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Proficient System for Real Time Cognitive State Classification Using Wireless Sensor Network and EEG System

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Abstract: Now a days, many individuals are indebted in making trips to different spots in repeated manner. With the expanding population of vehicles and their developments on the streets, mishaps are getting expanded. These effects are generally hitting the features because of the languor and use of cellular telephone while driving, intoxicated driving and sudden sickness of a driver. Cerebral action connected with the consideration supported on the undertaking of safe driving has got extensive consideration as in numerous Neuro-Physiological studies. These examinations have additionally precisely assessed moves in drivers' levels of arousal, exhaustion and vigilance as confirmed by variety in their undertaking execution by assessing Electro-Encephalo Graphic (EEG) changes. The proposed framework consolidates the utilization of a remote and wearable EEG gadget to record EEG signals from bristly locales of the driver helpfully. Also, the proposed framework handles EEG recordings and makes its interpretation into the vigilance level. The proposed framework is actualized for utilizing JAVA programming dialect as a versatile application for online investigation. Moreover, the wellbeing observing framework is actualized to screen the wellbeing state of the driver utilizing different sensors like temperature sensor, weight sensor and heartbeat rate sensor. When any variations from the norm is found in the driver's vigilance status, the vehicle naturally stop at the left half of the street with the sign and then the ready message will be sent to the approved individual who contains the flow area of the driver by the GPS through GSM module.

Key words: EEG, sensors, wireless sensor network, GSM module, GPS module

INTRODUCTION

Street mischance is the most undesirable thing to happen to street clients which happens regularly because of humanslips. The most heart-breaking thing is that the humans do not gain from their slip-ups on street. Every year, the national highway traffic safety administration conservatively evaluates that 100,000 police-reported accidents are due to direct consequence of driver weariness. This outcome results in 1,550 passing, 71,000 wounds and $12.5 billion fiscal misfortunes. Languor/weariness assumes a vital part in accidents which leads to different causes for the drivers using telephone gets occupied from their fundamental assignment which involves significant parcel of cerebrum and the minor part handles the driving aptitudes (Liao *et al*., 2014). This separation of mind hampers response time and three capacity of judgment. Utilization of liquor while driving is an adversity. Liquor diminishes fixation which diminishes response time of a human body. Appendages take more time to respond to the directions of mind. It hampers vision because of discombobulating.

According to the leaps enrolled by traffic investigation wing of Coimbatore City, the mischance rate increased consistently. As perthe statistics from 2004-2006, the mishap rate expanded from 6.7%-14%. In 2014, the street mishap raised by 21% in comparison with 2013 as demonstrated in Table 1.

The status of death is related to street mishaps, 338 IPC demonstrates that the status of harm at the outer parts of the human beings, like hand, leg etc., 337 IPC demonstrates the status of minor injuries because of mishaps like scratches on human body and 279 IPC demonstrates the status of vehicle harm due street mischances in Coimbatore city. It is fundamental to create frameworks that effectively screen drivers' working circumstances and alarm them if any unstable conditions strikes avert mischance. It is persuading that the outlined mechanical framework gives dynamic observation of driver's working circumstance, a constant checking of driver's EEG with brisk reaction and hence giving a very solid framework. Chennupati proposed a methodology for the detection of alcohol consumption and drowsiness state of the driver using alcohol sensor and eye blink sensor. If drowsiness is detected, it prevents vehicle from

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Table 1: Comparative statement of road accident cases for the past 11 year

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Heads	Reported cases	R	R	R	R	R	R	R	R	R	R
304(A) IPC	129	168	239	274	297	267	284	254	263	266	272
338 IPC	470	471	613	679	646	522	506	517	458	568	658
337 IPC	365	376	318	427	344	233	267	283	339	350	332
279 IPC	219	199	136	114	94	76	84	72	68	163	235
Total	1223	1214	1306	1494	1381	1098	1141	1126	1128	1347	1497

moving and a message is sent to the authorized person (Ramalakshmi and Thanushkodi, 2014). MEMS areused to locate the position of the driver. Uma demonstrated that, the signal acquires the EEG signal through electrodes placed on the scalp of the human head. This acquired signal is then amplified and filtered. Auto regression method is used for feature extraction. Alarm tone will be generatedduring the drowsiness state. Abdul Shabeer et al proposed a highly efficient automatic early detection of phone calls using antenna located on the top of the driver seat. With low range Mobile-jammer, the driver could be stopped from incoming calls. Malar proposed the smart cap technology which helps in preventing deaths caused by drunken driving and drowsiness while driving. The cap consists of five embedded electrodes, further the signals are processed and directed via the Bluetooth to microprocessor which decomposes the EEG signals. The voltage produced by the algorithmdrives the relay system in the absence of abnormalities but the engine stops if there is any abnormality being detected. However, these models have flaws: the conventional methods like alarm tone cannot alert the driverwho is in the state of drowsiness and the accelerometer which could not detect the exact state of the driver thereby the driver could not be able to control the vehicle.

MATERIALS AND METHODS

The proposed method which is the EEG-situated in-vehicle framework, intended to screen human vigilance level constantly amidst auto driving. To develop the framework, EEG signs have been recorded using a versatile and remote EEG gadget with dry sensors. For information securing, the remote and versatile EEG framework constitutes dry anodes, information procurement module, bluetooth move module and rechargeable batteries. The gadget is intended for rapid and helpful recording of an EEG sign of the occipital district which is related to the vigilance. This dry EEG framework surpasses the customary wet terminals with the conduction gel for long-haul EEG estimations. The sign nature of the dry EEG framework is practically identical to the Neuro Scan. For information investigation, the pre-stimulus EEG spectra of all the test concerning the centre of the forecast framework, the relationship in the middle of EEG and conduct has been displayed using bolster Vector Relapse (SVR) (Smola and Scholkopf, 2004). The remote and wearable EEG gadget transmits its recorded information by means of a bluetooth interface to the client's gadget. The overall block diagram has been shown in Fig.1.

EEG Measurement system: Another dry-contact EEG gadget with spring-stacked sensors has been proposed for potential operations in the vicinity or unlucky deficiency of hair and with no skin readiness or conductive gel utilization. Every test has been intended to incorporate a test head, plunger, spring and barrel. Seventeen tests have been embedded into a flexible substrate utilizing a one-time shaping procedure by means of a secured infusion forming system.

With 17 spring contact tests, the flexible substrate considers a high geometrical similarity between the sensor and the unpredictable scalp surface to keep up low skin-sensor interface impedance. Also, the flexible substrate launches a sensor cushion impact, along these lines dispensing with torment when power is connected (Huang *et al*., 2009). This sensor is more advantageous than traditional wet anodes in measuring EEG signals with no skin arrangement or conductive gel utilize. EEG signal acquisition and processing methodology has been shown in Fig. 2.

Sensors heart beat sensor: This sensor has been employed to quantify the heart thumps of the driver and the yield sign is given to flag molding unit, where the sign is adapted (Alenezi *et al*., 2008). It comprises of dry cathodes, information procurement module, bluetooth move module and then the sign is given to heartbeat molding circuit.

Here the sign is changed into square heartbeat. The changed square heartbeat sign is further given to the microcontroller. An ordinary heartbeat rate for a sound grown-up, while resting extends from 60-100 thumps every Moment (BPM). Amid slumber, this drops to as low as 40 BPM and amid strenuous activity, it can climb as high as 200-220 BPM.

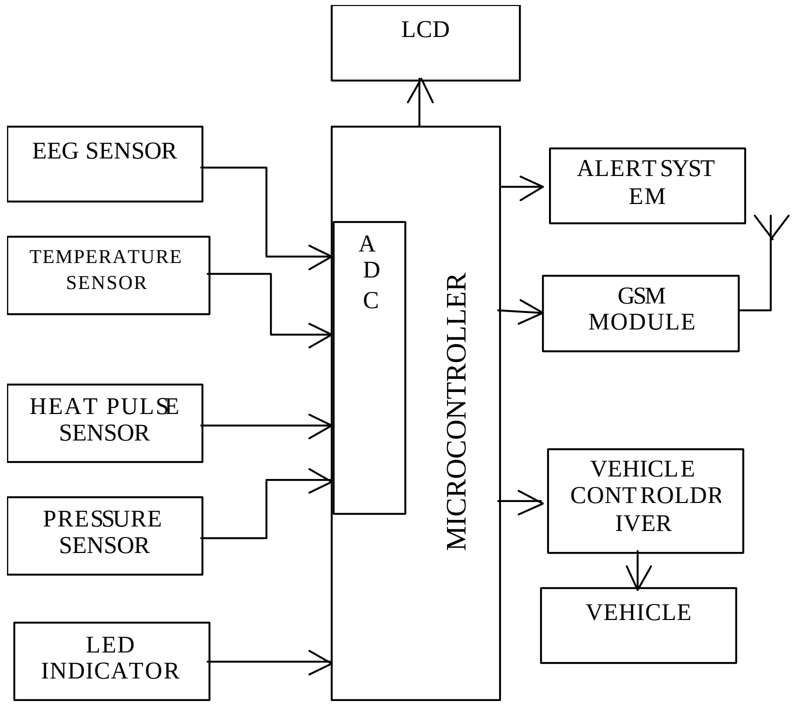

Fig. 1: Major components of vehicle and receiver modules

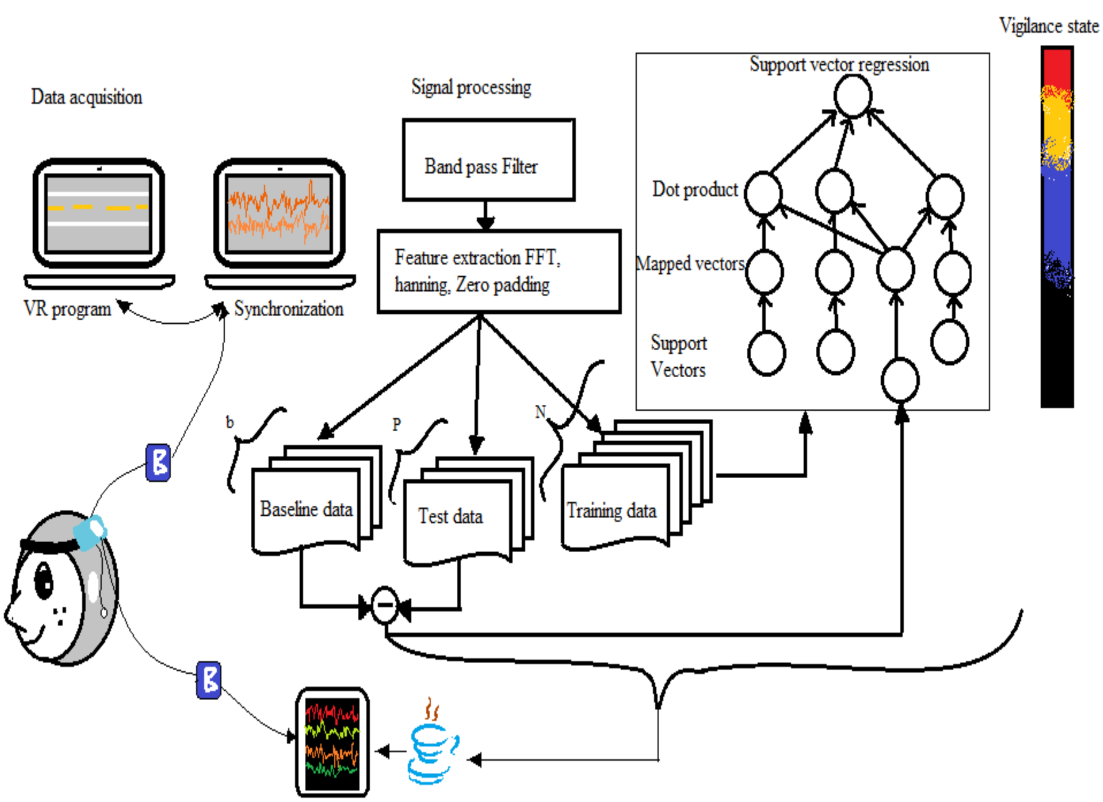

Fig. 2: EEG signal acquisition, processing and analysis system

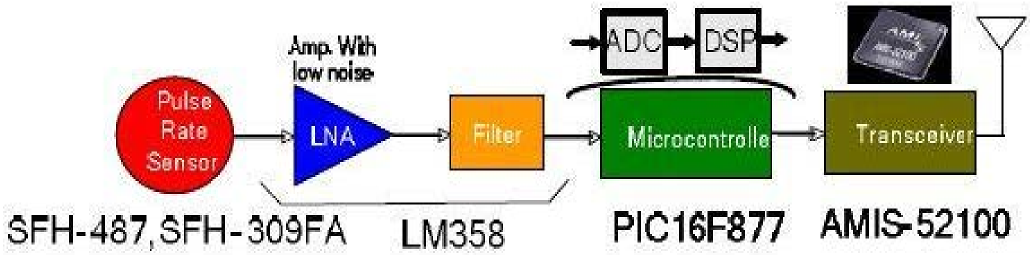

Fig. 3: Block diagram of A pulse rate sensor node

Temperature sensor: This gadget gathers data about temperature from a source and proselytes into a structure that is justifiable by other gadget or individual. Thermistor is a temperature delicate resistor employed for temperature estimation. There are two kinds of thermistors available, for example, positive temperature co-proficient and negative temperature co-effective. Here, negative temperature co-effective has been employed, where the safety quality is diminished when the temperature is expanded and further the variable voltage is given to the ADC.

Pressure sensor: This circuit is intended to quantify the changing weight. The weight is measured by the stomach which is one kind of transducer. At this point, when the weight is connected, the stomach gets moved forward. The movement of stomach relies upon the weight. Therefore, the voltage heartbeat relies upon the development of stomach. The voltage heartbeat is then given to Instrumentation enhancer segment to increase the signs.

Basic technology used in medical applications: The rapid development of technological advancements developed the potential for misusing of remote medicinal application market. Now a days, because of large scale remote system and portable figuring arrangements, for example, cell 3G and past, Wi-Fi cross section and WiMAX, guardians can be able to access into crucial data at anyplace and also inside the health awareness systems. The presence of pervasive registering comprising of RFID, Bluetooth, ZigBee and remote sensor system gives creative medium for information transmission for medicinal applications. Various physiological observing frameworks have been taken for consideration to propose and convey genuine clinical settings. These frameworks can be utilized for patients following as a part of circumstances where area data is crucial, for example and mass setback episodes. An alternate innovation utilizing as a part of WPANs is ZigBee, a purported IEEE 802.15.4. The standard is an

Table 2: Characteristics of biomedical signals

Sensors	Value range	Signal range
EEG sensor	0.05-60 Hz	15-100 Mv
Heart rate sensor	60-100 bpm (specifically 80 bpm)	N/A
Blood pressure	dc-60 Hz	40-300 mmHg
Temperature sensor	37.0° C (98.6°F)	N/A
Pressure sensor	440/90 mmHg	N/A

ultra-low power, low-information rate which is utilized for checking and controlling applications. Gadgets utilizing ZigBee has <1% life time in dynamic status (Lin *et al*., 2007). In large portion of life, the gadgets are in slumber mode to spare gadget's energy. A few frequently used therapeutic sensors are presented.

The principle errands of the medicinal sensors are to gather physiological flags and send them to the individual server. Normal medicinal sensors and qualities of the signs are demonstrated in Table 2. In this framework, the type and number of medicinal sensors are variable based on the applications.

Sensor nodes and hardware designs: Sensor hubs are intended to gather crude signs from a human body. The sign from a human body is typically frail and coupled with clamour. In the first place, the sign ought to experience intensification and separating methodology to build the sign quality and to evacuate undesirable flags and clamour. Thereafter, it experiences an Analog to Digital Change (ADC) stage to be changed over into a computerized manner for advanced transforming. The digitized sign is then transformed and embedded into the chip. The chip then packs this information and transmits over the air through a transmitter. The schematic diagram of a Pulse Rate Sensor Node has been illustrated in Fig. 3. The CCU additionally requires a micro-controller and a remote handset chip to arrange all workouts like the sensor hubs (Preetha and Parvathavarthini, 2013). The CCU equipment is made of the same handset chip from AMI semiconductor (AMI52100 IC) and the microcontroller PIC16F87. The estimated remote separation in the middle of sensors and the CCU (the

MICS connection) is 1 - 10 m. The CCU could accordingly be spotted at the waist of the patient or at an effectively open spot.

Prediction model: As per the previous studies, the behavioural omissions incited by mind waves relate to the progressions of EEG exercises. By connecting the force spectra with RTs, a nonlinear model has beenfavoured in the model fitting to cover the straight and nonlinear connections between the EEG power spectra and RTs. The bolster vector machine is an ordinary method for illuminating the multi-dimensional capacity estimation issue and has been connected to different fields for example, classification and relapse. When used to figure out the capacity estimate and relapse estimation issues, SVM has been indicated as the bolster vector relapse (SVR). Figure 2 demonstrates the graphical system of SVR, including the bolster vectors, mapped vectors and speck item operations (Karlen *et al*., 2009). SVR is a perplexing and substantial computational usage of a gauging calculation in light of organizing risky minimization standards to acquire a powerful speculation ab. The goal of ϵ -SVR is to find ϖ such that a function f(x) = (ϖ, X)+b has at most ϵ deviation from the targets y_i for all the training data X = {(x_i, y_i)}, where I = [1,2,…1] and (.,.) denotes the dot product. Accordingly, the ϵ-SVR can be formulated by minimization of Eq. 1) and 2 as the following:

$$\min \frac{1}{2}\left\|w\right\|^2 + C\sum_{i=1}^{l}\left(\xi_i + \xi_i^*\right) \quad (1)$$

$$\text{subjcet to} = \begin{cases} y_i - w.x_i - b \le \varepsilon + \xi_i \\ w.x_i + b \le y_i + \xi_i^* \\ \xi_i.\xi_i^* \ge 0. \end{cases} \quad (2)$$

where, ξ_i and ξ_i^{th} are stack variables. The constant C>0 determines the compromise between the fatness of f and the amount to which deviations larger than ε are tolerated.In this study, the SVR model has been actualized using a library of LIBSVM. The speck item operation of any two mapped vectors can be actualized by a bit capacity which satisfis Mercer's hypothesis. In this study, most generally used piece capacities, including direct, polynomial, outspread premise capacity and sigmoid capacity have been actualized and their exhibitions have been looked ahead (Manni *et al*., 2015). Equations of these four kernels are listed as follows.

Linear kernel:

$$k\left(x_i.x_j\right) = x_i.x_j \quad (3)$$

Polynomial kernel:

$$k\left(x_i.x_j\right) = (x_i.x_j + 1)^d \quad (4)$$

Radial Basis Function Kernel (RBF Kernel):

$$k\left(x_i.x_j\right) = \exp\left(\frac{\|x_i - x_j\|^2}{2s^2}\right) \quad (5)$$

Sigmoid Kernel:

$$k\left(x_i.x_j\right) = \tanh\tanh\left(\gamma\left(x_i.x_j\right) - ?\right) \quad (6)$$

Where:
σ = Determines the width of RBF function
d = A constant trading off the higher-order versus lower-order term in the polynomial
γ>0 = A scaling parameter of the input data and is a shifting parameter that controls the threshold of mapping.

The Root Mean Square Error (RMSE) is a conventional index for evaluating the performance of the predictor. RMSE can be estimated as follows:

$$RMSE = \frac{\sqrt{\sum(RT - RT)^2}}{n} \quad (7)$$

Where:
RT and R^T = denote the observed reaction times and the predicted reaction times respectively
n = Represents the number of validation datasets

Smaller RMSE implies more accurate prediction for this model (Haberman and Spinelli, 2012) .

Real-time vigilance prediction: The EEG-based framework using RBF-based SVR is a profoundly guaranteeing method for anticipating the driver's vigilance level. An endeavorhas been similarly made to check the possibility of the proposed framework by further actualizing the SVR model, in which the parameters of the actualized model (counting slack parameter of SVR, gamma estimation of RBF portion and support vectors of the got model) have been prepared using Matla bbased simulation (Neamen, 2007).

A transient relationship between the vigilance levels anticipated by the proposed framework and driver's conduct in light of standard traffic occasions or crisis when the member performed the path flight driving errand is more or less 70 min. Table 3.

Fig. 4: Snapshot of designed module

Table 3: Interpretation of the degree predicted By the proposed system

Degree of vigilance	RT(S)	Time before severe behavioral lapse	Warningfeedback required
1	RT<0.5625	Optimal performance (presumably alert)	No
2	0.5625<RT<0.9375		
3	0.937<RT<1.3125		
4	1.3125<RT<1.6875		
5	1.6875<RT<2.0625	~700	Yes
6	2.0625<RT<2.4375	~500	Yes
7	2.4375<RT<2.8125	~250	Yes
8	RT>2.8125	Severe behavioral lapse	Yes

RESULTS AND DISCUSSION

The proposed system hence offers the real time vigilance level of a driver using various sensors. This system has an EEG sensor which gives various brain wave signals as explained in the subsequent sections.

Beta (14-40 Hz) the waking consciousness and reasoning wave: Beta mind waves are proportional to the ordinary waking awareness and an increased condition of sharpness, rationale and discriminating thinking. While Beta cerebrum waves are critical for successful working for the duration of the day, they additionally can make out into anxiety, tension and fretfulness. The voice of Beta can be depicted similar to that bothering minimal internal pundit.

Alpha (7.5-14 Hz) the deep relaxation wave: Alpha mind waves are show in profound unwinding and normally when the eyes are shut, when slipping into a beautiful fantasy or amid light contemplation. It is an ideal time to program the psyche for achievement and it additionally uplifts the creative ability, visualization, memory, learning and fixation. It is the entryway to the subliminal personality and lies at the base of cognizant mindfulness. The voice of Alpha is the instinct which gets to be clearer and more significant the closer when reached to 7.5 Hz.

Figure 4 constitutes the overall circuit design. This design monitors the brain wave signals and health conditions of a driver. The outputs of the above mentioned brain wave signals are displayed using neuro-experimenter and if any abnormal condition is detected, the indications will be displayed on the LCD (Yuce *et al*., 2007) (Fig. 5 and 6).

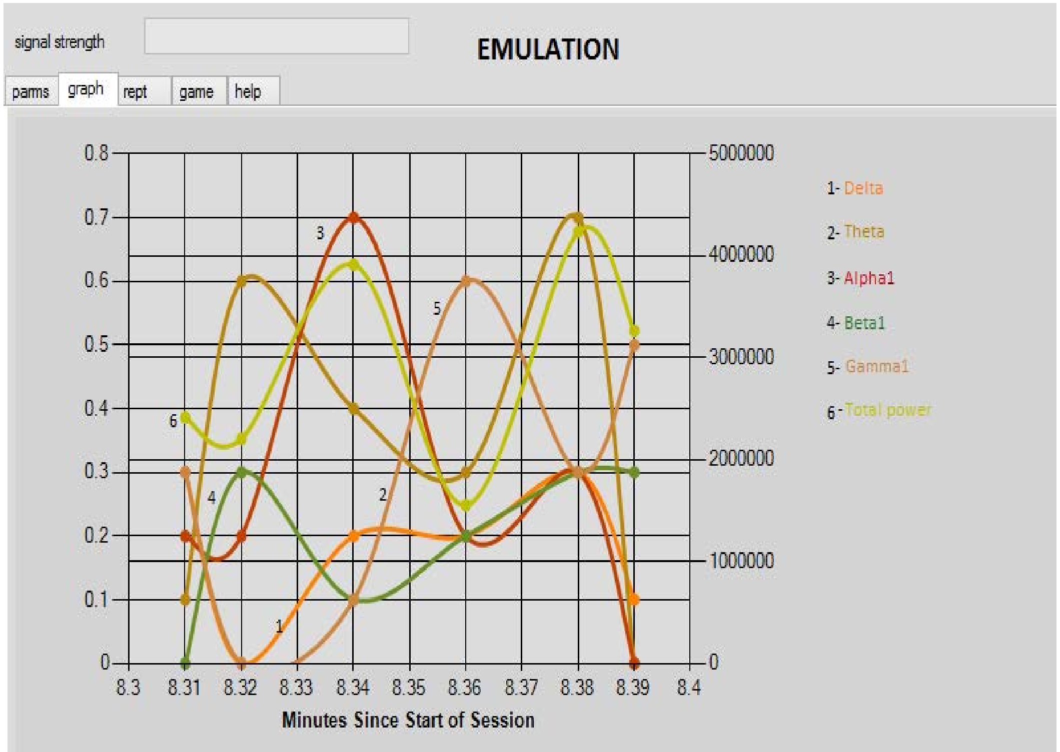

Fig. 5: Emulation output of EEG sensor analysis

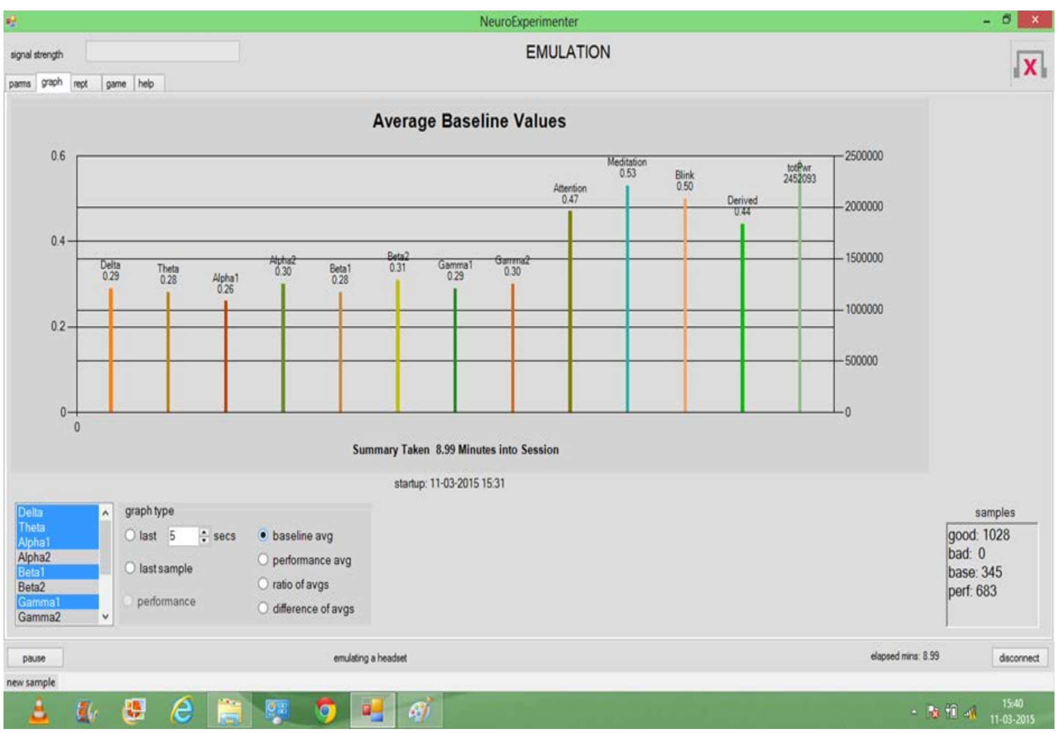

Fig. 6: Average baseline values of brain wave analysis graph

CONCLUSION

This study built up a driver vigilance forecast framework with the employment of WSNs as the key base empowering ordinary, constant, wandering wellbeing checking and wearable EEG gadget, an efficient expectation model and an on-going versatile App for the solution for anomaly amid driving. This new innovation overs an extensive variety of profits to patients, restorative work force and society through ceaseless observation in the walking, setting early discovery of anomalous conditions, managed restoration and potential learning disclosure through information mining of all assembled data. Taking into account, the proposed EEG framework, a connection was secured between the fluctuation in the behavioural record of driving execution (i.e., increment in RT) and the progressions in the mind action (i.e., inclines in EEG power spectra). Trial results showed that the RMSE could minimize to 0.124 ms when the SVR with a RBF piece was connected as the expectation model. Moreover, this SVR-based forecast model has been executed progressively for the subjects when they perform a maintained consideration driving task. Furthermore, a general WWBAN building design, imperative usage issues and the proposed model WWBAN in view of off-the-rack remote sensor stages and specially crafted with ECG and movement sensors. The recognition framework gives the anticipation sign to general society and park the vehicle consequently to one side of the street. This makes the proposed framework solid as well as to a great degree sheltered to counteract mishaps. Since this system manages natural signs to distinguish the variations from the norm, it is more proficient than the existing methods. Thus it greatly yields more benefits of saving thousands of human lives on roads every year.

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