration impulse pre-warning system is basically an automatic data analysis system that is set up from integrating the results by analyzing various test data collected from the test. When the design platform extracts a new data it will analyze the data and from its analyzed result to determine how many Gs of the vehicle's acceleration has and to display the result on the monitor. In the design of our pre-warning system we assume that when the acceleration exceeds 3G it will have acceleration impulse effect, therefore we will mark with red symbol under the main picture when the data is

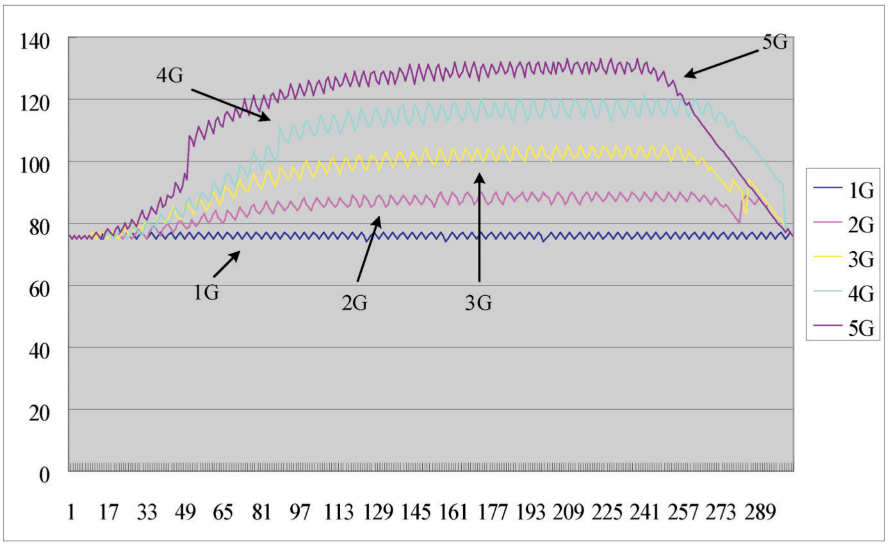


Figure 2. Test data in the x-axis.

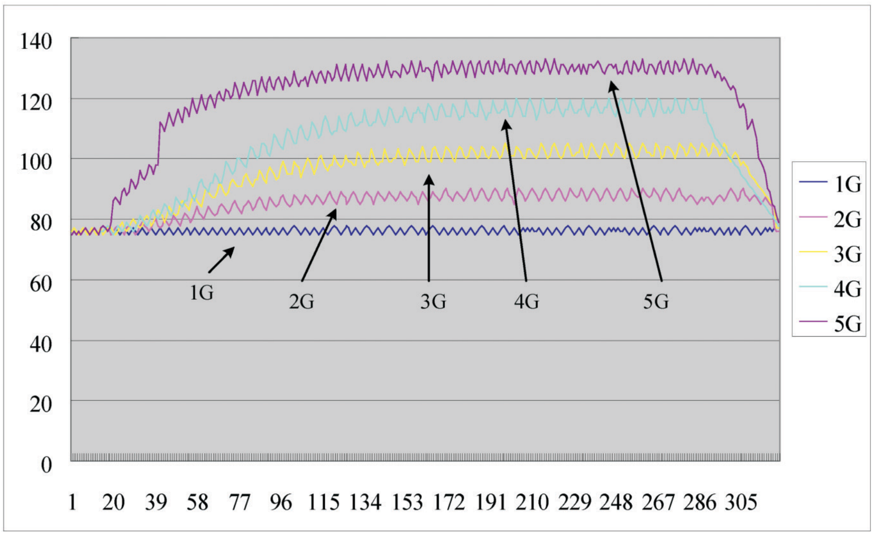


Figure 3. Test data in the y-axis.

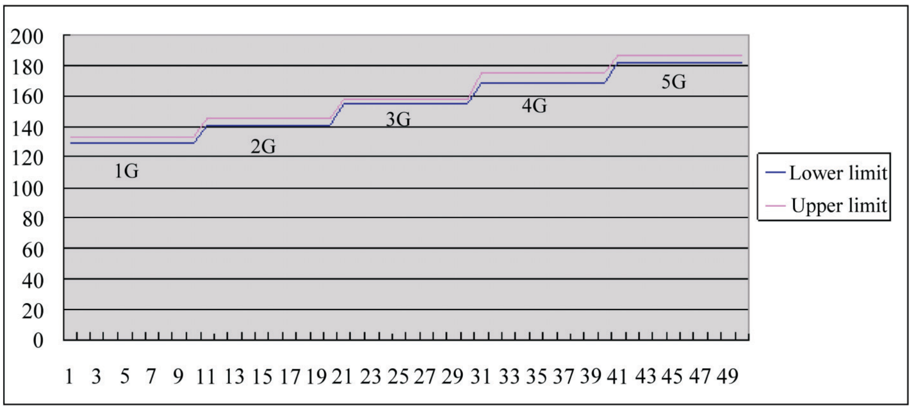


Figure 4. Data distribution resulting from 1G~5G vibrating force tests.

higher than 3G to signify it is in the dangerous stage. Furthermore in the actual test we found that when the acceleration exceeds 5G this vibrating force is far more than human being can be safely driving or seating in the vehicle we therefore do not extract any data when the acceleration force is more than 5G and the system design limit is also set at 5G. The system flow chart as shown in Figures 5 and 6.

3.4 System Design for Monitoring the Driving Behavior and Its System Flow Chart

Except for few buses and large-size touring buses, almost all compact vehicles are not equipping with any driving behavior monitoring system therefore it is impossible to trace driver's driving behavior for those cars drivers. Consequently they do not have any pre-warning and verification data available during the time prior to-, during and after the accident. The driving behavior monitoring system is not only to record the vehicle running conditions for certain time interval but also gives warning signal to the driver before occurring any dangerous condition and to advise the driver to correct his driving behavior.

When a car is running on the road the driver will always have certain preparatory action when he is going to perform any change, which can be modeled by an associated identifiable model, for example, when he decides to make right or left turn he will normally reduce his speed and enters into the turning lane he will then accelerate after he enters into 1/2 or 1/3 of the turning lane. In another example when a driver is driving in high speed and is going to make an emergent stop he will usually take a few stages to break or stopping the car instead of braking the car all the way in only one step from the considerations of the safeties of the passengers and pos-

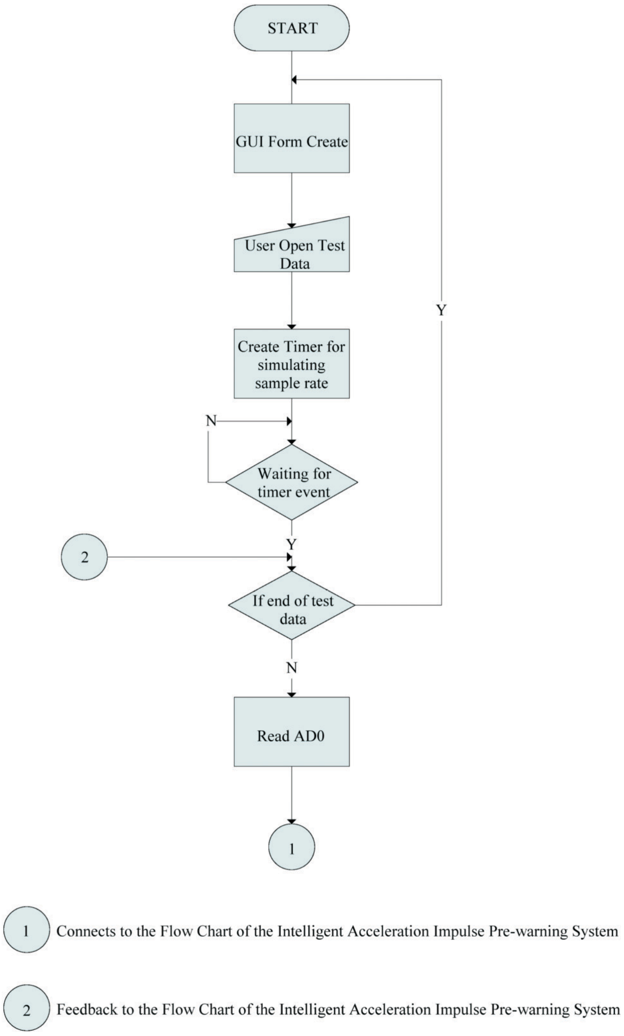


Figure 5. Flow chart of acceleration impulse pre-warning system (1).

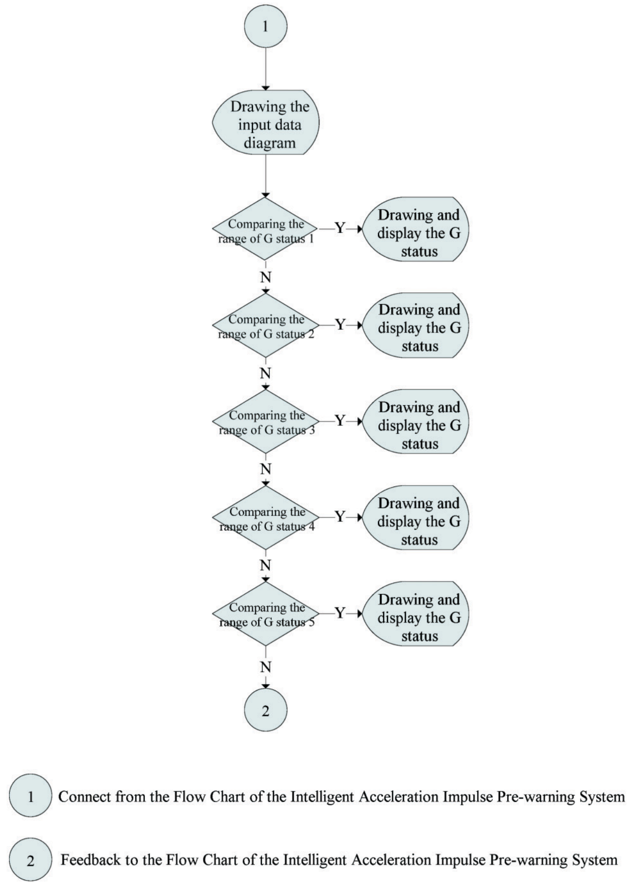


Figure 6. Flow chart of acceleration impulse pre-warning system (2).

sible material carried in the vehicle.

Based on the experience of driving a car and collected statistical data in normal driving situation we can analyze and develop some abnormal driving behaviors such as when the driver is not fully awake or he is unconsciously drunk that he is driving the car diverting toward to one side or could not keep the car running in a straight line due to he could not make correct decision or to determine the proper distance from the front car, or he could not clearly identify in front road condition or he has fallen asleep and even could not control the car. In this situation he is driving the car toward to right or left but he will not have any braking action and in the worst situation he is speeding while the car is constantly making changes in right or left turns.

The intelligent driving monitoring system is an automatic data analysis and simulation system. Since the behavior model used in the monitoring of driving behavior is rather complicated and it also needs to analyze data taken simultaneously in the x-axis and y-axis directions, in this paper we design and implement a simplified driving behavior monitoring system to analyze only one x-axis and one y-axis data to determine the driver's behavior. We will need in our future task to enforce this introductory system to consider not only one data point but to monitor the variation of data in an interval of time and then to make the decision from these integrated data information. It may also need to include some fuzzy process so that to accomplish a more delicate identification results. The system flow chart as shown in Figures 7 and 8.

4. Test Results and Its Distinguish from Other Systems

4.1 Test Results of Acceleration Impulse Pre-Warning System

When a vehicle endures acceleration impulse force it

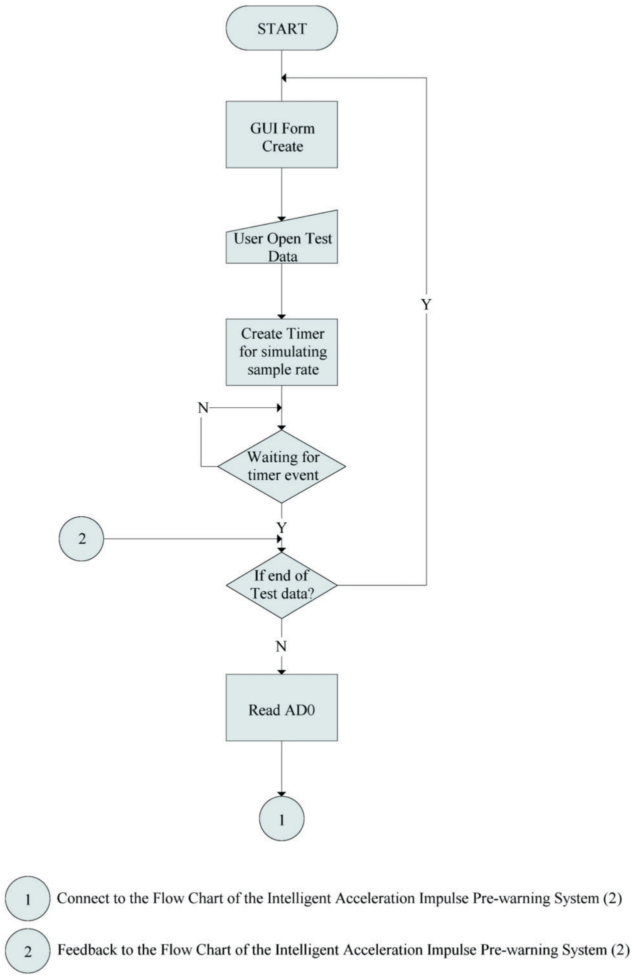


Figure 7. Flow chart of driving behavior monitoring system (1).

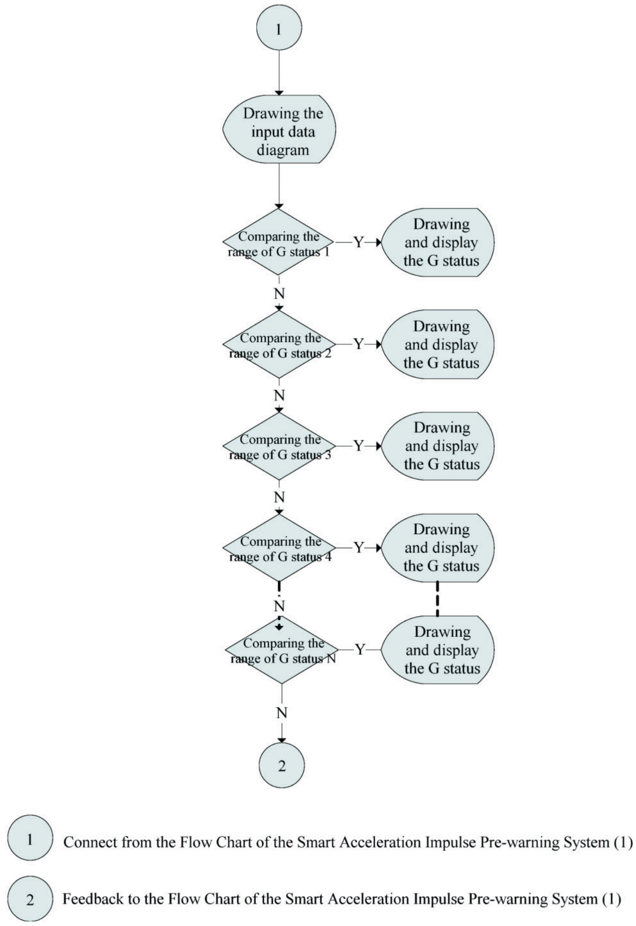


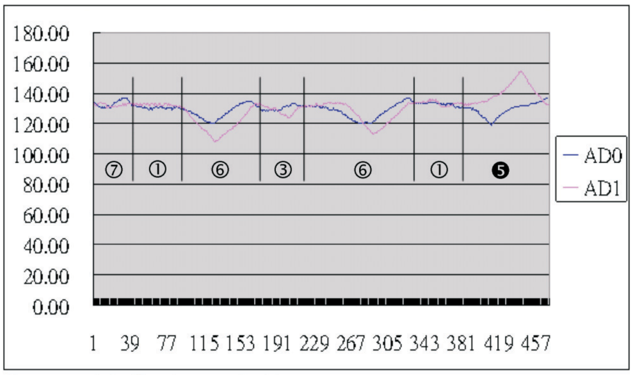
Figure 8. Flow chart of driving behavior monitoring system (2).

is almost for sure it will be abruptly moving toward forward or backward, the engine reinforces it to continuously rotate and is moving faster. Consequently the design principle of our pre-warning system is to use the acceleration sensor to measure and analyze the amount the car has moved forward or backward; make its decision based on the analyzed result. The test platform is installed on the car and it will measure the actual output of the acceleration sensor when the car suddenly accelerates. After analyzing the measured data it is found that when the sudden acceleration force has reached around 2G the car is still controllable therefore we assume that it will incur acceleration impulse effect when it reaches 3G acceleration force and we will use 3G as the threshold to issue a warning signal.

We input the measured data into the acceleration impulse detection system; when the input data has force higher than 3G it will mark on the figure a red warning label. When the system is actually implemented in the vehicle this warning label and control command will flow through the data bus directly into its relevant systems to provide a timely safety protection measure or signal.

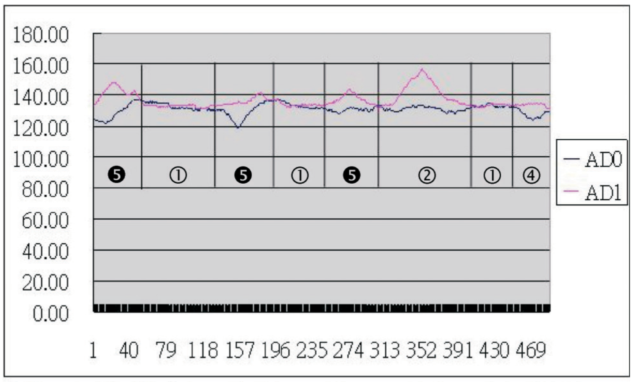
4.2 Test Results of the Driving Behavior Monitoring System

In the driving behavior monitoring test the data taken from the x-axis of the design platform is relating to the vehicle acceleration and braking decision while the data taken from the y-axis axis is relating to the decision to make right or left turn. In Figures 9~11 they analyze and display the results of many models of normal or abnormal driving behaviors. In the figure the label AD0 denotes the forward or backward movement, while AD1 represents the left or right direction movement. For an illustrative example consider the third section of Figure 9, it initially runs the test with high speed but with non-braking action it happens that the speed is too high



①Keep straight ②Left turn no braking ③Right turn no braking ④Apply brake
❺Left turn and apply brake ⑥Right turn and apply brake ⑦Accelerating

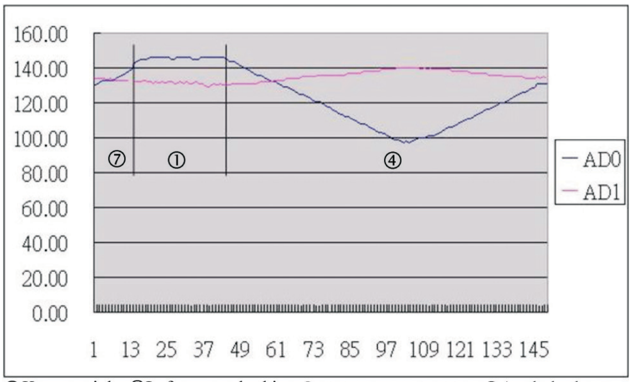
Figure 9. Vehicle makes right turn test.



①Keep straight ②Left turn no braking ③Right turn no braking ④Apply brake
❺Left turn and apply brake ⑥Right turn and apply brake ⑦Accelerating

Figure 10. Vehicle makes left turn test.

to make a safety turn, it instantly lows the vehicle speed to bring the vehicle safely back to its normal path and it then accelerates again to make its turn. The fifth section is the result of normal right turn, the vehicle decelerates first before making turn and it accelerates again after making 2/3 of the turn. In sixth section of Figure 10 it illustrates the vehicle makes a dangerous left turn, the speed is high when it makes left turn and it does not intend to make any speed deceleration that it is easy to incur accidence. In Figure 11 it is the situation when the driver is awake but he makes an abrupt acceleration and then makes an abrupt braking, his speed is accelerated to certain level but he is afraid to make further acceleration so that in it shows in the figure that the speed is keeping at the same level for a while, it makes a little skid toward the left when he abruptly applies the brake and all non-fixed objects in the car are all getting loose and scattering over everywhere.



①Keep straight ②Left turn no braking ③Right turn no braking ④Apply brake
❺Left turn and apply brake ⑥Right turn and apply brake ⑦Accelerating

Figure 11. Vehicle abruptly accelerating/abruptly applies braking test.

Each behavior is also given a name to signify its condition. In actual implementation this system will be integrated with the vehicle's data bus and to provide the real time data for the vehicle's control system and have the control system to make proper decision.

4.3 Test Data and Data Analysis

From the data that we collected from the model of vehicle moving behavior as described in the previous section we conclude in Figure 12 the correlations between vehicle moving directions versus vehicle moving speeds. From this figure it can identify which is the normal driving behavior that will not incur any dangerous action and which is the driving behavior that may easily generate accidence. It also displays their distributions.

The test results as shown in Figures 13 and 14 are the results possibly displayed in the user's interface. As shown in Figure 13, the behavior designated with green line is classified as a normal condition while the dangerous behavior is displayed in red.

4.4 The Integration with Vehicle's Data Bus

The acceleration impulse pre-warning system and the driving behavior monitoring system as discussed in the paper are the test systems designed only for experimental purpose. However if they only possess these described functions or they are separately implemented they will not provide many practical usages. The most important issue is that they need to be cooperated with the vehicle's data bus system so that it can convey the measured data through the data bus and integrating together with the control system to accomplish the main task of protecting the safeties of passenger's lives and properties.

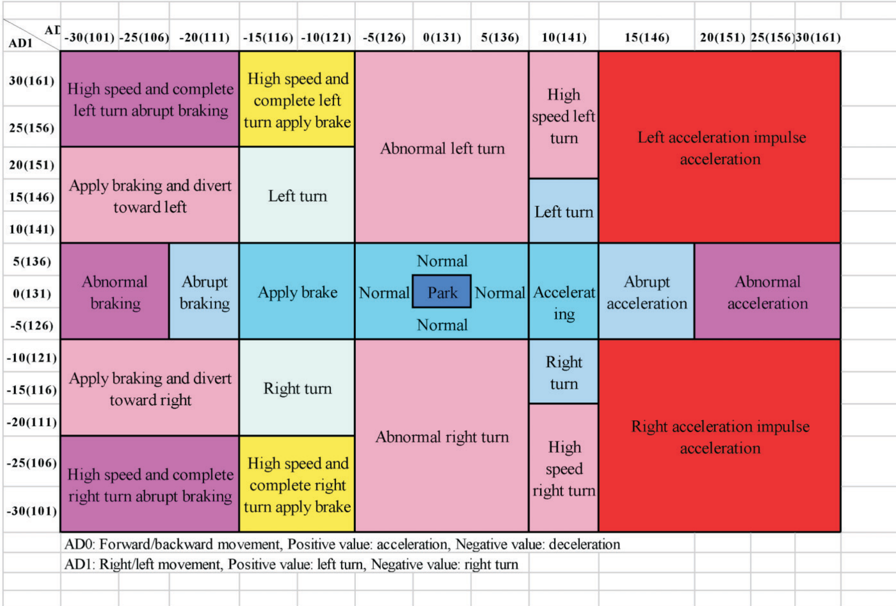


Figure 12. Correlations between vehicle moving directions with vehicle moving speeds.

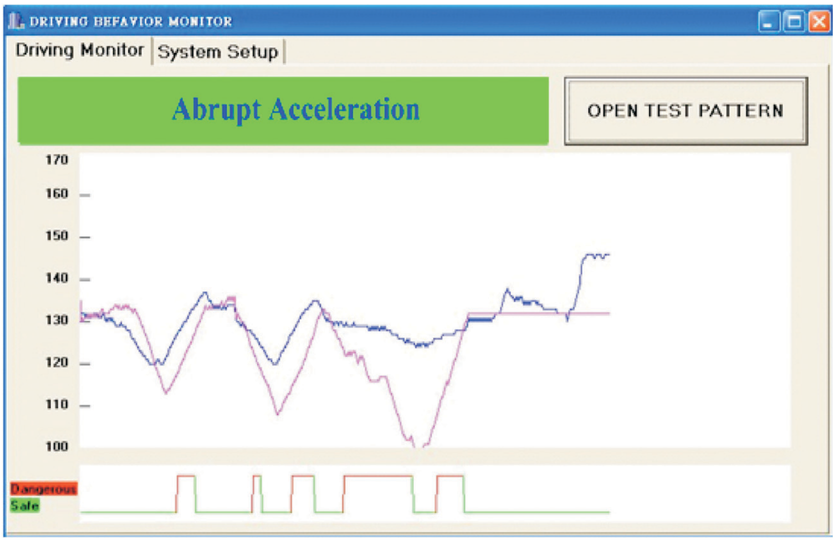


Figure 13. Model of abrupt acceleration.

5. Conclusion

If many instruments are equipped in a high speed vehicle to provide more than necessary information to the driver they will draw the driver to pay particular attention to these instruments and furthermore he needs to learn how to maneuver there instruments. Diversion, fatigue are two fatal factors in the car accidents.

The main task of our study is trying through the study of driver's driving behavior and in coordinating with the information provided from the pre-warning system to decelerate the vehicle speed prior to the happening of accident and if accident happens to reduce the damage to the least level. In our study we also realize that in addition to the items we have tested and verified they still have some tasks we can study in the near future such as the task when the car is running along a sloppy road how the driving behavior monitoring system can be incorporated with vehicle speed data, which is transmitted and obtained through the data bus system, to provide relevant data to the monitoring system to reflect a more accurate vehicle's moving condition and environment. To provide a more concise

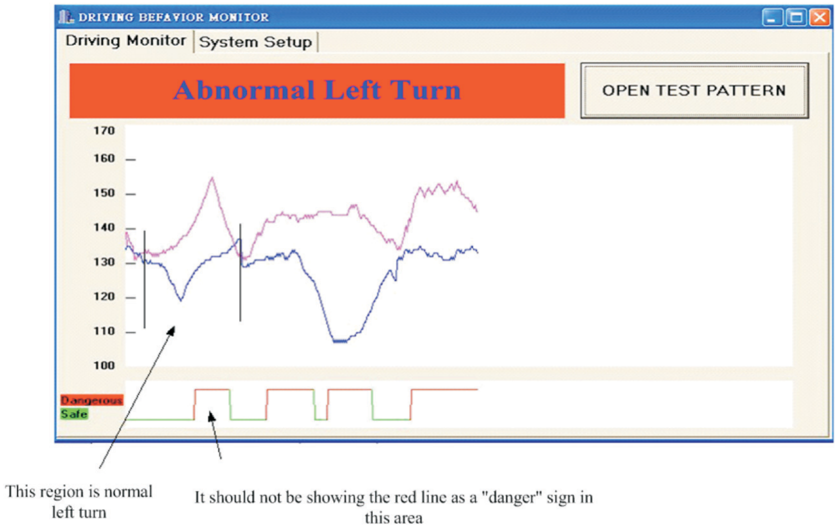


Figure 14. Model of abnormal left turn.

format for the data transmitted in the data bus system to save some system memory is also a challenge task.

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