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Non-Intrusive Drunk Detection Test Using Smart Phone

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Abstract— In India every year there are large number of fatalities in road accidents, a vast of them are due to drunken driving. The study investigated the anomalies in the gait pattern incurred after consuming alcohol. The proposed algorithm helps to alert the driver and to report the concerned authorities so that a suitable action can be taken against the driver as soon as anomalies are found. The study was conducted on 12 subjects including 7 bus drivers and 5 truck drivers who drive the vehicle on an average of 10 hours and 16 hours per day respectively. All the drivers were from Punjab, India. The anomalies were investigated by using accelerometer sensor integrated in the smart phone. The effect of alcohol on the parameters was evaluated by comparing the variance of gait stretch and step time. The listed parameters were analysed on PC after extracting the data from smart phone via Sensor UDP android app. The consumption of alcohol resulted in increase of mean variance of step time to 28 sec and 30 sec from 7 sec and 8 sec and of gait stretch to 2.25m/s^2 and 6 m/s^2 from 1.75 m/s^2 and 4 m/s^2 in case of Bus drivers and truck drivers respectively. This study highlights an efficient and non-intrusive method to detect the drivers under the influence of alcohol and thus would help to reduce the accidents.
Keywords—Smart phone, accelerometer sensors, gait, intoxication.

I. INTRODUCTION

Road accidents are the fourth leading cause of death in the world 70 per cent of them is due to drunken driving. The person driving a vehicle on public roads with alcohol content in his blood above the legal prescribed limit is termed as drunk driving. Consumption of alcohol causes deterioration of driving skills even at very low levels, which further progresses rapidly with the rise of alcohol in blood. The probability of causing crash increases with rising blood alcohol levels. India reports about 1.34 lakh fatalities in road accidents every year. A report from Ministry of health and sciences verifies that the consumption of alcohol affects the various body organs such as liver, brain, heart and kidney. The Regular consumers lose control over their temperament and actions. Simultaneously they become risk to the society. It is evident from the statistical report of Ministry of Road and Transport that in 2011, 35% of the road accidents were caused by Bus and Truck drivers only. The survey conducted by the Community against Drunken Driving (2011) in India revels that 59% of the heavy vehicle drivers admit that they are addicted to alcohol. Despite the fact that drunk driving is a serious problem, its detection has been so far relying on visual observations by patrol officers. Drivers under the influence of alcohol show a marked decline of perception, recognition, and vehicle control, so they tend to make certain types of dangerous manoeuvres. Government of India has set the max limit for blood alcohol content (BAC) while driving. A person is not allowed to drive with BAC level more than 0.03% or 30 µl alcohols in 100ml blood. However there is no minimum threshold below which alcohol can be consumed without risk. With increase in blood content concentration of alcohol there is progressive lose in driving ability (Reasons being- Increased time reaction, over confidence, impaired concentration of mind, and degraded coordination of audio visual senses). Currently, there is only one BAC detection method that can reliably measure a person's BAC without drawing blood. By measuring the concentration of alcohol present in a person's exhaled breath it is possible to achieve an indirect measurement of the person's BAC.

Wu Di et al. (2010) investigated using ECG technique that alcohol has a strong effect on brain, due to this people become excited after drinking. The coordination of the body reduces, the feeling of insensitivity begins, and the eyesight weakens. It was seen that with the increase of the amount of alcohol intake, the person went into the state of sleepiness. Sittiprapaporn (2013) said that working memory processing units were less available after alcohol consumption because of increased background oscillatory activity. The reduced alertness increases the risk of accidents. The Community against Drunken Driving (CADD) in India Reports (2011) "About 56 accidents and nearly 14 deaths occur on Indian roads per hour. Many drunken detection systems have been already developed. Most of these systems are camera based. Zhu et al. (2004) used the two cameras to capture eyelid movement, head movements and facial expressions to detect the fatigue level which can also be considered as reduced level of alertness. Albu et al. (2008) had conducted research in an easy way. They have used vision based system that detects the onset of sleep by analysing the time taken for eye blinking as soon as eye closes for more than usual time the system alerts the driver through audio output. Lee.et.al.(2006) had also used two cameras to detect synchronisation of eye sight line and driving lane path . Desai.et al (2007) had used the pressure exertion as their base. Pressure exerted by driver on

acceleration paddle decides the alertness of the driver. Krajewski.et.al (2010) had used steering pattern as their base. Saab used 'Alcokey' to take breath samples which are synchronised with the ignition system of the vehicle. All these research works suggests the integration of add-ons in the vehicle.

Although several authors have contributed their work on effect of alcohol on brain and drunken detection but as far as no work has been reported the use of smart phone to detect the drunk driving. Keeping this in view the authors have tried to fulfil the gap in the study. The advantage of such system is that it has communication functions and it is a ubiquitous device these days. The smart phone acts as hardware for development of anti-drunk driving system. Mobile phone is portable and all requirements are in-built in it. Minimum requirement for such a system is presence of simple sensor accelerometer in the smart phone. Accelerometers are devices that can measure acceleration (the rate of change in velocity). Accelerometer sensor in smart phone is made of silicon where the amount of flowing current correlate to the acceleration. Currently many mobile phone companies are providing smart phones at low cost. These contain multiple sensors of good quality. These phones are good enough for communicating with subject and to take readings. W. Palmer et al (2010) investigated that there was significant change in gait parameters some of them were increased stride length, high acceleration and less stability. In this paper the authors extracted and compared the gait parameters that is step time and gait stretch of the person in sober and in drunken condition. The Variance of these parameters was analysed and thus the results were concluded. Step time is the time taken to complete one gait cycle. Gait stretch is the difference between the maximum and minimum amplitude within a gait cycle. The purposed system is reliable, non-intrusive, light weight and power efficient. We don't need any extra hardware and service cost.

II. METHODOLOGY

A questioner was filled by each subject separately before the start of experiment. Subjects who intake only alcohol as intoxicating substance and were regular drinker were selected for the experiment. These subjects drive the heavy vehicle for more than 10 hours per day. In total 12 subjects participated and all of them wore shoes with flat sole. The subjects were drivers of heavy vehicle 7 of them were bus driver and 5 of them were truck drivers. Their age varies between 30 to 45 years. The height and weight of the subjects was measured before the start of experiment using digital weight scale and stadiometer. The mean weight and mean height of all the subjects was 75.5 kg and 173.6 cm respectively. The experiment was carried out in evening.

The experiment includes the use of Android based smart phone which had accelerometer sensor. A Samsung Galaxy Note II N7100 smart phone was used. The dimensions of phone were 151.1 x 80.5 x 9.4 mm (5.95 x 3.17 x 0.37 in) and weight was 183 g. High quality sensors were in-built in this phone. The accelerometer sensor could measure acceleration in 3 directions(x, y, and z). The range of this sensor was between -2g and +2g. The data was logged at regular intervals with frequency of 10 readings per second. The measured acceleration value represents the acceleration and direction relative to the phone. The three values from the sensors are used to drive one single value of resultant acceleration which can be further used to find the angle of acceleration in each direction.

$$R^2=Rx^2+Ry^2+Rz^2$$
$$\text{Cos } (x) = Rx/R$$
$$\text{Cos } (y)= Ry/R$$
$$\text{Cos } (z) = Rz/R$$

The magnitude of the acceleration does not depend on the orientation of the phone but depends on the location of mobile and place where it was placed on body. The goal of this research was to find and compare the listed gait parameters before and after the intake of alcohol. The subjects carried the Samsung Note 2 phone in the right pocket of the trouser. Initially the participants were asked to walk for 50m on defined paved path and thereafter they were asked to consume 180 ml of alcohol 42.8%v/v. The experiment was conducted using a single type of branded alcohol. The readings of gait parameters were taken again after 30 minutes as alcohol takes some time to get absorbed in blood. As the BAC level crossed the allowed Indian limits the reading were taken again. The Widmark's formula was used to find estimated BAC level. The accelerometer data was collected on the phone sensor and was send to computer by Sensor UDP android app. Sensor UDP app allows the user to send sensor data wirelessly from their android device. The analysis on PC helped in thorough investigation. All the readings were taken in m/s^2

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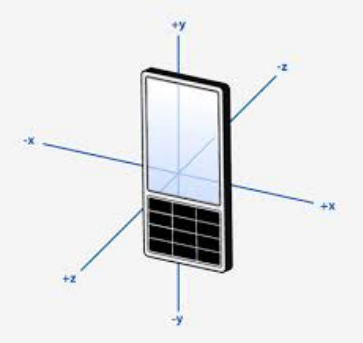


The Accelerometer detects acceleration along 3 axes

Subject placing Smart phone in his Trouser Pocket

III. RESULTS

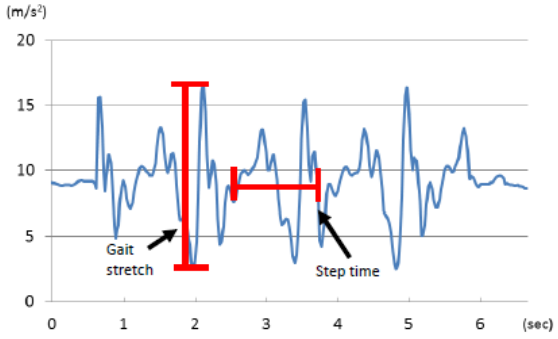
Consumption of alcohol causes unsteadiness. Optimum Consumption was confirmed by increased EBAC which was calculated using the Widmark's formula.

$$EBAC = \frac{0.806 \cdot SD \cdot 1.2}{BW \cdot Wt} - (MR \cdot DP)$$

Where 0.806 is a constant for body water in the blood (mean 80.6%), SD is the number of standard drinks containing 10 grams of ethanol, 1.2 is a factor to conversion factor, BW is a body water constant (0.58 for men and 0.49 for women), Wt is body weight in kilogram, MR is the metabolism constant 0.017 and DP is the drinking period in hours. MR is the metabolism rate which is different for different persons; it is usually taken 0.015 for male and 0.017 for females for Indian population. Gait parameters under the influence of alcohol had high variance than sober gait cycles. Graphs were plotted to view the change in pattern. The accelerometer data collected from the smart phone shows that variance levels of parameters have increased considerably after drinking.

Subjects	*Weight*	*BAC*
M1	76 kg	0.101645
M2	81 kg	0.093519
M3	75 kg	0.1034
M4	65 kg	0.123923

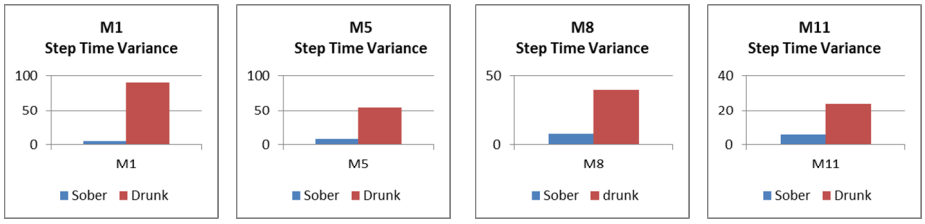
The readings show that all the subjects have crossed the Indian permitted limit of 0.03% BAC.



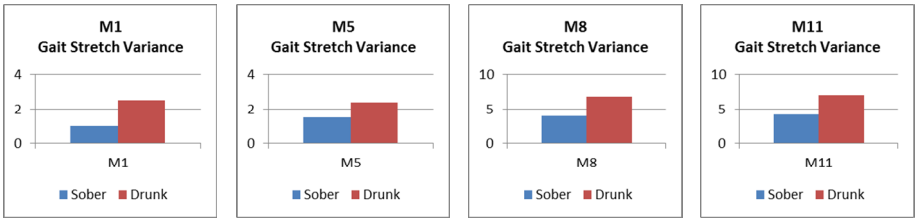
Gait parameters from y-axis accelerometer

The plots below show the variance of step time and gait stretch of normal and drunk person. The consumption of alcohol resulted in increase of mean variance of step time to 28 sec and 30 sec from 7 sec and 8 sec and of gait stretch to 2.25m/s^2 and 6 m/s^2 from 1.75 m/s^2 and 4 m/s^2 in case of Bus drivers and truck drivers respectively. Each graph here represents different subject. The plotted graphs are of 4 different subjects of whom two are bus driver and two are truck driver. It is evident from the graphs that the step time and gait stretch changes when the person is under intoxication.

Step time	It is the time taken to complete one gait cycle.
Gait stretch	It is the difference between the maximum and minimum amplitude of acceleration within a gait cycle.



Graphs showing Step Time variance for subjects in sober and drunken condition.



Graphs showing Gait Stretch variance for subjects in sober and drunken condition.

IV. DISCUSSION

The paper describes how a Samsung note 2 smartphone when carried in the trouser pocket can be used to detect the alcohol consumption. The result from the experiment holds true as the parameters changes considerably. Smart phones offer several important advantages. Firstly smartphones are now days a ubiquitous device. Secondly good smartphones can process and save large amount of data which can be easily transferred to PC by Bluetooth or email, this enables the authorities to analyse the drinking habits of the user. Thirdly smartphones are equipped with the applications that can be improved. For these reasons smartphones are more advantageous than convectional breath analyser. The traffic patrols need not to stop every passing vehicle to catch the drunk drivers thus the system will save time, energy and money. The exact location of drunk driver can also be found out using GPS of mobile phone. However this system has to be improved for the greater ease of use. The inclusion of additional mobile sensor platforms could allow us more accurate gait abnormality detection. A person's gait manifests itself throughout his or her entire body, and a smartphone placed in a pocket may have difficulty detecting at least part of the motion involved in the larger gait pattern. The use of supplemental devices with sensors could increase results. For example, use of smartwatches containing accelerometers can be used for gait abnormality detection These devices are worn on the wrist, and connect wirelessly to a smartphone. They can transmit any sampled accelerometer data back to the phone for transmission or analysis. Such data could be used to supplement the smartphone's own sensors for increased accuracy. Future studies should consider making use of such devices.

The system can be synchronised with ignition system of the vehicle so that the engine stops as soon as the smart phone confirms the consumption of alcohol by analysing the gait pattern. This system can also be used at a workplace where usually the unskilled or semi- skilled work force comes after consuming the alcohol. We can detect the drunken people and stop them from going to work. This will help us to create a better workplace with increased efficiency, discipline and customer satisfaction. We can further develop a application which is in-built in the operating system of the phone.

V. CONCLUSION

The purposed drunken detection system uses the smart phone sensor to extract the gait parameters. The increased variance in the parameters clearly shows that the subject had lost control over his voluntary actions. He is unable to perform the task of walking efficiently thus he is not fit for driving anymore. The judgment level while driving will be affected most. And chances of accidents have increased. As soon as it is established that there is variance in parameters the phone will alert the driver to not to

drive and will also signal the authorities to stop him from driving.

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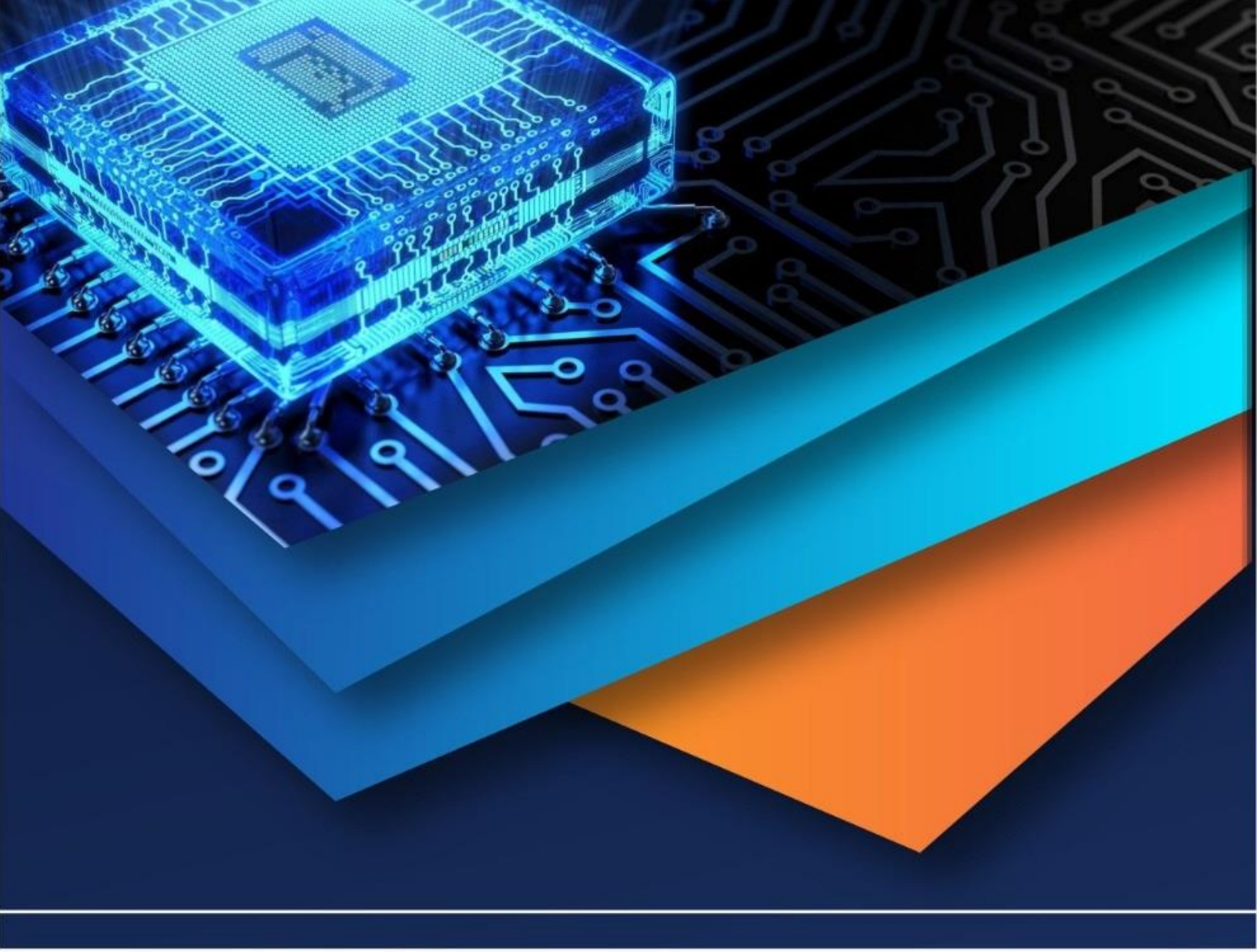

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