Real Time E-Crashcorder for Automobiles using ARM Processor

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Abstract— Modern vehicles use onboard computers to control driving systems, including braking and airbag deployment. The computers are connected to sensors throughout the vehicle and send the sensor data to EDR (Event Data Recorder aka Vehicle Black Box). But these EDRs have limitation, such as this EDR itself went wrong during the crash event. As a result the data that was stored is not good enough to figure out whether the car or the driver is to blame. Some of the stand-alone Digital Video/Audio Recorders that are currently in the market are used primarily for security purpose and thus are not going to help to analyze a crash event. The aim of this project is to design a next generation Vehicle Black Box (EDR), named as E-Crashcorder (Enhanced Crash Data Recorder). E-crashcorder records the value of accelerator pedal position, brake pedal position, steering wheel angle, crash severity, vehicle direction, wheel speed, transmission gear position, airbag deployment data, audio and video snapshot, when there is a change in 3-Axis MEMS Accelerometer. This data is used to find the actual accelerator and brake level applied by the driver, angle of steering wheel, direction and speed of the vehicle, vehicle status and location of the vehicle during the crash. These values are used for crash investigation.

Key words: E-Crashcorder, Vehicle Black Box (EDR)

I. INTRODUCTION

In the present day, everyone is running behind speed all want to come first. In such scenarios accidents are increasing. This also increases the amount of accident. An Accident is a disaster which is specific, identifiable, unexpected, unusual and unintended external event which occurs in a particular time and place, without apparent or deliberate cause but with marked effects.

In case of accident, the videos of black box are often used as the field evidence of accident as it records the moment of accident with videos. For such reason, the black box is mounted on the numerous cars currently. The main aim of this project is to integrate the Electronic Control Unit (ECU) within the vehicle which is responsible for the airbag control and deployment and stores the status of vehicle gathered from different sensors. It is equipped with several sensors and devices to record several crash data parameters such as Accelerator Pedal Position, Brake Pedal Position. After collecting and synchronizing all data, the E-Crashcorder saves them in Secure Digital (SD) Card. It has an USB port which is used to transfer the recorded data to a PC/Laptop. Benefits customers receive are accurate, real time, easy to interpret data, a tamperproof system and additional security.

The black-box is modified accordingly so that the system is triggered automatically as soon as abnormal readings are detected by the 3-Axis MEMS Accelerometer. The device continuously collects information. The data sets collected by the device are briefly stored and constantly replaced in a circular loop lasting about 30 seconds. Thus during an accident where airbags are deployed, the latest copy that is available in the memory is the data that was collected during the crash event. Immediately after a crash event, the recorder automatically stops after a few seconds. EDR data can be retrieved and analyzed to determine the driver's actions and how the vehicle performed at the time of a crash. A real time clock running in the microcontroller is used to timestamp every data that will be recorded.

In-vehicle monitoring technology has the potential to provide a wide range of safety benefits, including:

- Relatively inexpensive and continuous measurement of driving behavior and vehicle use, which is otherwise difficult to observe.
- More accurate and objective data retrieval about crash than the data's collected from people during investigation.
- Tools for employers to monitor and assess their staff who drive for work, improve safety, reduce crash rates and operational costs, meet their legal obligations and reduce the risk of prosecution or civil action.
- A method for insurance companies to differentiate between drivers based on their risk, rather than just by gender or age, and to tailor their insurance premiums accordingly
- A powerful research tool to enable the collection of large amounts of real-life, natural driving behavior and the effectiveness of safety interventions on that behavior
- A tool to inform further training and guidance needs
- Data to help highway authorities to identify problem locations on their road network.

II. RELATED WORK

The performance data recorder (PDR) was co-developed by Cosworth and Chevrolet. Cosworth is an engineering company in Northampton, England, that specializes in engines and electronics for automobile racing. The targeted users of PDRs are weekend racetrack drivers. The PDR goes well beyond the capabilities of typical in-vehicle data recorders by, among other things, capturing high definition video of the road ahead along with audio recorded using a dedicated cabin microphone. Performance data are stored on a removable secure digital (SD) card of whatever capacity the driver chooses. The acquired performance data are augmented by video provided by a forward-looking camera integrated into the rearview mirror and by audio from an in-cabin microphone. Everything is stored on an SD card and its universal serial bus-port slot is located in the glove box.

III. SYSTEM DESIGN

In the proposed method crash occurrence is detected by 3-axis MEMS accelerometer. 3-axis MEMS accelerometer is an electromechanical device that measures acceleration forces.

When the vibration level of 3-axis MEMS accelerometer exceeds the threshold level then the DC motor suddenly stops its rotation, which is the indication of crash occurrence and data collected from various sensors are stored in the SD card. Fig. 1.illustrates the block diagram of the proposed system. In this system ARM controller is powered with 3.3v and other devices are powered with 5v. Motor driver is used to drive the motor. In the initial stage all the sensors are initialized and sensor data is continuously monitored using 32- bit ARM Cortex microcontroller.

DC motor is used to demonstrate a accelerating or decelerating vehicle and crash occurrence indication. Acceleration and deceleration is provided by using variable resistor. Camera is used to record the snapshot in front of the vehicle during crash. The Global Positioning System receiver is used to read the current latitude and longitude of the vehicle point.3-axis MEMS magnetometer is used to measure the direction and orientation of the vehicle.

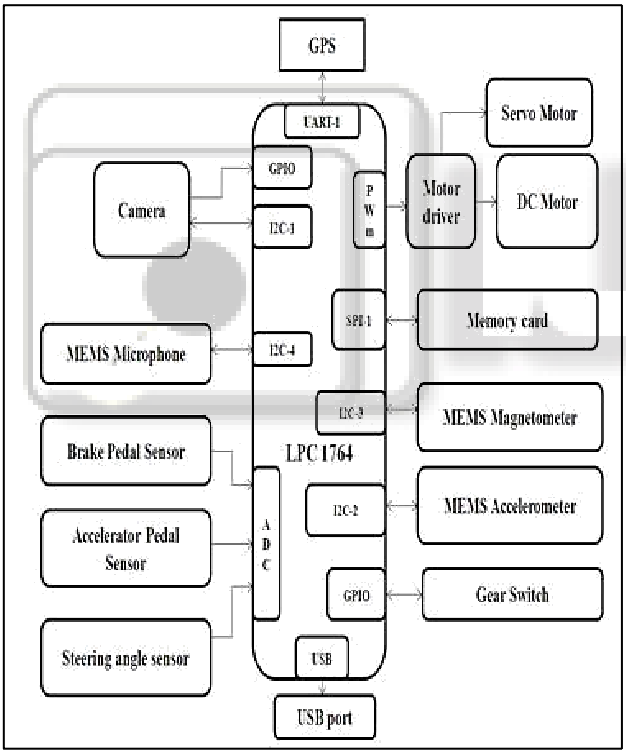

Fig. 1: Block Diagram

Microphone is used to record the audio inside the vehicle. After collecting and synchronizing all data, the E-Crashcorder saves them in Secure Digital (SD) Card.USB port is used to transfer the recorded data to a PC or Laptop.

IV. HARDWARE DESCRIPTION

A. ARM Cortex-M3:

The LPC1764 is an ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption. The LPC1764 operate at CPU frequencies of up to 100 MHz The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal prefetch unit that supports speculative branching. The peripheral complement of the LPC1764 includes up to 512 kB of flash memory, up to 64 kB of data memory, Ethernet MAC, USB Device/Host/OTG interface, 8-channel general purpose DMA controller, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 3 I2C-bus interfaces, 2-input plus 2-output I2S-bus interface, 8-channel 12-bit ADC, 10-bit DAC, motor control PWM, Quadrature Encoder interface, four general purpose timers, 6 output general purpose PWM, ultra-low power Real-Time Clock (RTC) with separate battery supply, and up to 70 general purpose I/O pins.

B. LPC Xpresso IDE:

The LPCXpresso is a new, low-cost development platform available from NXP. The software consists of an enhanced, Eclipse-based IDE, a GNU C compiler, linker, libraries, and an enhanced GDB debugger. The hardware consists of the LPCXpresso development board which has an LPC-Link debug interface and an NXP LPC ARM-based microcontroller target. LPCXpresso is an end-to-end solution enabling embedded engineers to develop their applications from initial evaluation to final production.

The LPCXpresso IDE, powered by Code Red Technologies is based on the popular Eclipse development platform and includes several LPC-specific enhancements. It is an industry-standard GNU tool chain with an optimized C library that gives engineers all the tools necessary to develop high quality software solutions quickly and cost-effectively. The C programming environment includes professional-level features. There is syntax coloring, source formatting, function folding, on- and offline help, and extensive project management automation.

The LPCXpresso target board, jointly developed by NXP, Code Red Technologies, and Embedded Artists, includes an integrated JTAG debugger (LPC-Link), so there's no need for a separate JTAG debug probe. The target portion of the board can connect to expansion boards to provide a greater variety of interfaces, and I/O devices. The on-board LPC-Link debugger provides a high-speed USB to JTAG/SWD interface to the IDE and it can be connected to other debug targets such as a customer prototype. Users can also use the LPCXpresso IDE with the Red Probe JTAG adapter from Code Red Technologies.

C. 3-Axis Accelerometer and 3-Axis Magnetometer:

The LSM303DLH is a system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor. The various sensing elements are manufactured using specialized micromachining processes, while the IC interfaces are realized using a CMOS technology that allows the design of a dedicated circuit which is trimmed to better match the sensing element characteristics.

The LSM303DLH has a linear acceleration full-scale of ±2 g / ±4 g / ±8 g and a magnetic field full-scale of ±1.3 / ±1.9 / ±2.5 / ±4.0 / ±4.7 / ±5,6 / ±8.1 gauss, both fully selectable by the user. The LSM303DLH includes an I2C serial bus interface that supports standard mode (100 kHz) and fast mode (400 kHz). The internal self-test capability allows the user to check the functioning of the whole module in the final application. The system can be configured to generate an interrupt signal by inertial wakeup/free-fall events, as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable on the fly by the end user. Magnetic and accelerometer parts can be enabled or put in power-down mode separately. The LSM303DLH is available in a plastic land grid array (LGA) package, and is guaranteed to operate over an extended temperature range from -30 to +85 °C.

D. DC Motor:

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion. DC motor has six basic parts -- axle, rotor (a.k.a., armature), stator, commutator, field magnet(s), and brushes. In most common DC motors (and all that BEAMers will see), the external magnetic field is produced by high-strength permanent magnets.

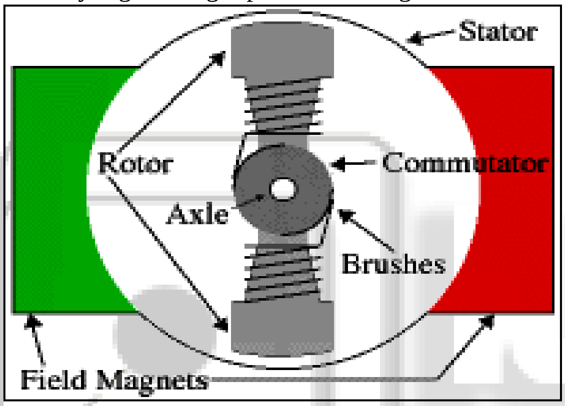

Fig. 2: Pole DC Motor

Fig.2.shows the simple 2-pole DC motor construction. The stator is the stationary part of the motor -- this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotates with respect to the stator. The rotor consists of windings (generally on a core), the windings being electrically connected to the commutator.

E. Servo Motor:

A Servo Motor is a motor which is part of a servomechanism. A Servo Motor is defined as an automatic device that uses an error-correction routine to correct its motion. The term servo can be applied to systems other than a Servo Motor; systems that use a feedback mechanism such as an encoder or other feedback device to control the motion parameters.

F. GPS:

LS20030~3 series products are complete GPS smart antenna receivers, including an embedded antenna and GPS receiver circuits, designed for a broad spectrum of OEM system applications. The product is based on the proven technology found in LOCOSYS 66 channel GPS SMD type receivers MC-1513 that use MediaTek chip solution. The GPS smart antenna will acquire up to 66 satellites at a time while providing fast time-to-first-fix, one-second navigation update and low power consumption. It can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment. Its far-reaching capability meets the sensitivity requirements of car navigation as well as other location-based applications.

G. Motor Driver:

The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source.

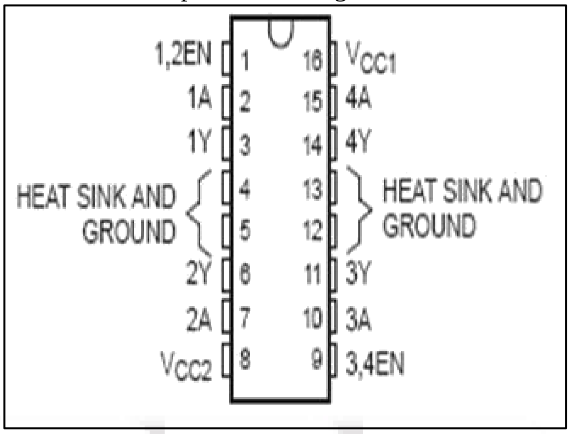

Fig. 3: Pin Diagram of L293D

Fig. 3.shows the pin diagram of L293D.Drivers is enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

1) Features:

- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Output Current 1 A Per Channel (600 mA for L293D)
- Peak Output Current 2 A Per Channel (1.2 A for L293D)
- Output Clamp Diodes for Inductive Transient Suppression (L293D)

H. Memory Card:

The TwinMOS Micro SD Memory Card is functionally compatible with the SD Memory card but is smaller in dimensions. It can be inserted into a passive SD or miniSD memory Card Adapter and operate as an SD Memory Card. TwinMOS Micro SD Card TM is ideal for digital devices designed to use Micro SD Card.

I. Linear Taper Potentiometer:

A linear taper potentiometer (linear describes the electrical characteristic of the device, not the geometry of the resistive element) has a resistive element of constant cross-section, resulting in a device where the resistance between the contact (wiper) and one end terminal is proportional to the distance between them.

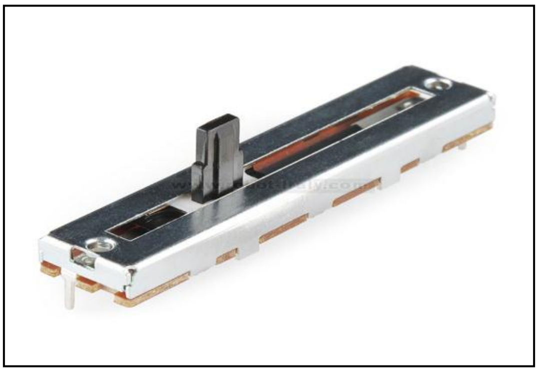

Fig. 4: Linear Taper Potentiometer

Fig.4.shows the configuration of linear taper potentiometer. Linear taper potentiometers are used when the division ratio of the potentiometer must be proportional to the angle of shaft rotation (or slider position), for example, controls used for adjusting the centering of the display on analog cathode-ray oscilloscope.

V. RESULTS AND DISCUSSION

The monitoring parameter acceleration value is simulated using one of the 1kΩ linear taper potentiometer (Acc. pedal sensor), which is connected through the (ADC 0) pin24 of LPC1764. Brake value is simulated using another 1kΩ linear taper potentiometer (Brake pedal sensor) is connected through (ADC 1) pin23 of LPC1764. 3-Axis magnetometer and accelerometer is connected with LPC1764 through (I2C 0) pin 21.

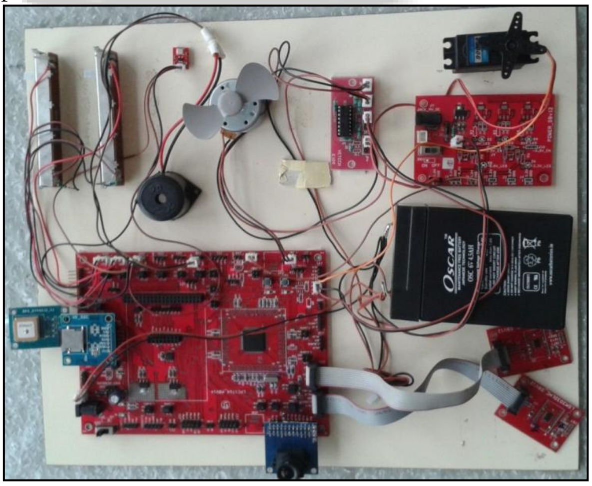

Fig. 5: Hardware of Proposed System

Fig.5. Shows the Hardware of proposed system. 12V DC motor is controlled by PWM 1of LPC1764.It is connected through the pin 31 of LPC1764. DC motor rotates based on the value given by the accelerator and brake linear taper potentiometer. If the Acc. Pedal sensor position is increased from minimum, then the DC motor will start to rotate.

When the Acc. Pedal sensor value reaches 0.5 kΩ, then Dc motor rotates at 100 RPM. Further the speed of the DC motor is increased by increasing the Acc. Pedal sensor value. If the Brake pedal sensor is increased from minimum, then the DC motor rotation speed is reduced. This indicates the acceleration and brake applied by the driver. Servo motor indicates the steering angle rotation. It is connected through the pin 43 of LPC1764.Steering angle is measured using another LSM303DLH is connected through (I2C 1) pin 22 of LPC1764.Bush button is used to provide gear input. Maximum gear position given to push button is 5.12V battery is used to provide power supply to all the units. Another one push button is used to provide ignition status input to the LPC1764. Buzzer is connected through (ADC 5) pin28 of LPC17634 which is used to indicate the ignition status. When the ignition status is in ON position the buzzer will produce a sound.

GPS receiver is connected with LPC1764 through (UART 0) pin 10.It is used to provide longitude and latitude position of the E-Crashcorder. Camera is connected through pin 39 of LPC1764 and MEMS microphone is connected through (ADC 2) pin25 of LPC1764.All the recorded data are stored in separate text files from 1.txt to 10.txt using LPC1764. Those text files are stored in SD card and also viewed in the system through the USB cable using flash magic software.SD card is connected with LPC1764 through pin 42.

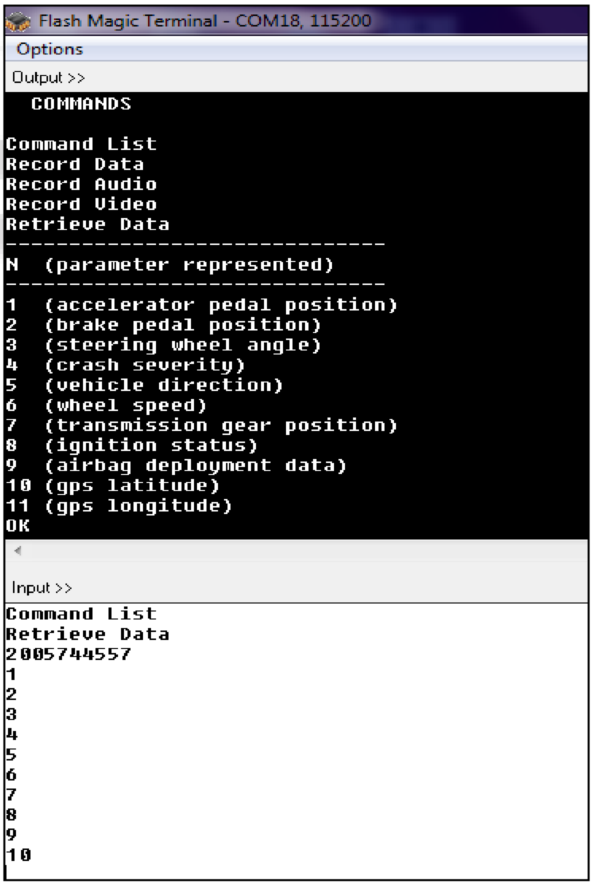

Fig. 6: Inputs Given To Retrieve Data Using Flash Magic

Fig.6 shows the Input given to the system to retrieve the recorded data using flash magic software. Audio and vedio.Fig.7 (a),(b) shows the recorded data retrieved from E-Crashcorder using USB cable.

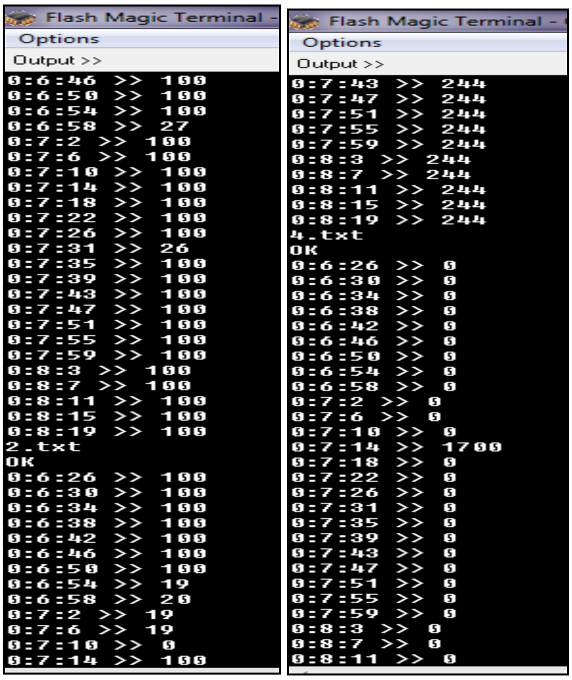

Fig. 7: (A), (B) Recorded Values in the Text Files

VI. CONCLUSION

Accidents are common in nowadays as the number of vehicles were increased. Many new safety standards are being introduced. Black box is an advanced technology and used for recording the data inside the aircraft cabin for accident detection and further investigations. This project tries to make a system which can be a safety standard in coming years. The main aim of this work is to implement the same in automobiles. In recent days onboard computers are used in automobiles to record various parameters such as speed, time of journey, engine temperature and driver's behavior during crash. But these parameters are not enough to find out the true happening during crash. To overcome the difficulty in investigation some other parameters has been included in this project.

Various components such as 3-Axis MEMS Accelerometer, 3-Axis MEMS Magnetometer, Microphone, Global Positioning System, Accelerator pedal Sensor, Brake pedal Sensor, Steering wheel sensor are used in this black box. The black box continuously collects the information from above components when it is initiated. When the motion detected by 3-axis MEMS accelerometer exceeds the threshold value, then the controller starts to collect the information from above components. The data such as accelerator value, brake value, steering wheel angle, crash severity, vehicle direction, wheel speed, transmission gear position, airbag deployment data, audio and video snapshot are the most vital parameters, which are used for future investigation.

REFERENCE

[1] M.M Ahmed, M.A Abdel-Aty "The Viability of Using Automatic Vehicle Identification Data for Real-Time Crash Prediction", Intelligent Transportation Systems, IEEE Transactions on Vol. 13, June 2012 Issue 2, pp. 234-242

[2] P.Angkititrakul, D. Kwak ,S. Choi ,J. Kim ,A. Phucphan ,A. Sathyanarayana and J.Hansen "Getting start with UTDrive: Driver-behavior modeling and assessment of distraction for in-vehicle speech systems" in Proc. Interspeech 2007, Antwerp, Belgium, June 2007,pp. 1334–1337. 2007

[3] P.Angkititrakul ,M.Petracca ,A.Sathyanarayana and J.Hansen "UTDrive: Driver behavior and speech interactive systems for in-vehicle environments" 2007 in Proc, IEEE Intelligent Vehicles Symp., Istanbul, Turkey, pp. 566–569.

[4] C.Berka, D.Levendowski, M.Lumicao, A.Yau, G.Davis, V.Zivkovic, R.Olmstead, P.Tremoulet and P.Craven "EEG correlates of task engagement and mental workload in vigilance, learning, and memory tasks", Aviation, Space, Environ. Med, , vol. 78, no. 5, May 2007, pp. 231–244.

[5] M. Broy" Challenges in automotiv software engineering"in Proc, 28th Int. Conf. Software Engineering, Shanghai China,May 2006.

[6] Constantinos Patsakis, Agusti Solanas "Privacy-Aware Event Data Recorders:Cryptography Meets the Automotive Industry Again" ,IEEE Communications Magazine, vol. 13, Dec 2013 , pp. 122-128.

[7] Cosworth and Chevrolet "Advances in Automotive Electronics", IEEE vehicular technology magazine, ,vol. 14, June 2014, pp. 4-12.

[8] I.Damousis and D.Tzovaras "Fuzzy fusion of eyelid activity indicators for hypovigilance-related accident prediction" IEEE Trans.

[9] Intelligent Transport System, vol. 9, no. 3, Sep 2008, pp. 491–500.

[10] Y.Dong, Z.Hu, K.Uchimura and N.Murayama "Driver inattention monitoring system for intelligent vehicles: A review" Proc. IEEE Intelligent Vehicles Symp., Xi'an, Shaanxi, China, june 2009, pp. 875–880.

[11] T.Ersal H.Fuller,O.Tsimhoni, J.Stein and H.Fathy "Model-based analysis and classification of driver distraction under secondary tasks" IEEE Trans. Intell. Transport. Syst. vol. 11, no. 3, Sep 2010, pp. 692–701.

[12] A. Giusti ,C.Zocchi and A. Rovetta "A noninvasive system for evaluating driver vigilance level examining both physiological and mechanical data", IEEE Trans. Intell. Transport Syst., vol. 10, no. 1, Mar 2009, pp. 127–134.

[13] Hwase Park and Daesik Ko" A Design of the Intelligent Black Box using Mining Algorithm", International Journal of Smart Home Vol. 6, 2012,No. 2,pp. 1-6.

[14] M. KutGila, M. Jokela, Markkul and M.Rue M. "Driver distraction detection with a camera vision system" in Proc. IEEE Int. Conf. Image Processing (ICIP 2007), SanAntonio, TX,USA vol. 6, sep 2007, pp. 201–204

[15] M. Kutila, M.Jokela, T.Mäkinen, J.Viitanen, G.Markkula and T.Victor "Driver cognitive distraction detection: Feature estimation and implementation", Proc. Inst. Mech. Engineers, Part

D: J. Automobile Eng, vol. 221, no. 9, Sep 2007, pp. 1027–1040.

[16] Yulan Liang, M.Reyes and J.Lee "Real-time detection of driver cognitive distraction using support vector machines", IEEE Trans. Intell. Transport. Syst. vol. 8, no. 2, June 2007, pp. 340–350.

[17] C.T Lin, R.C.Wu ,S.F.Liang, W.H Chao W.H, Y.J Chen and T.J Jung . "EEG-based drowsiness estimation for safety driving using independent component analysis" , IEEE Trans. Circuits Syst. I: Reg. Papers, vol. 52, no. 12, Dec 2005, pp. 2726–2738.

[18] Murphy-Chutorian, E.San Diego, C.A.La Jolla, M.M.Trivedi "Head Pose Estimation and Augmented Reality Tracking: An Integrated System and Evaluation for Monitoring Driver Awareness" , Intelligent Transportation Systems, IEEE Transactions on ,Vol. 11, Issue 2 , ,June 2010, pp. 1245-1250

[19] E.Murphy-Chutorian andM. Trivedi "Head pose estimation and augmented reality tracking: An integrated system and evaluation for monitoring driver awareness",IEEE Trans. Intell. Transport. Syst. vol. 11, no. 2, June 2010, pp. 300–311.

[20] Nanxiang Li, J.Jinesh, Jain and Carlos Busso (2013),"Modeling of Driver Behavior in RealWorld Scenarios Using Multiple Noninvasive Sensors', IEEE transactions on multimedia, vol. 15, no. 5, pp. 1213-1225.