Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2017
(ICMERE2017) 18 – 20 December, 2017, Chittagong, Bangladesh

ICMERE2017-PI-000

ADVANCES ON SENSING TECHNOLOGIES OF ROAD ACCIDENT PERTAINING EFFECTIVE NOTIFICATION: A REVIEW

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Abstract- *Recently, traffic accident detection is becoming one of the interesting fields due to its tremendous application potential in Intelligent Transportation Systems. Both of The automotive companies, government and researchers have made abundant enhancement in alleviating this thread, but still the probability of mischievous effect caused by accident is not reduced. The digit of succumbed people is increased due to lack of post-accident rescue and EMS service. Factitive detection subpoena can reduce invaded populace owing to this mishap. In this paper, we present an existent scenario of numerous accident detection systems and its application to reduce breakneck road accident. Both of physical sensor i.e. Metal touch sensor, Moveable part (MEMS), Accelerometer, and Shock sensor, piezoelectric sensor and Non-physical sensors i.e. Ultrasound, Sonar, Acoustic sound, Gyroscope, GPS tracking, Android phone, and Image processing are described in brief. Therewithal, consolidated portrayal on several communication schemes has been illustrated.*

Keywords: GPS, GSM, MEMS, VANET, Ad-Hoc, Image processing, Sensors.

1. INTRODUCTION

Every year, traffic congestion and traffic accidents have been rapidly increasing in bracing to increasing number of vehicles. Even though the roadway design and signal system have been improved to relieve traffic congestion, traffic casualties and property damage have not decreased. Since vehicle is a primary means of transportation, the traffic accident is a serious issue of society. By reflecting information from 180 countries, the Global status report on road safety 2015, has indicated that worldwide the total number of road traffic deaths has plateaued at 1.25 million per year, with the highest road traffic fatality rates in low-income countries [1]. Around 1.3 million people die in road crashes each year, 20-50 million are injured or disabled according to the Association for Safe International Road Travel (ASIRT). Road crashes cost USD $518 billion globally, costing individual countries from 1-2% of their annual GDP. Currently, Road traffic crashes rank as the 9th leading cause of death and account for 2.2% of all deaths globally. The road traffic injuries are predicted to become the fifth leading cause of death by 2030 unless any action is taken [2].

A number of technological and sociological improvements have helped reduce traffic fatalities during the past decade, e.g., each 1% increase in seatbelt usage is estimated to save 136 lives [3] each minute that an injured crash victim does not receive emergency medical care can make a large difference in their survival rate, i.e. Analysis shows that reducing accident response time by 1 min correlates to a six percent difference in the number of lives saved [4].

2. TECHNOLOGICAL ADVANCEMENT

Numerous accident detection techniques has already been adopted and implemented successfully in commercial level. But in terms of precision grade and false alarm are major limitations of those systems. We have tried to represent a present scenario of different accident detection mechanism and its limitations.

2.1 Measurement of Maximum Negative Acceleration

One of the most important and basic risk factors in driving is speed. It affects the severity of a crash along with the probability of risk of being involved in a crash. People need some processing time to decide whether or not to react before executing an action. The distance between starting to brake and a complete stand still is longer at high speeds. The braking distance is proportional to the square of speed [5]. As speed increases the possibility to avoid a collision becomes smaller. A moving body contains kinetic energy according to the low of Kinetic Energy $Ek = \frac{1}{2}mv^2$. When an accident occurs, kinetic energy is transformed into destructive forces [6] cause injury to occupants as well as to the vehicle. Two forces work on the vehicle to decelerate the speed when break is applied. One is the gravitational force and the other one is the friction force. Using Hydraulic brake maximum (27-33) km/h speed

difference tolerable for non-destructive vehicle motion within one second interval. More than this limit it is assumed that accident occurred or something serious. Implementing this limit various sensor measures the speed microcontroller decides accident occurred. But all time speed are not wisely treated for accident occurred as sometimes running vehicle pervaded from serious accident and stopped a little bit later.

2.2 Metal Contact Placed in Front and Back of Vehicle

Most popular accident detection module is metal contractor which detect crash by closing the control circuit by two metal contacts which is normally opened. When serious front or back clash occurred the metal contact comes close and detection circuit gets the signal as high (logic 1) [7].Simple block diagram can describe the methodology in details.

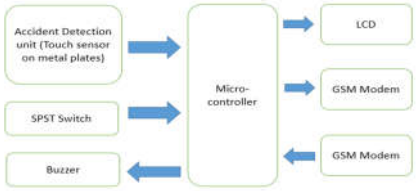

Fig. 1: Block diagram of metal contact accident detection system

When a breakneck accident frontal part of a heavy vehicle totally ruined and the sensor part also destroyed prior to complete its bestowed task as processing time required few second. It worked effectively for light accident or non-destructive collapse.

2.3 Ultrasonic Sensor

Ultrasound are more than 20 kHz to several Giga Hz which are beyond of our hearing frequency limit. Various types of ultrasound device used for different purposes both medical and engineering application. Bulletin 873M General Purpose Ultrasonic Sensors are designed to detect solid or liquid targets by using sound waves. These compact sensors provide enhanced flexibility for areas with limited space and are excellent for standard packaging and assembly applications. They are ideal for sensing targets that are challenging for photoelectric sensors to detect, including clear, shiny, or non-reflective objects [9].

2.4 Shock Sensor

Shock sensor can be integrated in various ways to match the vehicle requirements. It could be activated by vibration or triggered by highly effective safety system airbag. This airbag system contains several components and mechanism which all work together to ensure the physical integrity of the passengers to the highest degree [6]. The sensitivity of the employed sensor is adjusted to meet the standards adopted in safety airbag systems [10].

2.5 Using MEMS

Micro-electromechanical systems (MEMS, also written as micro-electro-mechanical, Micro Electro Mechanical or microelectronic and micro-electromechanical systems and the related micro mechatronics) is the technology of microscopic devices, particularly those with moving parts. It merges at the nano-scale into nano-electromechanical systems (NEMS) and nanotechnology. MEMS are also referred to as micro machines in Japan, or micro systems technology (MST) in Europe. An MEMS accelerometer measures acceleration (change in speed) of anything that it's mounted on. Single axis accelerometers measure acceleration in only one direction while dual-axis accelerometers, which are the most common, measure acceleration in two directions, perpendicular to each other. Three-axis accelerometers measure acceleration in three directions. Since gravity causes all objects to accelerate towards the earth, accelerometers are very handy for measuring the orientation of an object relative to the earth. A two-axis accelerometer can be used to measure the level of an object and a three-axis accelerometer measures an object's acceleration in every direction. When the MEM sensor is shacked it assumes that the accident occurred [14].

2.6 GPS Module

A GPS module is connected to a microcontroller which detects when the critical speed is exceeded and triggers the sending of different text messages, using GSM technology, to a police database and the driver. The text sent to the database contains the details of the car. The text sent to the owner informs them that they have over sped and the fine they are supposed to pay. It is innovative because it uses both GPS and GSM technology. It also helps in the advancement of science and technology by diversifying the usage of GSM technology [15].

2.7 Image Processing

Vision based detection system includes Gaussian Mixture Model (GMM) is used to capture the moving vehicles, and the detected vehicles are tracked in mean shift algorithm. After that the three decisive parameters including the direction of the moving vehicles, the speed, and the changes in the position of the vehicles need to be gathered to make the final decision [16]. Typical vision based detection system consisting two parts, training stage and detection stage. They each include three consecutive modules: (1) low-level feature extraction module; (2) feature encoding module; (3) detection module. In both stages, OFSIFT features are extracted from samples, and then quantized into visual words and their spatial information is added. Finally, those encoded feature vectors are fed into the ELM classifier for training and then for detection.

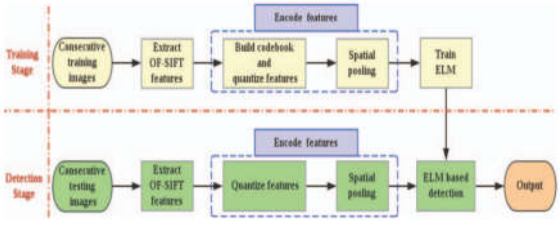

Fig. 2: Framework of vision based traffic accident system.

Each sample is defined as a fixed window. Training samples are picked manually from several video frames and labelled as positive or negative samples depending on whether their inner information represents the target region or not. Testing samples are obtained by using a sliding window strategy on all video frames without labels. In the low-level feature extraction module, some preparatory steps should be performed for OF-SIFT descriptors, including demonising image, calculating optical flow, truncating tiny oriented flow magnitude, and normalizing flow magnitude within the window [17].

2.8 Gyroscope

The Gyroscope senses the rotation/tilt of the car and reads the data after processing in degrees per second. This rate of rotation is used for evaluating if the car has rotated to its side or flipped completely 19]. Gyroscope provides accurate measurements that are not subject or susceptible to external forces. However, when the system returns back to its original position, there is a tendency to drift and not returning to zero. This is because of the integration over time. Therefore, gyroscope data are reliable only on the short term because it begins to drift on the long term [20]. Equations 1-3 are used to calculate roll, pitch, and yaw angles using gyroscope data.

$$\text{Roll} = \text{Roll} + G\,X / \text{Frequency} \quad (1)$$

$$\text{Pitch} = \text{Pitch} - GY / \text{Frequency} \quad (2)$$

$$\text{Yaw} = \text{Yaw} + GZ / \text{Frequency} \quad (3)$$

2.9 Acoustic Sound

This involves developing methods for processing acoustic signals and recognizing accident events from the background traffic events. A database consisting of sounds from vehicle crashes, car braking sounds, construction sounds, and traffic sounds was created. We compute the Mel Frequency Spectral Coefficients as a feature vector for input to the classification system. A neural network is used to classify these features into categories of crash and non-crash events. The classification testing results achieved 99% accuracy [22]. After analysing traffic acoustic patterns when volume of traffic is low and high, we concluded that their frequency bands are commonly 70 [Hz] but their sound pressure levels are -64 ~ -50 [dB] when volume of traffic is low and they are increased by 20 [dB] when volume of traffic is high. Though the value of sound pressure is quite different from one of accident sounds but it can be entered into sound sensor, we have to consider the increment normal to compose the accident sound detection system [23].

Table 1: Acoustic patterns of interfering elements in the accident sound detection system

Classification	Prominent Frequency (Hz)	Maximum Sound Pressure (dB)
Small sized car 1	1,126	-19
Medium sized car 2	868	-18
Large sized bus 1	3,214	-20
Siren of ambulance 1	1,525	-14
Siren of ambulance 2	1,525	-13

2.10 Sonar Module

Obstacle avoidance sonar systems are usually used in a forward-looking mode to detect and avoid obstacles either floating in the sea column or lying on the sea bottom [12] or roar surface both of forward or backward direction. A minimum distance can easily detect by the aid of sonar module. When a vehicle comes too closer than a certain safe level it activates the control unit and gives an alarm.

2.11 Using Real Time Image Processing

Generally image processing and object tracking technique have been adapted to traffic video analysis to address queue detection, Vehicle classification and volume counting [18]. Image from CCT can be used in both of traffic control and automatic accident detection scheme. Different types of technique used for filtering original image from rapid changing background. Advanced shadow elimination technique for individual vehicle tracking the first step, acquisition image sequence and predetermining the detection zones at each time. The background subtraction algorithm requires a relatively small computation time and shows the robust detection inn good illumination conditions [21].

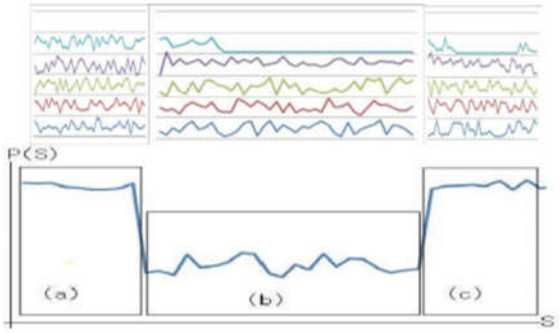

Fig. 3: (a) Normal traffic flow rate, (b) One lane is stopped and (c) Detour area and abnormal condition occurred.

2.12 Vision-Based Real Time Video Processing

Three traffic accident parameters including the changes of the vehicles position, acceleration, and the direction of the moving vehicles are gathered to make the final accident decision [16]. Adaptive traffic motion flow modelling technique, using Farneback Optical Flow for motions detection and a statistic heuristic method for accident detection. The algorithm was applied on a set of collected videos of traffic and accidents on highways. The results prove the efficiency and practicability of the proposed algorithm using only 240 frames for traffic motion modelling [24]. This method avoids to utilization of a large database while adequate and common accidents videos benchmarks do not exist.

Hidden Markov model (HMM), which can realize multi-classification for different traffic scenes. The process mainly consists of three parts: ROI setup, image compression and feature extraction, and HMM training process and testing experiments. The region of interesting is designed to generate the area that contains most information. It will also eliminate the zebra

crossing and useless background like plants and irrelevant constructions, which will bring disturbance to the feature generation. The feature extraction from image sequences is very important since it will determine the classification result a lot. As good features will lead to higher incident detection rate, as well as fasten the feature generation speed for the implementation for real-time system. Finally, a good classifier should be chosen for the AID system, HMM was selected since it is a good multi-classifier for special-temporal input [26]. The block diagram of our method is shown in Fig. 4.

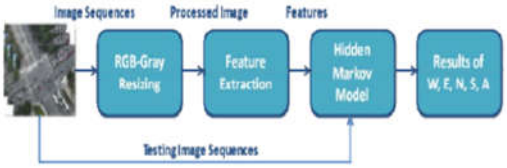

Fig. 4: Block diagram of image processing and HMM training process

2.13 Hydraulic Lens

It based on Smoothed Particles Hydrodynamics (SPH), a motion flow field is obtained from the video through dense optical flow extraction. Then a thermal diffusion process (TDP) is exploited to turn the motion flow field into a coherent motion field. Approximating the moving particles to individuals, their interaction forces, represented as endothermic reactions, are computed using the enthalpy measure, thus obtaining the potential particles of interest. Furthermore, we exploit SPH that accumulates the contribution of each particle in a weighted form, based on a kernel function [25]. The experimental evaluation is conducted on a set of video sequences collected from YouTube, and the obtained results are compared against a state of the art technique. Thermal diffusion process and Enthalpy model used to detect the traffic collapsed.

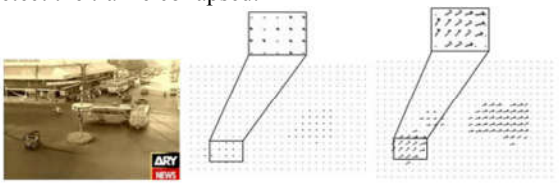

Fig. 5: TDP. The original frame (first column); the motion flow field (second column) and the coherent motion flow field (third column) after applying TDP.

Fig. 6: Enthalpy model. The original frame from a video sequence (a); the potential particles are annotated in red (b).

2.14 Accident Detection Using Smartphone

Now a days smartphone have become a part of our body that's why it is most effective way to use the smart phone's Sensor And Hardware [28] as some common hardware is embedded in every phone such as Gyroscope, Accelerometer, Gesture, Barometer , Bluetooth, Wi-Fi GPS & GSM module. Using Android platform total system implementation can be successfully archived within very low cost and better reliability [27]. People usually carry a smartphone every time so having a system or software installed in a smartphone it can be a life safer device not only communication device.

2.15 Piezoelectric Effect

The piezoelectric effect is a special material property that exists in many single crystalline materials. Quartz, Rochelle salt, topaz, tourmaline, sugar cane, Berlinite ($AlPO_4$), bone, tendon, silk, enamel, dentin, Barium Titanate ($BaTiO_3$), Lead Titanate ($PbTiO_3$), Potassium Niobate ($KNbO_3$), Lithium Niobate ($LiNbO_3$), Lead Zirconium Titanate (PZT) etc. are examples of such crystalline structure. PZT is well known energy converting source because it has high electro mechanical coupling coefficient. The relation between generated voltage and number of PZT plates are proportional [41].When serious collapse occurred huge pressure fall upon the PZT plates crossing a threshold voltage it can be identified as accident.

2.16 GPS Map Matching

GPS navigation is a component that accurately calculates geographical location by receiving information from GPS satellites. [30] Speed is one of the primary attributes of vehicle accident. The GPS provides speed and position in every 0.1 second. The position data will be used in the map matching algorithm to locate the vehicle on the road. The present speed will be compared with the previous speed in every 0.1 second through a Microcontroller Unit. Whenever the speed will be falling below the safe calculated threshold speed, the system will generate an accident situation. It will check the vehicle location from map matching module and generate an accident situation if the vehicle is found outside the road network [29]. This will reduce the false accident detection drastically. The map matched accident location is then sent by utilizing the GSM network.

2.17 Dynamic Bayesian Network

Dynamic Bayesian network, a kind of Bayesian network, can solve problems in dynamic environments. However, as node and state values of node in Bayesian network grow, it is very difficult to define structure and parameter of Bayesian network. The algorithm which is to solve the uncertainty of environment in many studies has been issuing. The probabilistic approach is the most successful method, though there are many methods to deal with uncertainty [33]. This technique generates and evolves structure of dynamic Bayesian network to deal with uncertainty and dynamic properties in real world using genetic algorithm. Effectiveness of the generated structure of dynamic Bayesian network is evaluated in terms of evolution process and the accuracy in a domain of the traffic accident detection [34].

Bayesian network is represented as directed acyclic graph (DAG) and comprised of nodes and arcs which mean environment variables and the dependence

between nodes, respectively [35]. We can easily model by learning data, because we can collect large amounts of data at low cost in proportion to increasing number of data. The necessity of learning of Bayesian network is increased by these properties. As the DAG structure can be generated in geometrical progression in spite of low number of nodes, it is a NP-hard problem to find the optimal DAG structure [36].

2.18 Multi-mode Radio Positioning Technology

GSM and GPS bidirectional location detection technology. GPS location signal is affected by the terrain and the buildings, there will be location blind area; the signal based on GSM mobile network positioning covered a wide range, but the location accuracy is restricted by GSM mobile networks. The main difference of the double location technology integrated GPS with GSM network from the traditional vehicle location is that GSM module of the vehicle equipment has location roles, when going into location blind area; the vehicle equipment can be automatically cut to the GSM location [39].

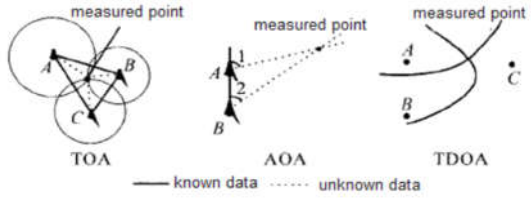

Fig. 7: Location technology based on web

2.19 Communication System

After detecting the accident it is the most important step for rescue is effective communication method. Bluetooth and Wi-Fi can't be implemented as far its range is about several hundred meters. Most widely used communication device is GSM module or Interface with GMS based phone. As the service area of GSM is very wide it can be the universal way for sending SMS the desired ones. Near field communication (NFC) is a set of communication protocols that enable two electronic devices, one of which is usually a portable device such as a smartphone, to establish communication by bringing them within 4 cm (2 in) of each other (tapping) [31]. An NFC reader is used to identify each passenger by detecting his/her ID. Then the IoT device sends and matches this ID with the corresponding remote database entry [32].

GSM/GPRS Modem:

The GSM/GPRS modem utilizes the GSM network to send the location of the accident. The modem can be controlled by a microcontroller through AT Command set. The Wavecom Q2403 is proposed for this system. It supports dual frequency (GSM/GPRS 900/1800MHz) with voice function and RS-232 interface. This modem supports all the AT Commands.

VANET: Vehicular AD-Hoc Network (VANET) containing location by GPS system those are connected with a microcontroller are more feasible than GSM network. VANET is the wireless network in which communication takes place through wireless links mounted on each node (vehicle) [37]. Each node within VANET act as both, the candidate and router of the network as the nodes communicates through other intermediate node that lies within their own communication range. VANET are self-organizing network. Although some fixed nodes act as the roadside units to facilitate the vehicular networks for serving geographical data or a gateway to internet. Higher node mobility, speed and quick pattern movement are the main characteristics of VANET. This also causes rapid changes in network topology. VANET is a particular type of MANET, in which vehicles act as nodes. Unlike MANET, vehicles move on predefined roads, vehicles velocity depends on the speed signs and in addition these vehicles also have to follow traffic signs and traffic signals [38].

3. COMPARATIVE STUDY

Table 2: Comparative study of different accident detection and notification system.

	Pros	Cons
negative acceleration:	Faultless, less false alarm, Loyal	Need high speed calculation
Metal contact and PZT	Low cost, Unequivocal	Applicable for nos destructive accident
Ultrasound	Reliable, Bad weather friendly	Limited range
MEMS	More immaculate, reputable	High cost of MEMS sensor
GPS	Universal, feasible	Limited to service area
Gyroscope	Dependable	Less accurate.
Acoustic sound	Applicable for breakneck accident	Not often effective For side collapse
Sonar module	Very bad weather conciliatory	Required more processing time
Image processing	Trustworthy, immaculate	Required more processing time
Real time image processing	More Feasible and Authentic	Required more processing time
Hydraulic lens	Low cost, reliable	Not accurate
Smartphone	Universal, Catholic	Often Inexact
Bayesian network	Newer technique and more trustworthy	Very high costing required
Multi-mode radio	Low costing, emancipation of sensor	Often inexact

4. CONCLUSION

In this review paper we are tried to demonstrate more than 25 processes for accident detection and alerting system. Now a day some system is already has been successfully adopted and implemented commercially i.e. Toyota, BMW, and Nissan etc. Though every system has some limitations and malfunctioning report in accurate precision level. Continuous research are being going on, both of Electrical, Mechanical and Communication experts are involved in this indispensable field. Our research is being helpful for finding a comparatively better process for designing and adopting a low cost and more accurate system.

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