TRAIN COMFORT ANALYSIS USING ACCELERATION MEASUREMENT AND NEURAL NETWORK

A thesis submitted by

HARCHAND (GL)	**(18ES33)**
MAHESH KUMAR	**(18ES37)**
SADAM RAHIMOON	**(18ES39)**

Supervisor

Prof. Dr. Bhawani S. Chowdhry

Co-Supervisor

Engr. Ali Akbar Shah

Submitted in the partial fulfillment of the requirements for the degree of Bachelor of Engineering in Electronics

Faculty of Electrical, Electronics & Computer Engineering

MEHRAN UNIVERSITY OF ENGINEERING & TECHNOLOGY, JAMSHORO

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CERTIFICATE

This is to certify that "**Project/Thesis Report on, "TRAIN COMFORT ANALYSIS USING ACCELERATION MEASUREMENT AND NEURAL NETWORK"** is submitted in partial fulfillment of the requirement for the degree of Bachelor of Electronic Engineering by the following students:

HARCHAND (GL)	**(18ES33)**
MAHESH KUMAR	**(18ES37)**
SADAM RAHIMOON	**(18ES39)**

______________________ ______________________

Supervisor **Co-Supervisor**

PROF. DR. BHAWANI S. CHOWDHRY ENGR ALI AKBAR SHAH

____

(Chairman, Department of Electronic Engineering)

Date: __________________

DEDICATION

We are dedicating our whole efforts to our respected

<u>"PARENTS & TEACERS"</u>

Whom we are really inspired. their pure love, devotion

Natural attitude and sincerity matter of great

Pleasure and pride for us.

Their encourage and simulating morally, socially and

academically based teachings have always been

proved for us a

<u>"PATH TOWARDS SUCCESS"</u>

They have given us name which caused our

identification in society

ACKNOWLEDGEMENT

It is enormous thanks to Almighty ALLAH who is Omniscient and Merciful who bestowed & enabled us to complete the task.

Always some people get a bigger share than other people not because they are better but because they arrive at the right time and right place to offer their services. So thanks to all those who helped us in completing this project.

With great respect and thanks, we express our gratitude to our Supervisor **Prof. Dr. BHAWANI S. CHOWDHRY** and Co-Supervisor **Engr ALI AKBAR SHAH** for allowing us to work in this project.

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May ALLAH bless all these wonderful people.

ABSTRACT

The railway is the backbone of the country's economy as passengers rely heavily on it due to its affordability. However, in Pakistan, not only the safety of the railway is compromised but also its ride comfort. there is an absence of any standardization platform status that could rate the riding standards of the trains currently operational in Pakistan. To address this, we are aimed at providing a solution that will not only analyse the railway ride comfort based on acceleration measurement but also will acquire brain signals, which will exhibit the current comfort of passengers. This proposed instrumentation will comprise EEG sensors and a train-mounted accelerometer module (in order to understand the effect of train vibration on the human comfort level), which will be tested on volunteers from different age groups on almost all of the operational trains of Pakistan. The data collected will pass through a machine machine-based data analytic model which will provide the comfort rating of the various trains. This study will ultimately help passengers from different age groups in making the decision of which train they should choose for traveling. Moreover, as this project is in collaboration with the Pakistan Railways, they can use this study in determining their fair rates.

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List of Abbreviations

EEG	Electroencephalograph
TF Record	Tensor Flow
ACK	Acknowledge
HSR	High-speed railroad

CHAPTER 1

INTRODUCTION

High-speed railroads (HSRs) have been widely and rapidly developed in worldwide transportation because of advantages such as positive energy efficiency, safety, and dependability. The constant acceleration of high-speed trains raises the excitation frequency of track imperfections and amplifies the contact between the vehicle and the track, reducing train comfort. Under these conditions, people are growing increasingly unsatisfied with train trip comfort. Furthermore, the irregularity of the tracks, a sort of stationary random excitation, and the variable arrangement of seats in the automobile body are to blame for the passengers' uncertainty of ride comfort. As a result, it is critical to increase passenger trip comfort and use the stationary random vibration method to study the zonal distribution of train comfort and the key influencing elements in order to offer a theoretical foundation for comfort improvement. [1]

Train ride comfort is the main indexes of evaluating in the trains, has the significant influence on riding and safe during the travel. The most sensitivity of human sensation differs in the direction of vibration and sound. As the vibration environment becomes more complex as the increasing the speed of train. Train is the most used system in traveling and it is most uncomfortable when vibration or motion in vertical direction [2]

The riding experience and well-being of passengers during transit are significantly impacted by ride comfort, one of the key metrics used to assess train performance. [3] The vibration directions and frequency range to be considered in real application may typically be identified from this perspective since the sensitivities of human sense vary in vibration directions and vibration frequency.[4] The vertical direction is the direction that researchers focus on the most when it comes to ride comfort. [5,6,7]. Due to their non-negligible contribution, such as lateral, vertical, and roll vibration in [8], vibrations from other directions begin to catch the researchers' attention as the vibration environment becomes more and more complex as train speed increases. Since the human body is not sensitive to vibrations over 20 Hz, which is notably true in the lateral and roll directions [9], the frequency range that is often taken into account for ride comfort is 0.5–20 Hz [10]

Acceleration on the carbody floor and human-seat interactions must be used to measure ride comfort in cars [11,12]. Most studies have so far ignored the human-seat system out of simplicity and merely evaluated ride comfort using acceleration at the seat base [13]. However, because of the intricate dynamics of the train seat, the vibration that is conveyed from the floor to the seated passengers can be altered. It was demonstrated through experimentation that passengers could dampen the flexural vibration of the car's body and that their distribution, posture, and foot position may affect the car's dynamics [14, 15] Therefore, investigating ride comfort methodically utilising a comprehensive track-train-seat-human system will allow for more precise vehicle dynamics description and ride comfort evaluation using the accelerations measured at the human-seat interfaces [16, 17, 18]

The authors of the given study have long been interested in the running features and behaviours of wheeled modes of transportation. Their study is primarily concerned with ride safety, passenger comfort, and strategies to improve these. For these goals, they developed several simulation models, ran numerous computer simulations, and conducted tests on test stands. Their study focuses on rail vehicles as well as their safety and comfort. Various occurrences have been seen during these actions. Among them, it has been discovered that it is feasible to indicate decreasing running safety or comfort by studying changes in vehicle characteristics such as: mass and inertia parameters, suspension system parameters, contact element design (wheel/rail contact), the influence of input factors, including the excitation of a vehicle's mechanical system, stochastic phenomena during track running, and other influences.

In this paper, we use EEG sensor which detect the activities in human brain which is appearing in the human brain during the travel, it actually detects the how much people is uncomfortable in the train and ACCELEROMETER which actually placed/fixed at the seat and detect the vibration occurred in the train. And then we acquire the results which is detected from the EEG and ACCELEROMETER and then both data transfer to the main embedded server via wireless connection and data showed on the web page and set thresh-hold that how much vibration and noise safe for human, mean not effect-able for human.

Now a days, train speed is increasing rapidly (600 kmph and 1200 kmph) in developed countries so peoples demand to increase safety and comfort of the train , if only increase in speed in not effect-able without safe in train during the travel,.in Pakistan trains are in some how bad condition and more uncomfortable to travel at least 100km continuously, so there should need of analysis and meed the standard (The standards ISO 2631 EN 12299)

The railway is an important part of the national economy. Because of the benefits of environmental preservation, convenience, speed, and safety, an increasing number of passengers prefer to travel vast distances by train [19].According to recent study, in Pakistan 80,000 peoples used train to travel and also generating 240 million dollars per year In 2014, the Ministry of Railways launched and started Pakistan Railway's Vision 2026, which looks to increase PR's share in transportation sector of Pakistan from 4% to 20%, using US$3.9 billion China–Pakistan Economic Corridor rail upgrade. The vision includes building new locomotives, development and.improvement of current rail infrastructure and increase in average train speed, improved on-time performance and enhance of passenger services. The first phase of project was completed in 2017, and the second phase was completed in 2021. Among them is the ML-1 project which will be completed in three phases with the cost of US$4.9 billion.

Fig 1.1 Components

1.1 HISTORY

Pakistan Railways is indeed the binding force that connects every part of the country. It is the mode which the majority of the population adopts to travel and gets connected. Undoubtedly, Pakistan Railways has the infrastructure that suits the need of the people in a very orderly manner. Whether it is cargo or transportation Pakistan railways is indeed the first option of the majority. Sir Henry Edward, who was then the commissioner of Sindh, started the study on railways in the year 1858. According to the proposed plan, a railway track from Karachi city to kotri, Chenab to Multan and then to Lahore would be developed. Finally, on the 13th of May 1861, the track connecting Karachi and kotri was activated. The track was a hundred and five miles long; the track holds its position today and is used by traffic. Moreover, in 1889 a line connecting kemari and Karachi city was developed, and subsequently, in 1897 the track from keemari to kotri was inaugurated. During the last quarter of the 19th century, a rail line connecting Peshawar, Lahore, and Multan was initiated. The project was later completed in the starting few years of the 20 centuries [2,3]. Then the single solitary organization had the following segments: Scinde Railways. Indian flotilla company, Delhi Railways, and the Punjab Railways.

1.2 PROBLEM STATEMENT

Safety and comfort are the key parameters of any transportation, so a compromise to them can lead to a catastrophic outcome. There are different factors that can create ride discomfort such as, vibrations, slouched posture on seats, and temperature. This Project focuses on the analysis and diagnosing the ride comfort level based on acceleration measurement units (mainly accelerometer), EEG sensors by using Neural Network algorithm.

1.3 AIMS AND OBJECTIVES

1.3.1 AIMS:

Aim of this project is to provide comfort ride in train and safe travel, also meet with safety standard.

1.3.2 OBJECTIVES:

i. Developing Sensors connection (ADXL345 And EEG) with NodeMCU using Arduino IDE. And creating an access point.

ii. Creating the main server, which runs under Python Language, Collects Data from both sensors, via a Wifi access point, Configured in the third NodeMcu. And performs data analysis and Monitoring.

iii. Showing the real-time data on graphs and comfort level in the results on Graphical interface.

1.4 PROJECT SCOPE

In Pakistan the many areas where trains are popular to travel but safety and safe travel is important during travel, in local class there is noise and pollution but in business class noise is , but some how less as compare to local class so , this project is to reduce noise and make train comfortable by analyzing through EEG sensor and ACCELEROMRTER sensor which detect the vibration and factors affecting on human body , by though we make train comfortable and safe travel and also, people can rate the train service that which is better for passengers by using application.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review allows us to understand the current state of research in a particular field. It also includes information about improvements, methods, and potential research topics. It distinguishes your research from the research of others in the field.

2.2 COMFORT ANALYSIS

The main goal of this research aims to provide a solution that will not only analyze the railway ride comfort based on acceleration measurement but also will acquire brain signals, which will exhibit the current comfort of passengers. The aim is to analyze the comfort of the train through acceleration measurement and EEG sensors by using a neural network algorithm.

Different acceleration inputs, interconnected system architectures, preparation algorithms and objective functions were orderly examined, and optimum parameters were derivative. There has been obtained a new understanding of how anthropometric data affects riding comfort. According to the findings, the suggested technique is more accurate than existing standards in estimating subjective ride comfort. On public roads and in a controlled setting, data from a variety of field experiments involving 10 individuals were used to train neural networks. The study is supplemented by a clustering and sensitivity analysis, which finds the most crucial variables affecting the subjective assessment of ride comfort.[20]

To predict the journey comfort of bus passengers in real-time, a three-layer artificial neural network (ANN) model is developed. The trip comfort of bus passengers is a significant aspect that is known to attract increased ridership towards a sustainable public transport system. The ride comfort index in ISO 2631-1997 (vibration dose value and maximum transient vibration value), passenger-related features (posture, location, facing, gender, age, weight, and height), and vehicle-related parameters (speed, acceleration, and jerk) are the inputs. The output is passenger rating (collected from a specialized mobile application). The ANN model performed satisfactorily and showed good input-output correlation, with an average MSE of 0.03 and an R-value of 0.83, respectively. To determine the relative importance of each variable in the ANN model, sensitivity analysis was also carried out. The results showed that all influencing factors contributed similarly, between 4 and 6 per cent. According to the connection weight technique, elements connected to passengers often contribute somewhat more to trip comfort assessment than do ones related to vehicles. Given that automated bus guidance systems use a significant degree of machine learning and artificial intelligence, it is crucial to design ANN models that can accurately predict how comfortable a bus journey would be (AB). The current research findings can assist AB designers and engineers in enhancing AB technologies to increase passenger comfort aboard. [21]

To demonstrate a systematic method for objectifying human comfort it includes the subjective comfort evaluation's prediction into the idea stage of the product development process. The subjectively perceived comfort of each passenger is calculated using a human feeling model based on artificial neural networks (ANN). In this study, two instances of the implementation of the proposed approaches are discussed. The first illustration shows an examination of comfort-related design elements for the drive train, such as the mass of inertia and the damping of the dual mass flywheel, as well as the friction coefficient gradient of the clutch friction pair. It is anticipated that the subsequent vibrational characteristics and subjective evaluations will occur during startup. In the second illustration, a 5-speed manual transmission's gear rattle tendency is determined. The ANN-based models representing the NVH specialists are developed to forecast the occurrence of gear rattles and to assess the resulting annoyance level. As a result, there is a solid link between subjective assessments and anticipated evaluations. As a result, the suggested approach may be used to assess various gearbox systems for new product concepts. As a result, the development period and expenses could be drastically cut. [22]

To identify the possible pathways for comfort degrading in high-speed rail systems and established an evaluation approach using machine learning to measure passenger comfort, this study uses the subjective approach to measure overall ride comfort, collecting real-time data from twenty passengers. It was identified that the passengers who were in a state of comfort the brain areas (BA6/13/20/24/31/40/47) of passengers who experienced discomfort had strong beta band activation. An evaluation model based on the LightGBM algorithm was trained using six different types of characteristics collected from EEG data to assess the general comfort of train passengers. [23]

A model predictive control (MPC) approach integrated with machine learning to manage energy consumption and occupants' comfort (thermal and visual comfort) in a smart building is developed. To learn and estimate the building's requirements, climatic conditions, and electricity usage, neural networks (NNs) are established. The performance of the proposed learning-based MPC approach is compared to a model-based building control framework on a building that has been installed using EnergyPlus software. Resulting of the simulation, In terms of maintaining residents' comfort and lowering energy usage, the control method exceeds the traditional MPC by a wide margin. [24]

BP neural network and MATLAB software is used to obtain the correlations between the ride comfort indices to examine the relationships between different ride comfort rating metrics. Ride comfort is essential to both vehicle design and evaluation, different evaluation methods are discussed and recommended in research for assessing ride comfort in rail. The findings of this study can instantly change one index to another. They can easily obtain the evaluation result in terms of the required ride comfort index even when the raw data are unavailable or incomplete and the ride comfort is evaluated using one technique.[25]

A new approach for evaluating passenger car vibration comfort based on the precise contents of vibration signals is developed utilizing deep learning. To create a sample dataset, four-passenger automobiles are tested at various speeds and on various kinds of roads. A new data augmentation approach for deep learning that incorporates data segmentation and resampling is presented and tested to get around the dataset size limitations. Two fundamental models are created using two neural networks, the feed-forward neural network and gated recurrent units, where the gated recurrent units take into account the time sequence characteristic of vibration data. In addition, the frequency content is considered by generating two additional structures by adding a Fast Fourier transform layer to the fundamental models. The findings in this study show that the suggested data augmentation strategy quickly increases the dataset and makes it possible to use deep learning to evaluate ride satisfaction. [26]

To analyze and find patterns between the subjective comfort values reported by study participants on a comfort scale of 1- 7, mechanical vibrations were noticed, measured in m/s^2. To ensure the quality of the data, statistical techniques were applied to data that had been gathered as part of an earlier independent study. The machine learning models analyzed in this research have shown substantial possibilities for identifying complex patterns connecting emotions and thoughts to mechanical variables. During the estimation of the 6 or 7 levels of comfort, the precision level of models was up to 50%. [27]

To estimate lateral car-body accelerations a neural network-based optimal model is trained. It is possible to define the lateral dynamic behavior normally by comparing these predictions to the values obtained from the train measurements. Any variation from this general character will indicate a decline in comfort or a possible degeneration of the suspension and damping components. This model was developed using data from a particular train unit that included characteristics like lateral and vertical car-body accelerations, among others, that were recorded every second in 2017. The prediction of lateral car-body accelerations yields a minimum average inaccuracy of 0.034 m/s2. The average error is approximately 2.27% as reflected in the coaches of passengers in EN14363. Hence, an effective model is produced. [28]

To explore the comfort of the journey in rail cars, a rigid-flexible coupled train-seat-human model was created. For evaluating ride comfort, the weighted acceleration r.m.s. value at the seat pan was used. A power spectral density perspective was used to describe the contribution of various carbody modes to ride comfort. When the seat and bogie positions are far from the first bending mode's nodes, the first bending mode's function is more essential than that of other bending modes. In this case, the first bending mode's bogie spacing filter effect can be used to estimate the peaks and drops of the equivalent acceleration at the floor or human-seat interface as a function of speed or first bending frequency. To appropriately assess ride comfort, the human seat system had to be included. With higher bending rigidity or slower speed, the ride comfort showed a general trend of improvement. Also, effectively increasing the damping ratio of the bending modes increased ride comfort. The riding comfort was decreased by stiffening or dampening the human-seat vertical contact with the seat pan. No matter the speed, the carbody centre and two ends of the ride were the least comfortable riding experiences. [29]

The ride comfort at vertical vibrations of the railway vehicle is analysed and evaluated using Sperling's and the mean comfort methods. The two methodologies share the fact that the comfort indices—namely, the ride comfort index NMVZ and the ride comfort index Wz—are used to estimate the comfort sensation. The values of these indexes were calculated by numerical simulations. The advantage of using numerical simulation results over experimental results—on which the majority of earlier research was based—lies in the ability to examine ride comfort indices while accounting for the influence of velocity and specific parameters that affect the behaviour of vertical vibrations of the carbody, such as carbody flexibility and suspension damping. The numerical simulation applications were created using a "flexible carbody" type model and an original model of the secondary suspension. These models were based on a theoretical model of the vehicle that takes into account significant aspects impacting the behaviour of vertical vibrations of the carbody. The results primarily demonstrate that, under equal vehicle operating conditions, the two assessment techniques result in dramatically different ride comfort outcomes.[30]

Anthropometric dummies and mathematical models were used to analyze the comfort and safety of passenger rail vehicles. In train emergency impact modelling with impediments, oscillograms of parameters for the dynamic interaction of dummies with interior car elements and a control cabinet of an electric train were obtained. The resulting analysis has made it possible to identify the internal components of the rolling stock that are most likely to cause injuries and draw conclusions regarding their safety. The outcomes of the analysis of the passenger rolling stock's comfort and safety can be applied to the creation of technical solutions for locomotives and trains. [31]

Pressure changes primarily take place as trains move through tunnels. Passengers on trains experience aural discomfort because of these aerodynamic effects. This study investigated passenger pressure comfort by conducting a field investigation on the Cologne-Frankfurt/Main high-speed rail line and a simulation study in the pressure chamber TITAN (DLR-Institute of Aerospace Medicine) with 31 individuals. The discomfort of passengers was identified with the help of a generalized estimation equation model based on the parameters contributing to creating discomfort.[32]

As a resource for social consumption during the transportation process, the comfortable surroundings in railways passenger coaches could be considered. In order to develop a quantitative technique for calculating the RPCB while taking ticket prices into account, the authors of this study have chosen a number of objective and subjective criteria. Making the initial data dimensionless, figuring out how much each index weighs, and then figuring out the RPCBs are the three steps of this method. The data gathered from two different types of trains were used to validate the suggested strategy. The findings indicate that the RPCB and ticket price have a linear relationship with a correlation coefficient of 0.9616.[33]

To qualitatively assess and validate the comfort of transit trains by using longitudinal acceleration data gathered in Beijing subway systems and passenger feedback data. First, they create four regular fuzzy set-based comfort measurement models, whose parameters are established by field data and the experiences of subject-matter experts. The four regular fuzzy set models are then averaged to provide a combinational model, which elaborates a detailed measurement for the comfort of the ride. They conducted a questionnaire survey in the Beijing subway to verify the developed models. It is found that the averaging model performs better than any ordinary fuzzy set model when compared to the comfort levels and values derived by other models. Additionally, the improved model has higher accuracy and resilience for measuring riding comfort than the average model.[34]

2.3 METHODS:

There are numerous techniques that are used for ride comfort analysis as mentioned above. All of these come with different pros and cons in terms of accuracy, cost, availability, etc. A detailed discussion of this technique is given below in context to this. They are referenced from this set of research papers [35-41].

2.3.1 OBJECTIVE RIDE COMFORT MEASURES

An innovative dummy is an effective tool for an objective vehicle ride comfort evaluation. [35] The advantages of using an objective ride for comfort measures are the characterization of driving impression, impression scales of driving for comparisons, repeatability, and problem identification that occurred during driving. [36]

Fig 2.1 Dummy Model

2.3.2 SUBJECTIVE RIDE COMFORT MEASURES:

This type of ride comfort analysis relies on how the user is feeling. The questionnaires ask users to attribute their pain to a particular area of the seat. The automakers created thorough subjective evaluation methods using highly organized questionnaires. Body mapping is another approach that is employed in subjective measurement. The respondent will be asked to rate the parts of their bodies that are uncomfortable and to assign a scale to that discomfort. [37]

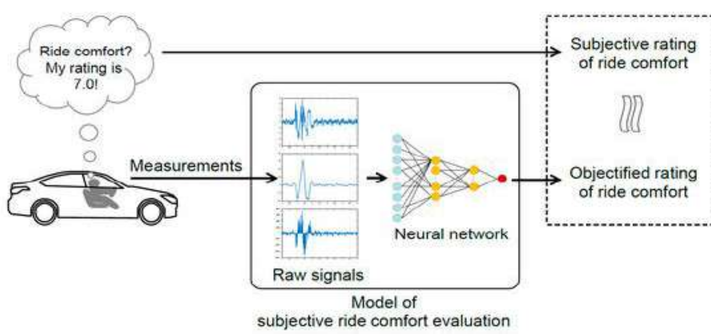


Fig 2.2 Model of Subjective ride comfort

2.3.3 RIDE COMFORT ANALYSIS USING ARTIFICIAL NEURAL NETWORKS (ANNS):

Several real-world applications have long used artificial neural networks (ANN), one of the artificial intelligence algorithms. It has the capacity to detect any set of input and output accurately without the need for a physical model, and yet the outputs of ANN do take into consideration all the dynamics connecting the input to the output. [38]

2.3.4 VIBRATION COMFORT EVALUATION FEED-FORWARD NEURAL NETWORK.

An artificial neural network of this kind that does not have looping connections between nodes is known as a feedforward neural network. Due to the fact that all input only travels forward, feedforward neural networks are so termed. Here is how it works; a classifier employs the equation $y = f^* (x)$. The network feedforward will map $y = f(x; \theta)$. After that, it stores in memory the value of that most closely resembles the function.[39]

2.3.5 Sperling's Method

The most popular techniques for evaluating passenger comfort on trains include Sperling's method. The dynamic reaction of a passenger to the vehicle body during an average train trip must be monitored by sensors to determine the degrees of ride comfort. With the frequency weighting curves corresponding to the various assessment techniques, the recorded time-domain accelerations would be processed. The frequency-weighted accelerations were used to produce the different ride comfort indices, including Sperling's index (WZ), Mean Comfort index (Nmv), and Continuous Comfort index (CC). After that, the frequency-referenced accelerations were weighted using the proper frequency factor to account for different ride comfort indices. [40]

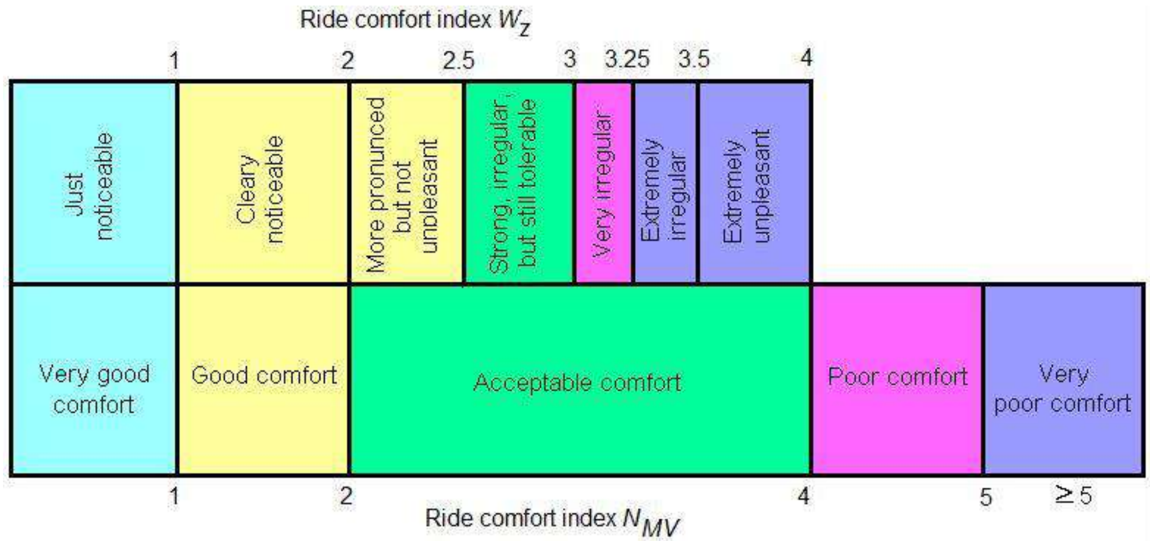


Fig 2.3 Ride Comfort index

2.3.6 COMFORT ANALYSIS USING ANTHROPOMETRIC DUMMIES.

A good motor vehicle seat should provide potential seat users with a sufficient level of vibration comfort. The anthropodynamic dummies that will be used to assess the vibration comfort have a structure similar to a seated human body, taking into mind the body areas where the experimental testing will be conducted. Where the head, thorax, and abdomen are distinct, a dummy with at least four degrees of freedom should be employed.[41]

CHAPTER 3

COMFORT LEVEL ANALYSIS

3.1 INTRODUCTION

In Pakistan, rail transportation plays a significant function in providing the necessary framework to fulfil the demands of a rapidly expanding economy. A comfortable environment in railway passenger carriages can be regarded as a resource for social consumption during the transport process. However, the Safety and comfort of passenger traffic one of the key problems of railway transport. The project is complemented by a clustering and sensitivity analysis, which finds the most critical factors influencing subjective ride comfort assessment. In this chapter objective of comfort level analysis is achieved.

3.2 BLOCK DIAGRAM

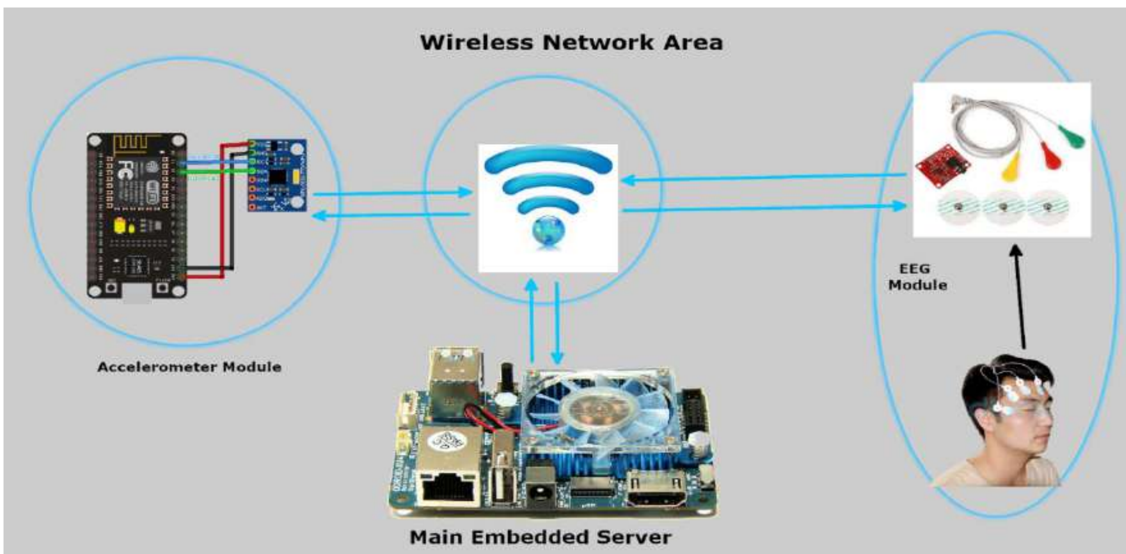
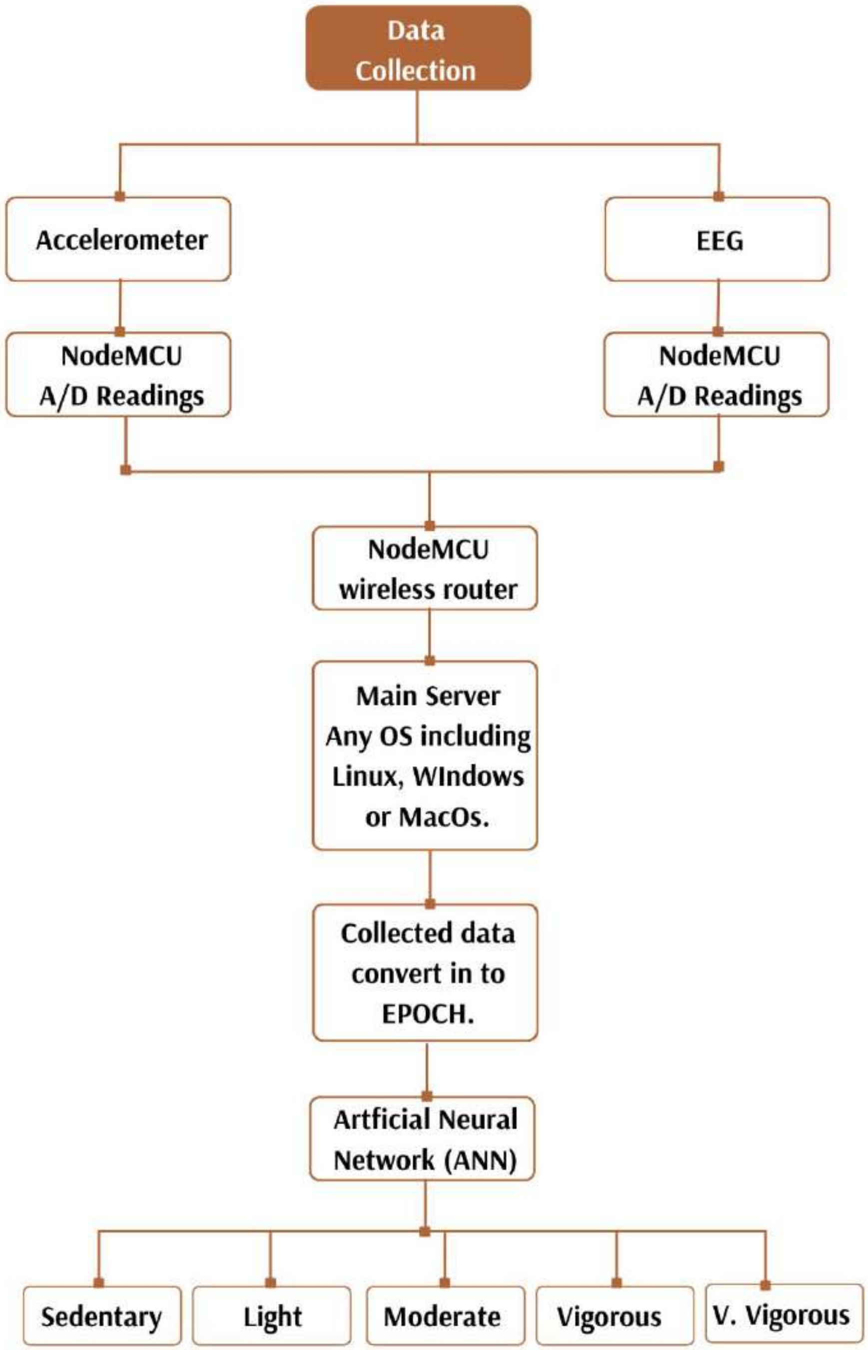


Fig 3.1 Block diagram of project mechanism

This block diagram shows the working mechanism of the project. Both the EEG and Accelerometer sensors are connected to the NodeMCU(Microcontroller) hardware. There is a third NodeMCU hardware which is acting as a wireless router which is connecting the sensors with the main embedded Server.

3.3 FLOW CHART OF COMFORT LEVEL ANALYSIS



3.4 METHODOLOGY

This chapter comprises both hardware and software parts. For the hardware part, the EEG sensor and Accelerometer are being used to collect the data. Each sensor is attached to NodeMCU(ESP8266) which collects analog reading and converts it into a digital reading. EEG Sensor sends data to the main server every millisecond. Whereas the Accelerometer sensor also sends the data to the main server every second with x, y and z positions. The NodeMCU is a component rich MCU with coordinated Wi-Fi and Bluetooth network that has a wide scope of uses such as in IoT projects. So, to establish a wireless router another NodeMCU is used which acts as an access point. All client and server communication is being done via a Wi-Fi interface. This access point connects all the sensors with the main server. The main server, which is running under Python Language, Collects Data from both sensors, via a Wi-Fi access point, Configured in the third NodeMCU. and performs data analysis and Monitoring.

The main server converts all the gathered data into EPOCH. The data coming from EEG is divided into 5 Epochs. Where Epoch means, that server collects 600 samples and divides them into 600/10 segments. Then, performs AI techniques to calculate the current outcome of the real-time EEG readings. Along with the EEG, Accelerometer data is also collected into 100 samples and divided into the correct Epoch Timelines, so that states of Jumps, comfort or jerks, can be calculated during each Epoch time.

3.5 PRESSURE POINTS VALIDATION

We have identified and validated the pressure points that are optimal for the collection of the EEG data during the field trial through "The Mehran Express Railway" from Karachi to Hyderabad. The points in the human body which go under the effect of discomfort during the journey on the train are identified. We also validate the point on the human head where the EEG sensor is going to attach.

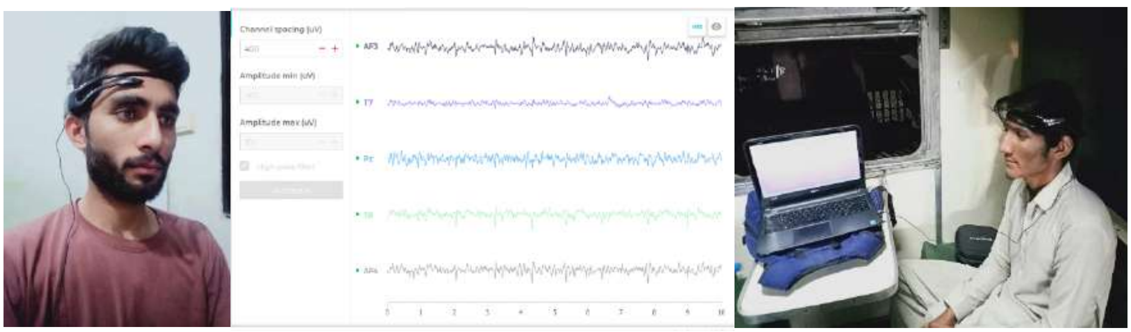


Fig 3.2 Pressure point validation during field trials

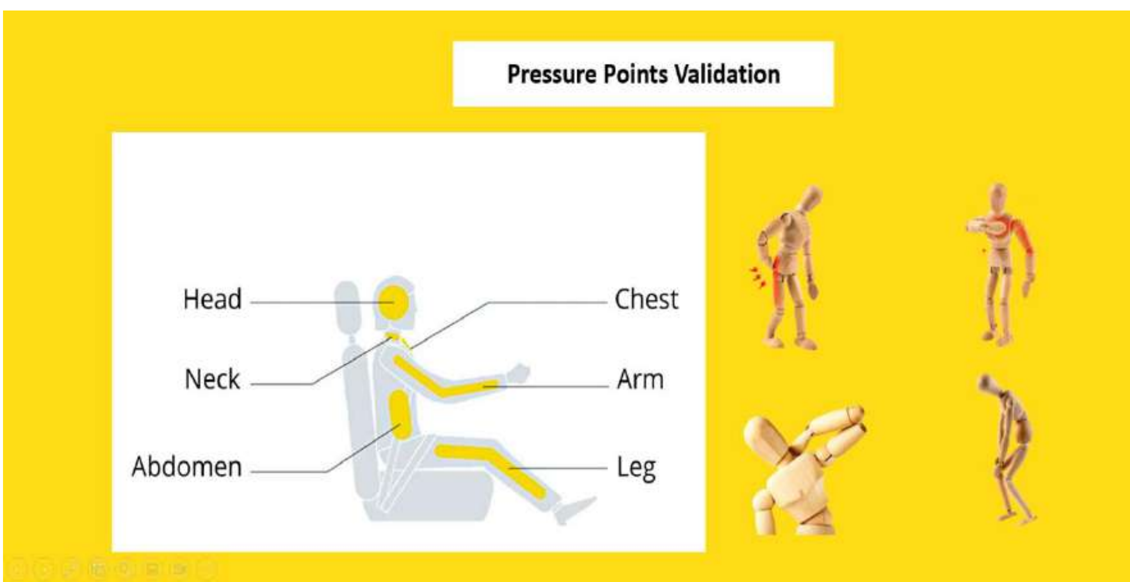


Fig 3.3 Pressure points

3.6 HARDWARE CONNECTION

All the sensors are connected to NodeMCU Hardware which fetches analogue readings of the EEG sensors and accelerometer (ADXL345), which sends the data to the database (main server) created in Python. Simplex communication of the sensory network and the main server is performed using a wireless network.

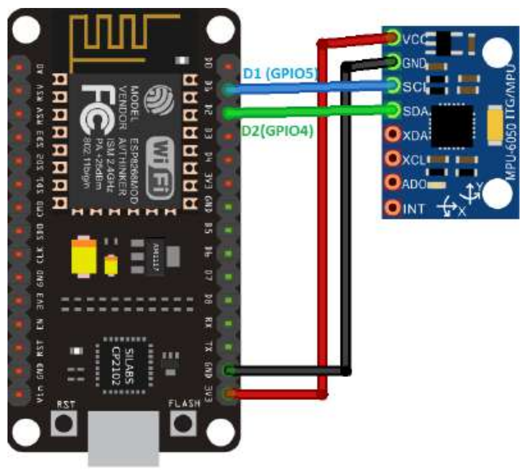
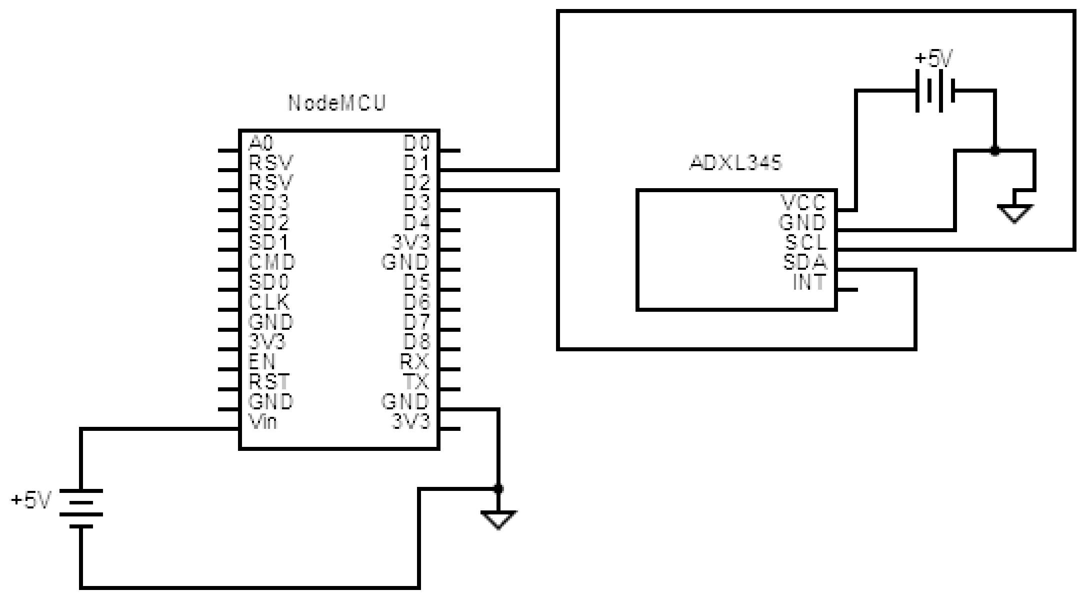


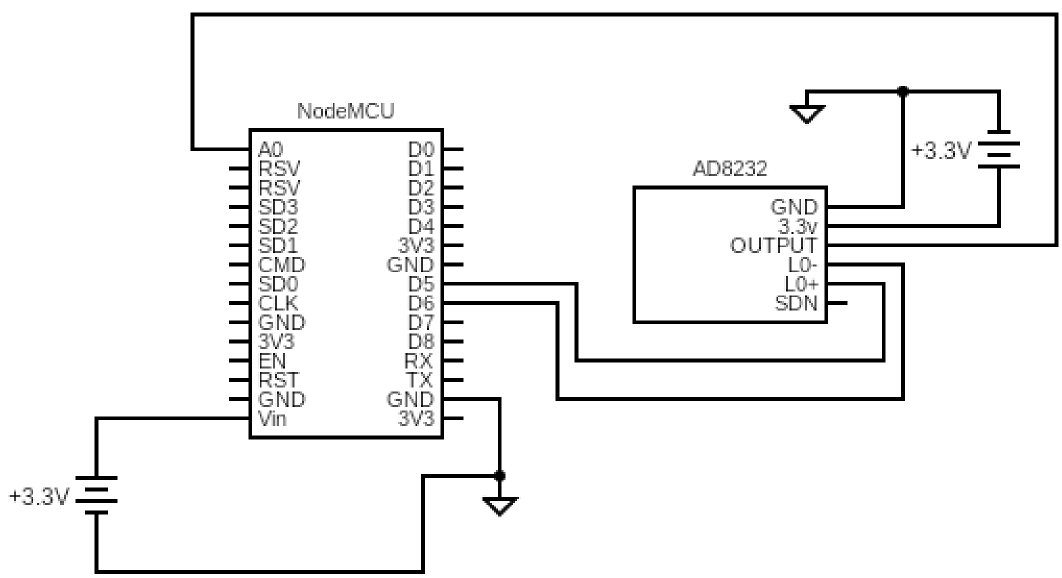
Fig 3.4 SPI Connection between ADXL 345 and NodeMCU

Fig 3.5 EEG Connection

3.6.1 CIRCUIT DIAGRAM OF ADXL 345 MODULE



3.6.2 CIRCUIT DIAGRAM OF EEG MODULE



3.7 ARDUINO IDE CODE OVERVIEW

There are two parts of the code here. One is the Hardware side Code, which is written in C++, and the other is written in Python.

3.7.1 WIRELESS ROUTER (ACCESS POINT)

A Wi-Fi chip called the Lolin NodeMCU ESP8266 V3 can be utilised in a number of IoT applications. This module features a built-in Micro-USB that is simple to configure and contains switches for the flash and reset. To configure the NodeMCU Arduino IDE is being used. After putting the header file in the code, we named the wireless network "StressAP" along with the password "987654321". A static IP address is assigned to make sure that its IP address does not change. To start the serial data a baud rate of 115200 is also fixed.

3.7.1.1 COMPLETE CODE OF CREATING ACCESS POINT

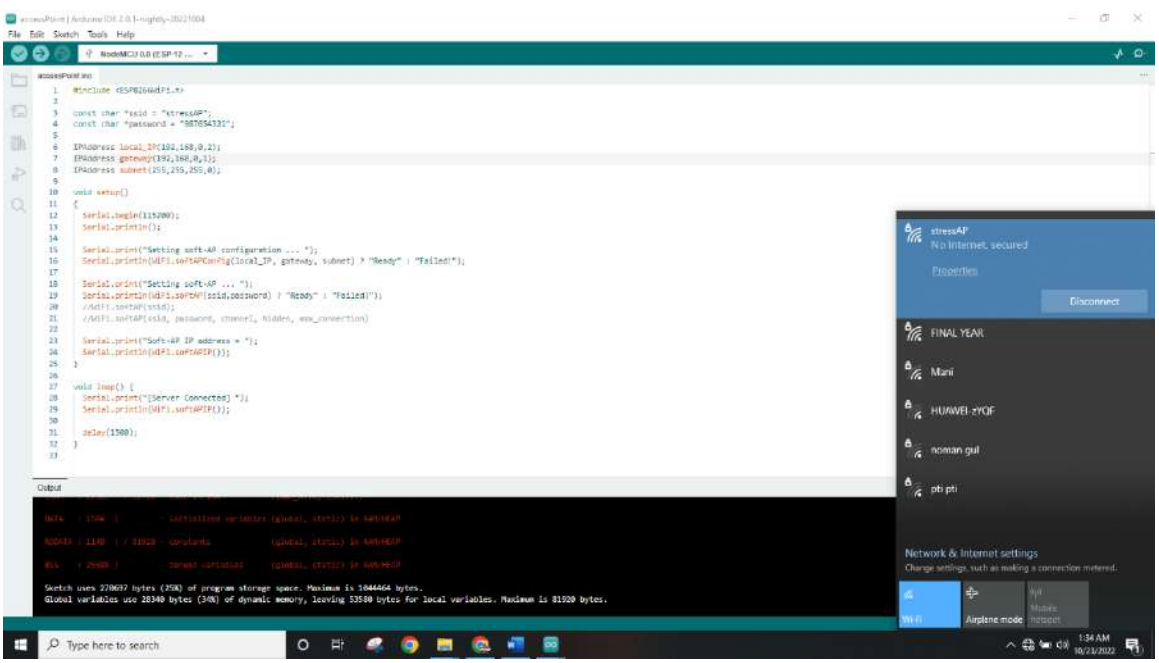


Fig 3.6 Code for creating wireless network "StresAP"

3.7.2 ACCELEROMETER MODULE

An accelerometer "ADXL345" is connected with NodeMcu hardware through SPI connection. The accelerometer is capable of measuring acceleration forces in 3 axes so we defined three variables named x, y and z with their initial float value of 0.0. The force that moves an object is known as the acceleration force. Only gravity is acting on an object while it is at rest. Thus, the ADXL345 provides acceleration forces in g units, where g is the gravitational acceleration of 9.8 m/s^2. The highest acceleration that the ADXL345 can measure can be changed to be up to ±4g, ±8g, or ±16g. In this module, the ADXL345 has been set to ±4g. The forces of acceleration may be static (due to gravity only) or dynamic (due to motion and gravity). Arduino IDE is used to set up the module. To set up the accelerometer in Arduino the libraries including "Adafruit ADXL345" and "Unified Sensor library" is being installed. In addition, a static IP is assigned to the NodeMCU so that, it does not have the dynamic IP. Because, if it has a dynamic IP then it will not be able to connect with the access point and vice versa to send the collected data from Accelerometer. The accelerometer module tries to find the access point with a delay of 1 second. Once, the module is connected to the access point it will upload the collected data to http://192.168.0.106:8050/updateADXL and print the real-time data in a serial monitor.

3.7.2.1 COMPLETE CODE FOR CREATING ACCELEROMETER MODULE

Fig 3.7 Code for creating Accelerometer Module

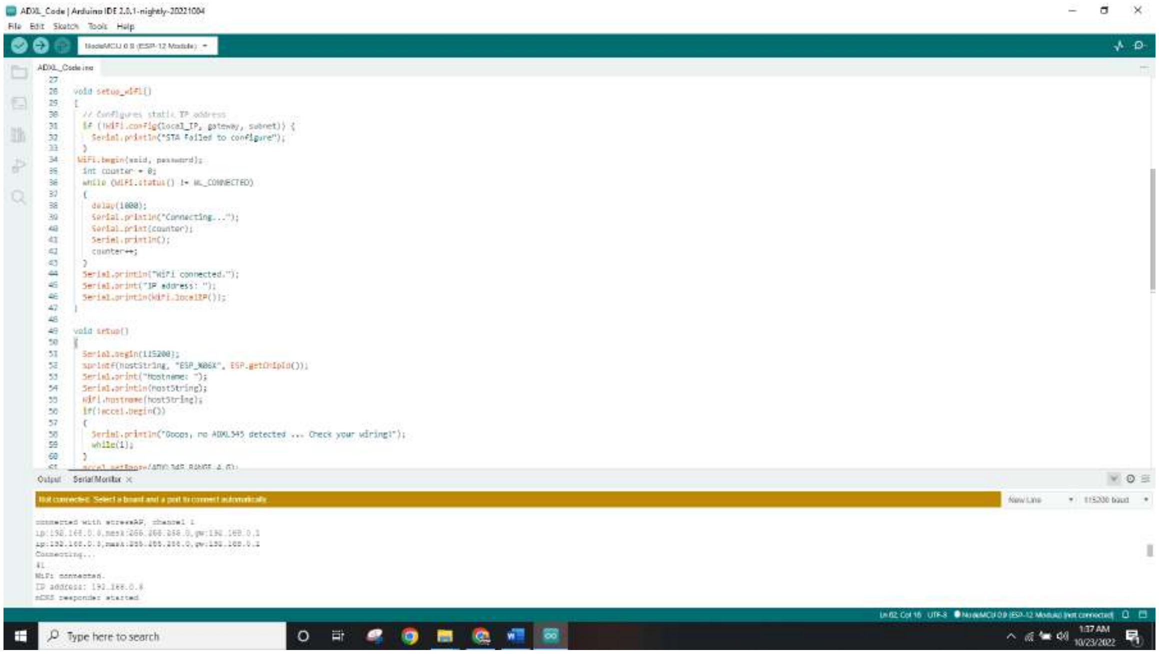


Fig 3.8 Code for creating Accelerometer Module

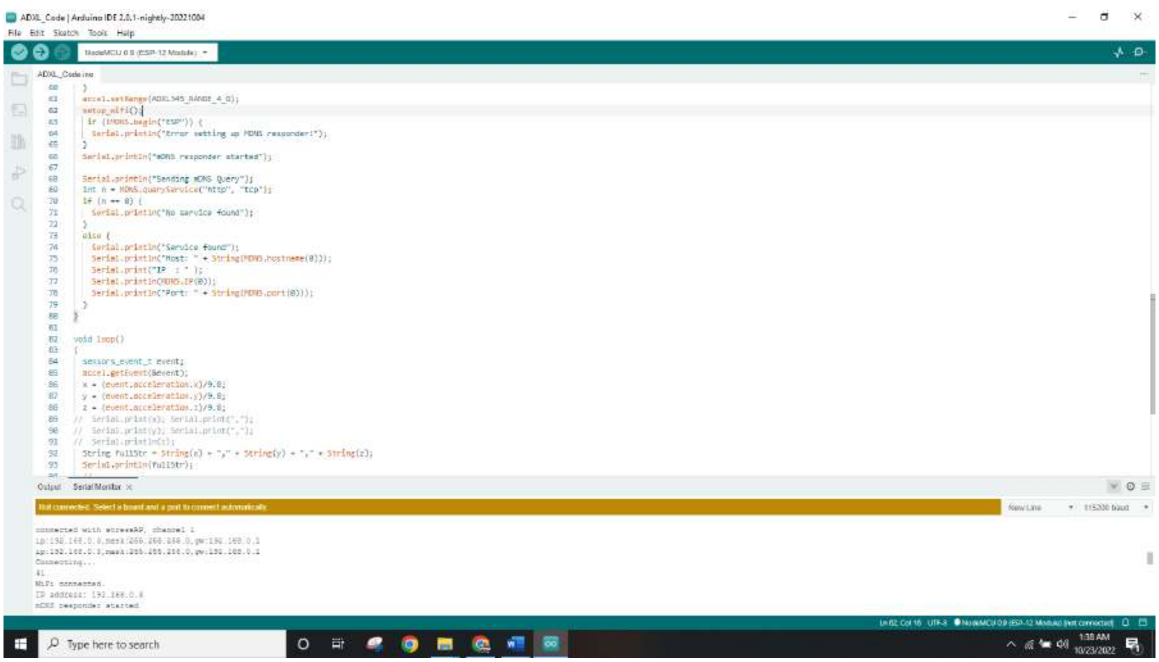


Fig 3.9 Code for creating Accelerometer Module

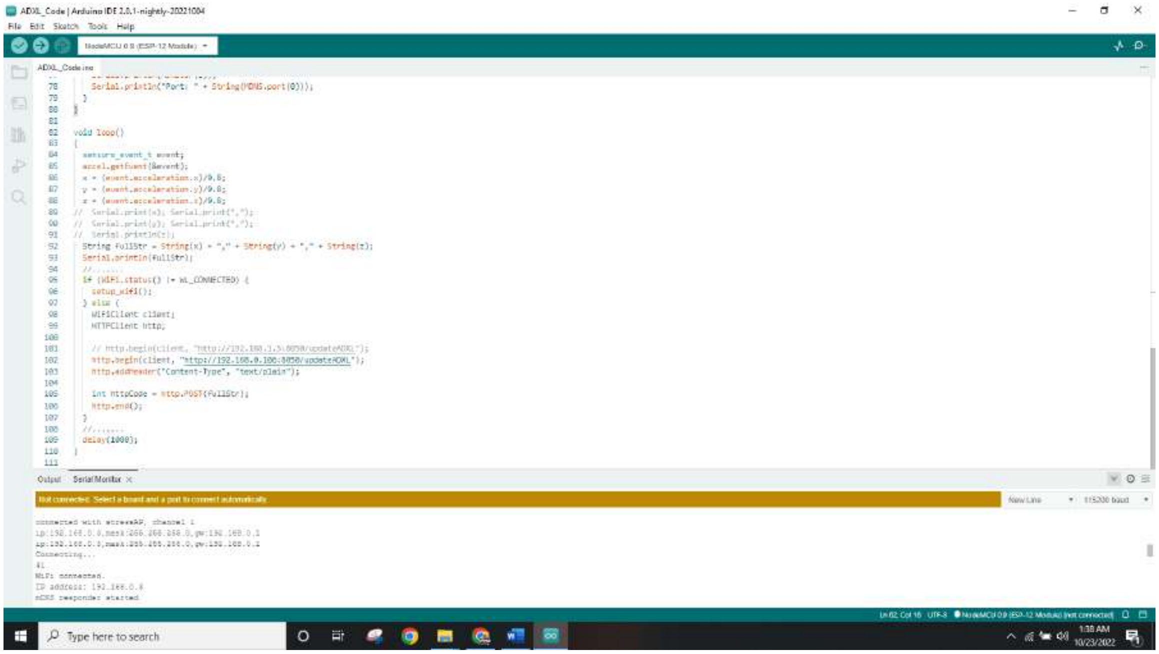


Fig 3.10 Code for creating Accelerometer Module

3.7.2.2 SERIAL MONITOR OUTPUT OF ACCELEROMETER MODULE

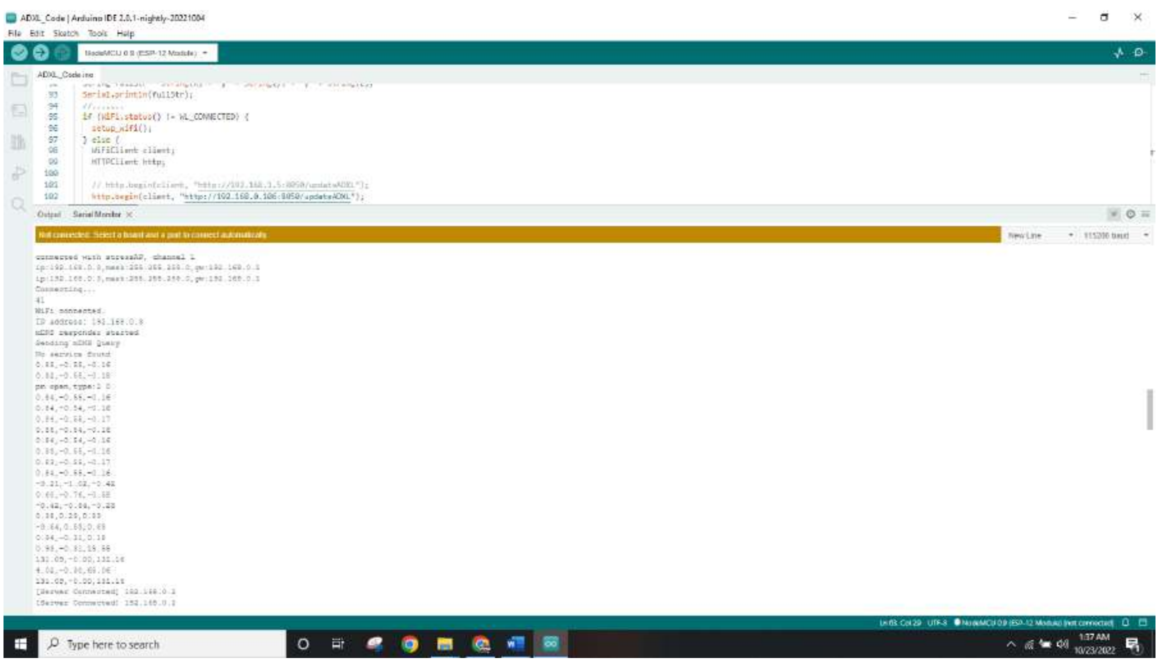


Fig 3.11 Serial monitor result of Accelerometer Module

3.7.3 EEG MODULE

An AD8232 ECG Sensor is being used to monitor the stress level which is connected to the NodeMCU hardware. To set up the connection we used Arduino IDE and included the libraries such as ESP8266 which gives the specific Wi-Fi functions that we are calling to establish a network connection. The heart rate in ECG lies between 60 to 100 beats per minute, in our module, we initialize it by 72. Along with that, we have initialized the upper threshold at 618 and the lower threshold at 590. Whereas, the minimum value coming from the sensor is 0 and the maximum value is 1023. It also has a static IP which tries to connect with the access point named "StressAP". Once, the connection is built, it will send the data to the access point.

3.7.3.1 COMPLETE CODE OF EEG MODULE

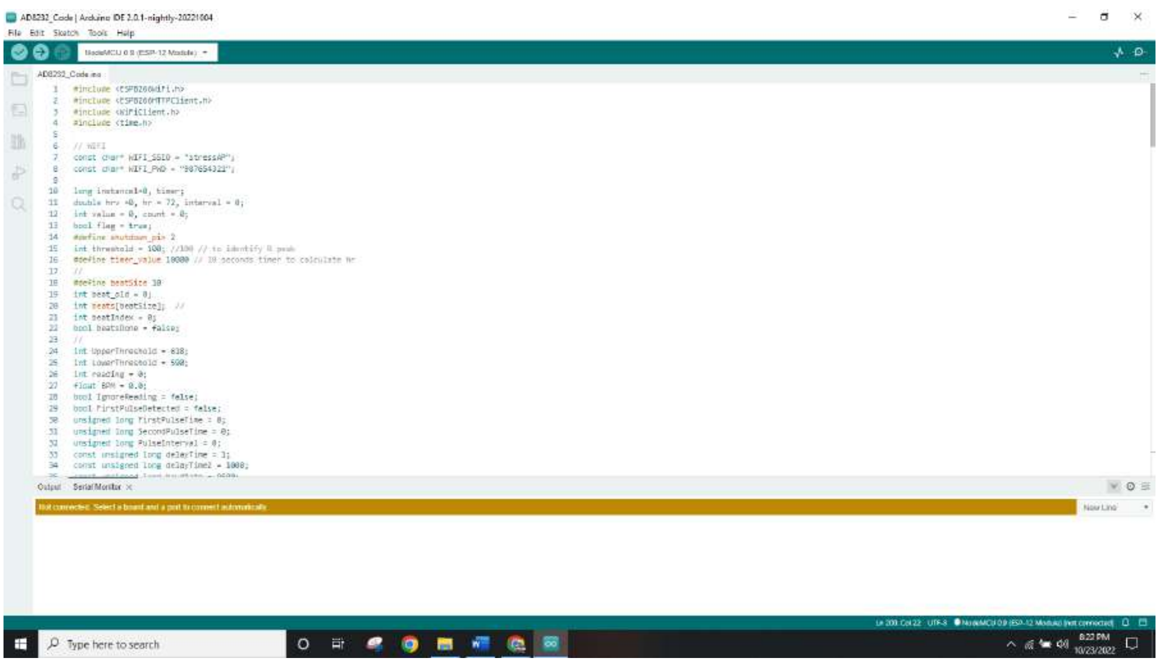


Fig 3.12 Code for building EEG Module and sending data to access point

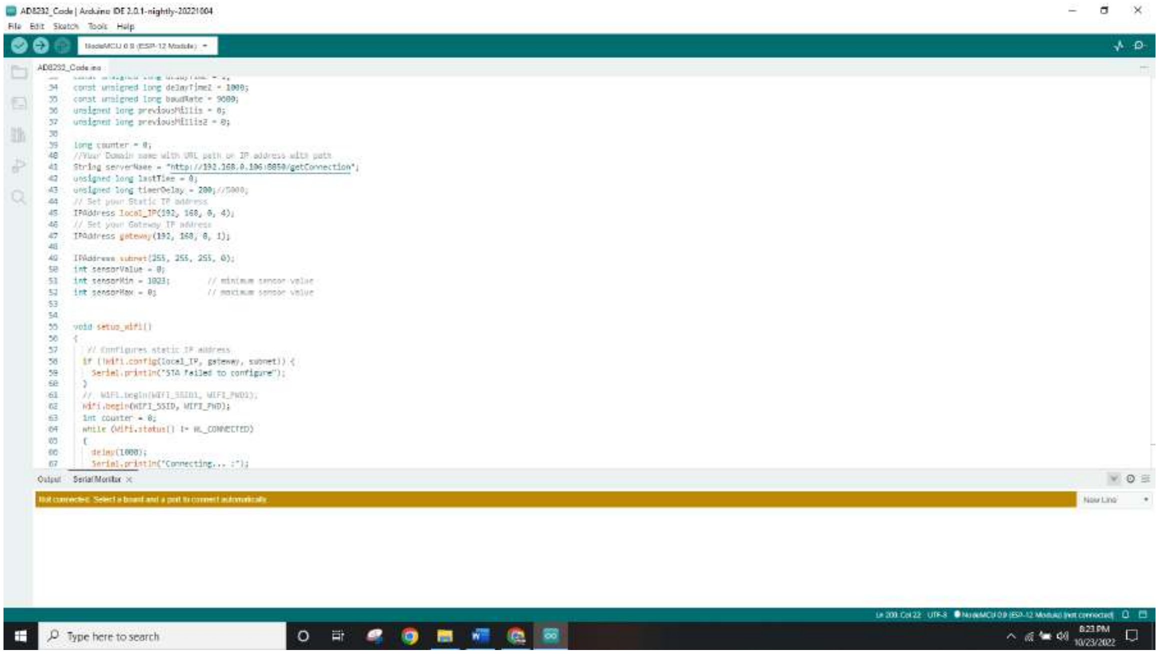


Fig 3.13 Code for building EEG Module and sending data to access point

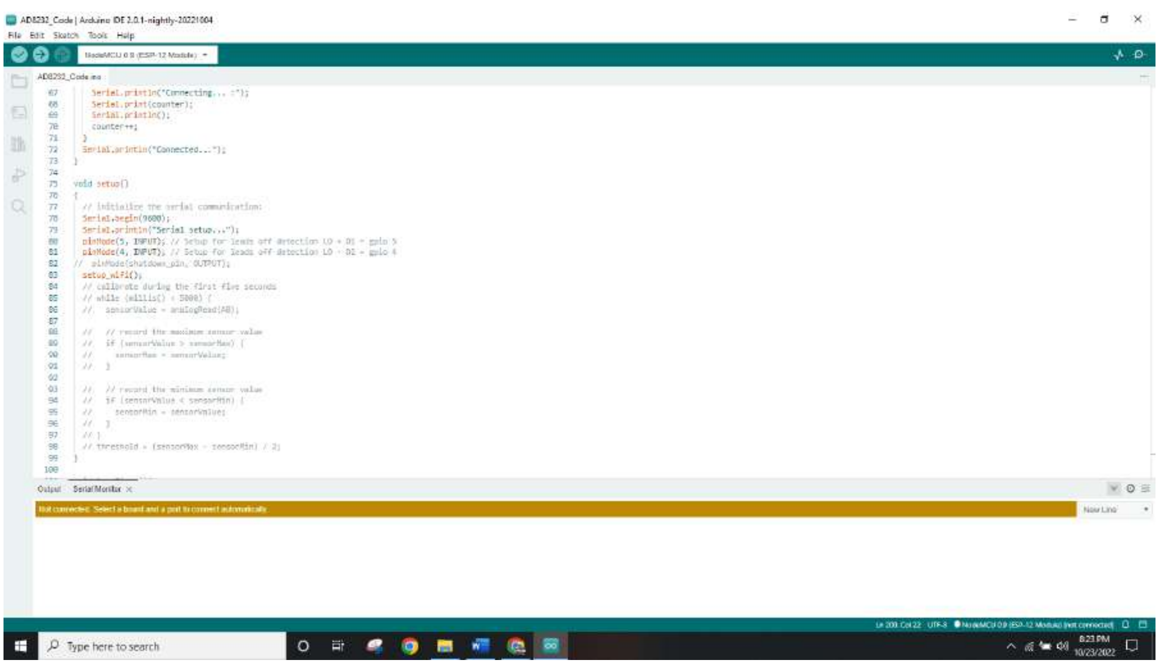


Fig 3.14 Code for building EEG Module and sending data to access point

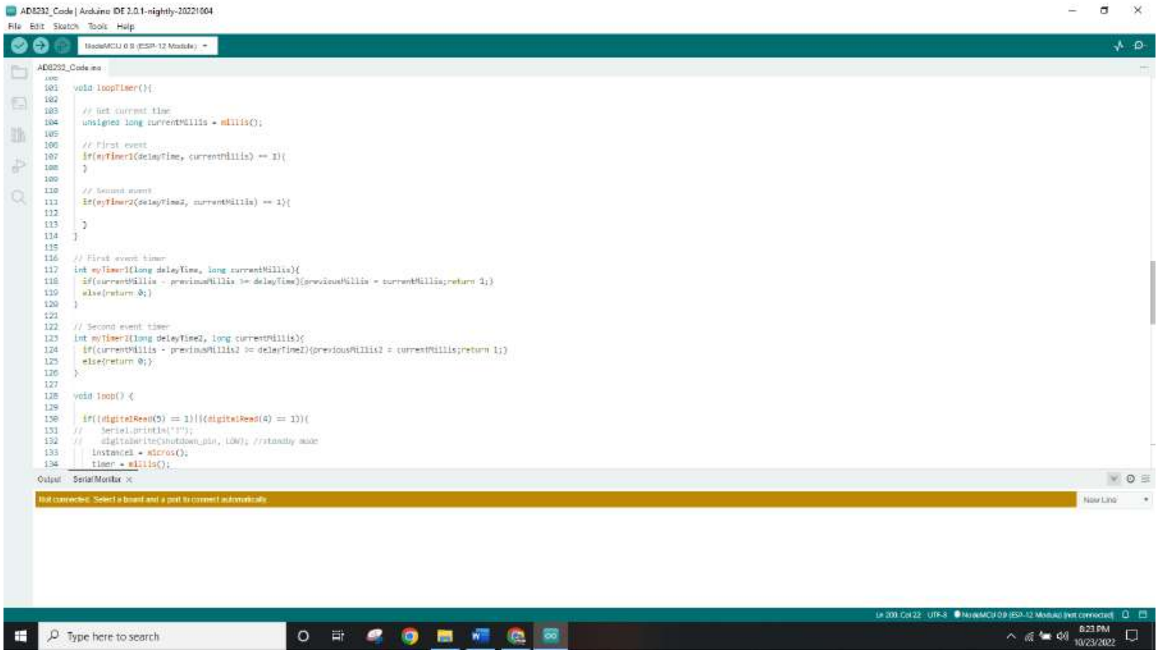


Fig 3.15 Code for building EEG Module and sending data to access point

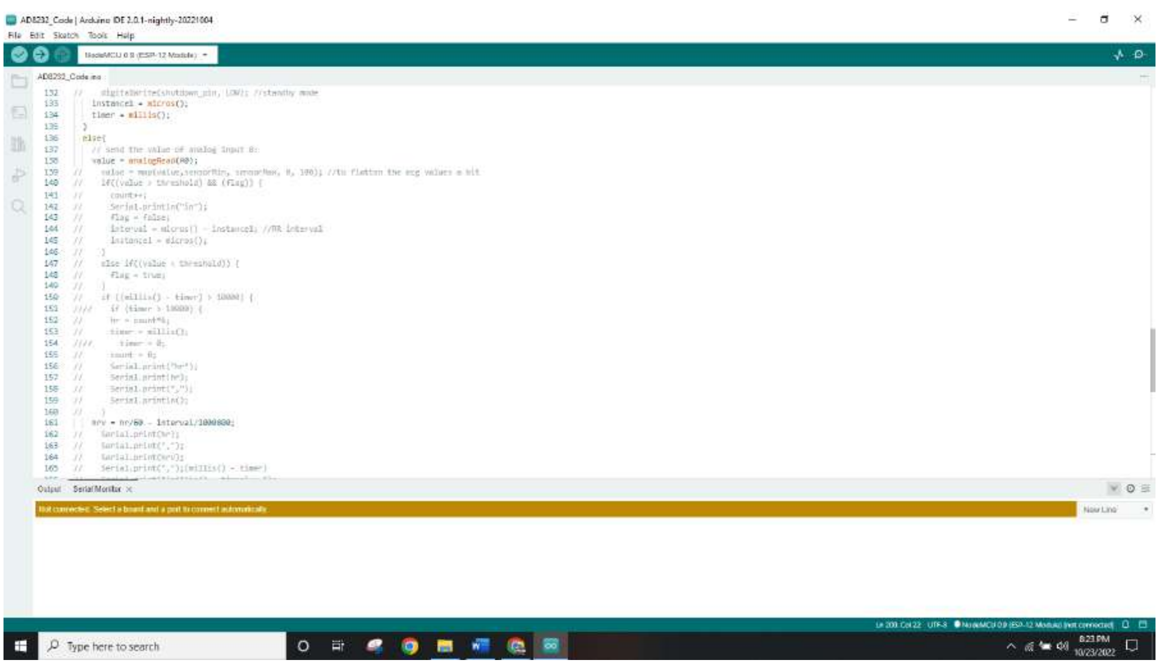


Fig 3.16 Code for building EEG Module and sending data to access point

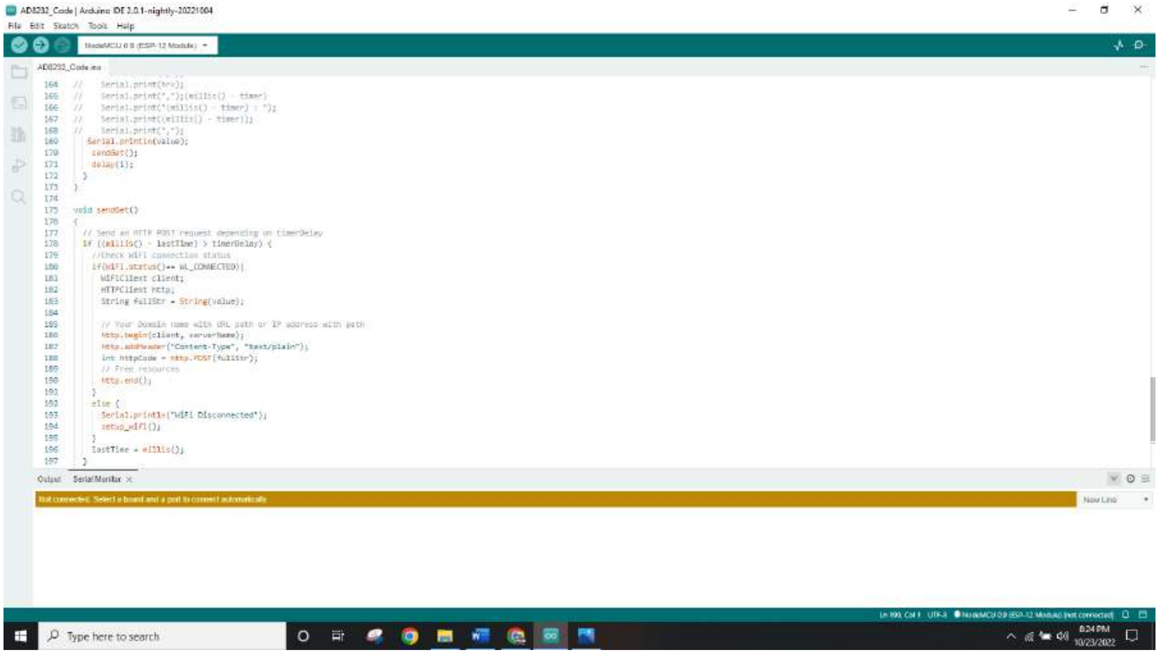


Fig 3.17 Code for building EEG Module and sending data to access point

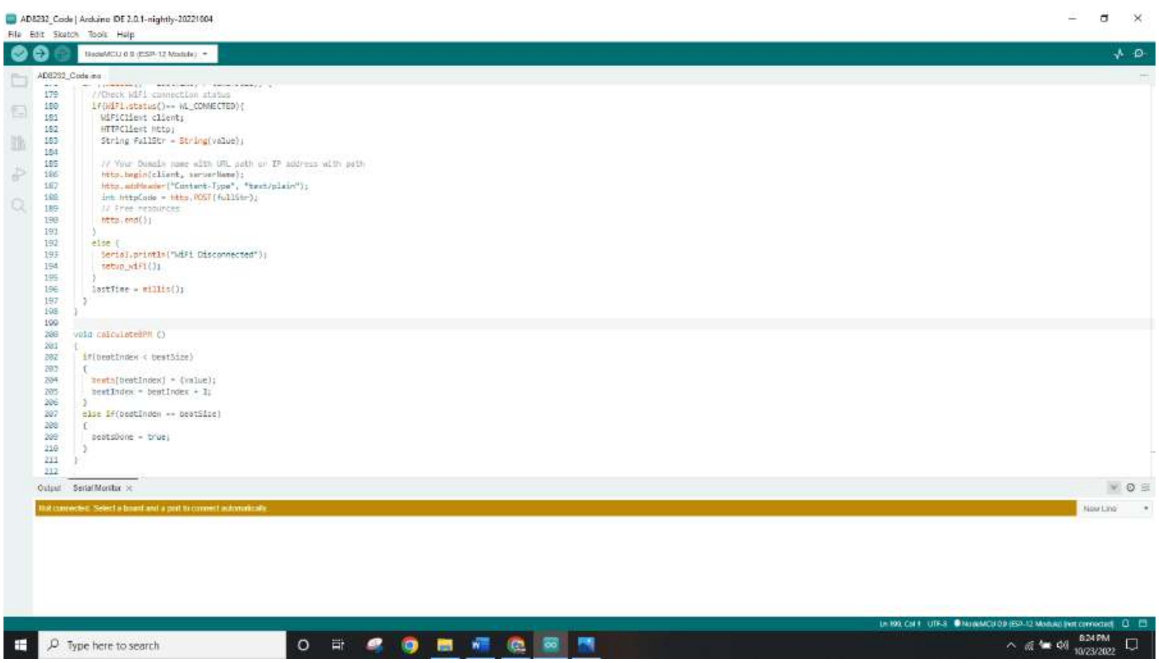


Fig 3.18 Code for building EEG Module and sending data to access point

3.8 PYTHON CODE OVERVIEW

In this section, the code flow in python is discussed. There are various files in this section which are being discussed one by one.

3.8.1 FLASK BLUEPRINT

The fundamental idea behind blueprints is that they list the actions that should be taken when an application is registered. When sending requests between endpoints and creating URLs, Flask correlates the view functions with blueprints. The flask blueprint in this case is correlating with the template file.

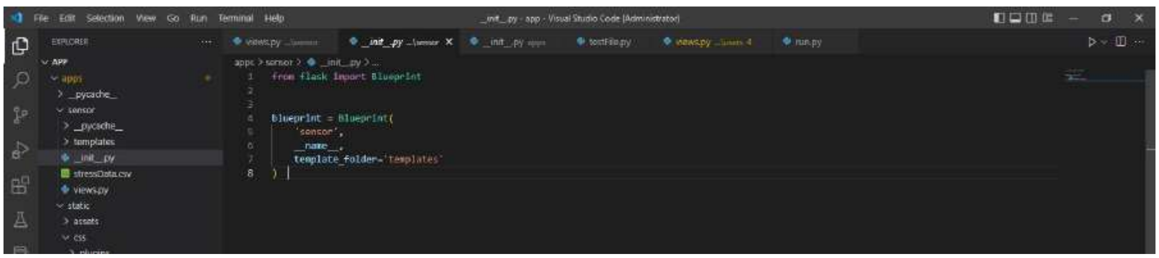
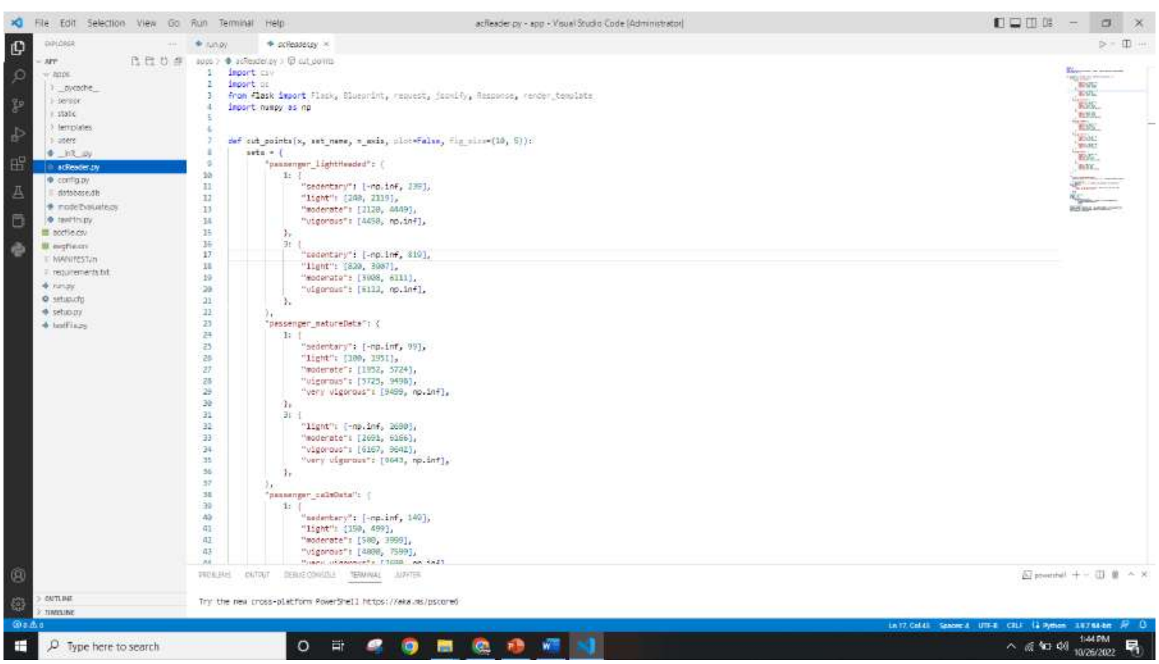
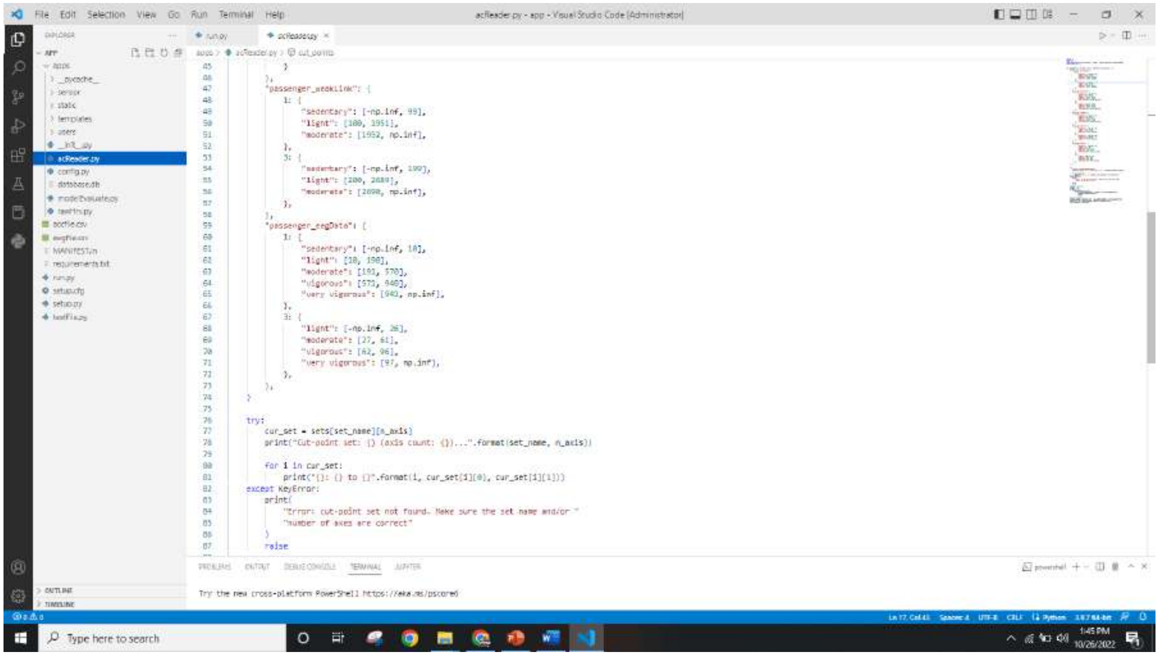


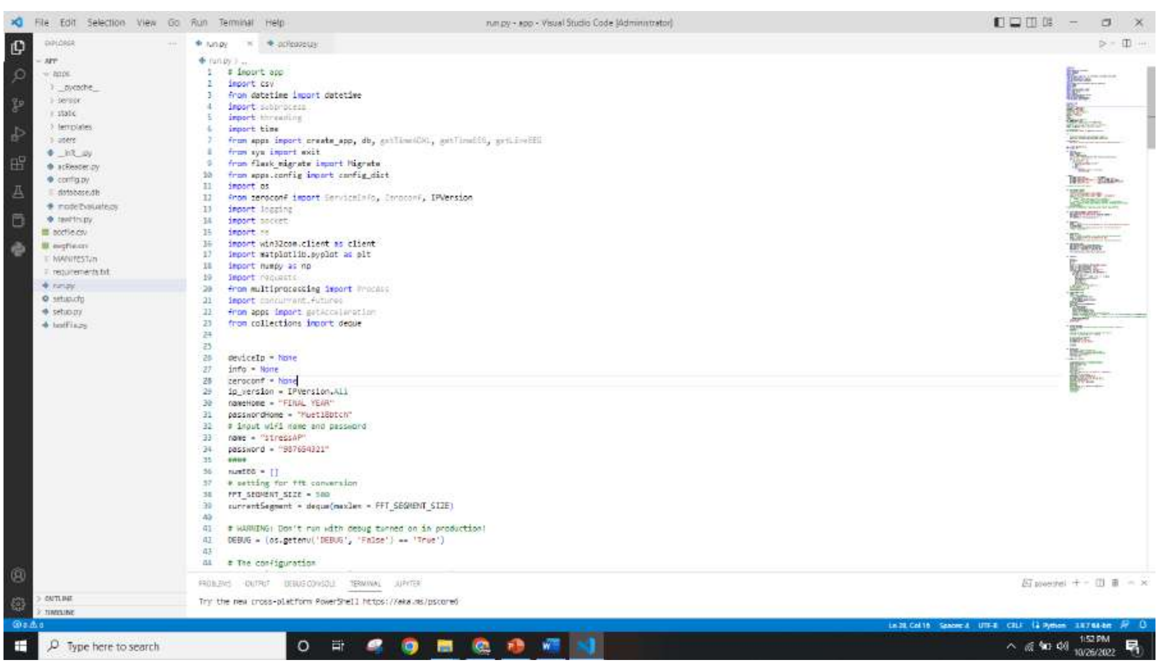
Fig 3.19 The code for creating Flask Blueprint

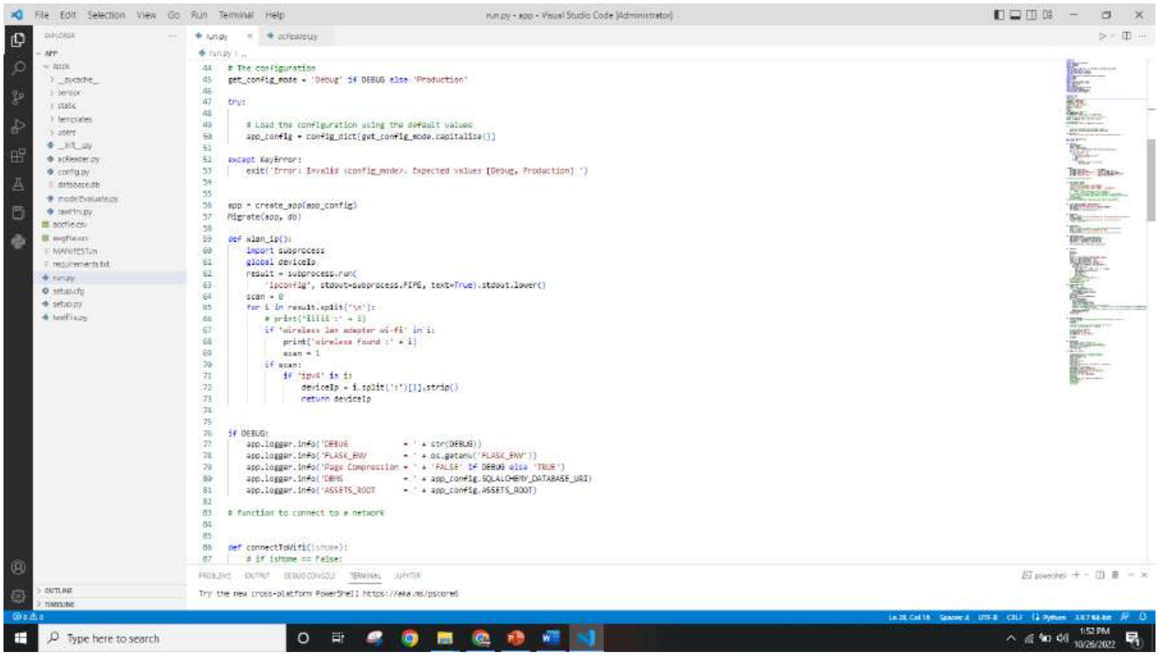
3.8.2 PYTHON CODE OF WIRELESS NETWORK

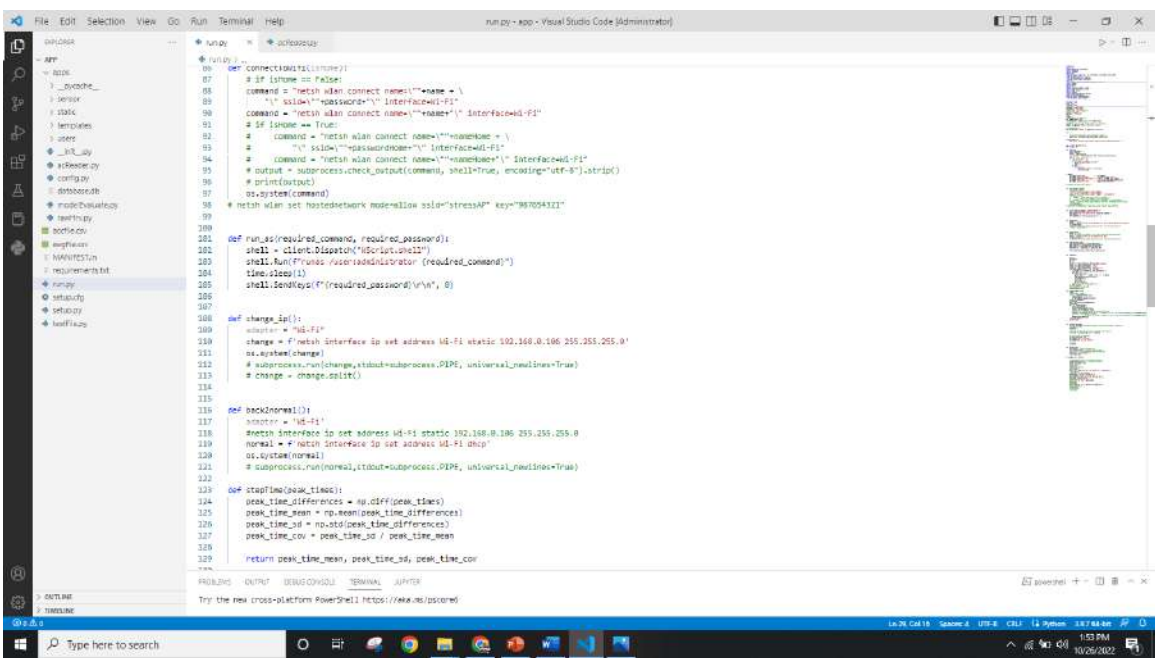




3.8.3 MAIN PYTHON RUN CODE







CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT OF THE PROJECT

We have created a graphical interface to show the real-time data and results. The Update Results () method shows the results of the current stress state on the right-hand side of the graphical display, with EEG data at the top and Accelerometer data at the bottom, And combined results at the end of both the individual results.

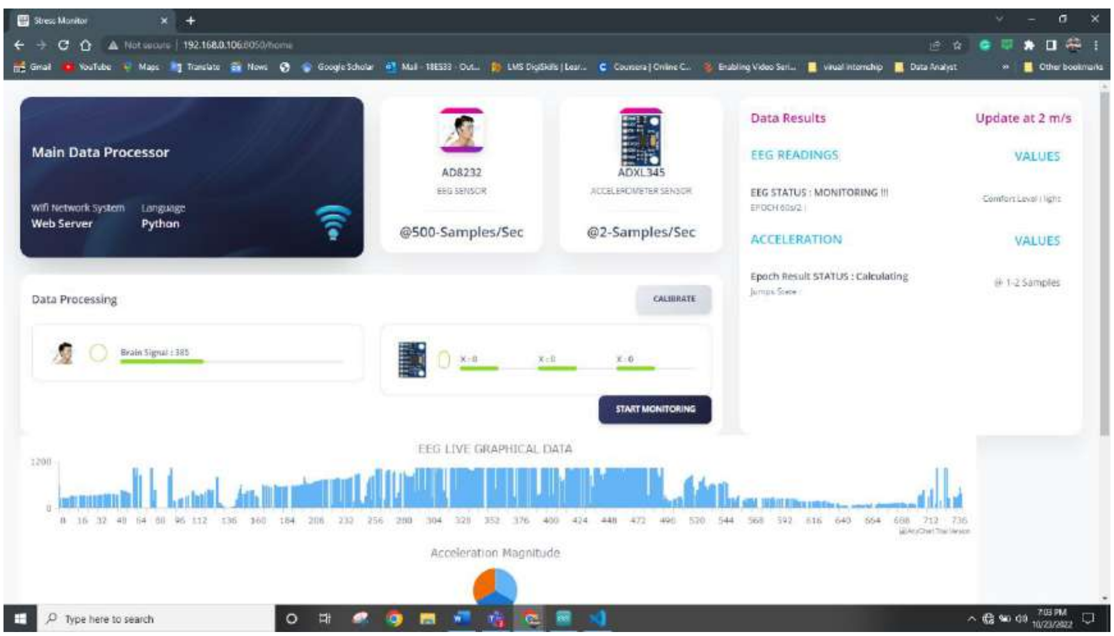


Fig 4.1 Graphical User Interface

Fig 4.2. Data Results

4.2 TIME INTERVAL

Initially, we have to make sure that both sensors are sending data to the server. This is also shown in the form of a Graphical Interface, where real-time sensor data is shown in the graph.

If data is coming correctly, then we can start the monitoring, by pressing the start monitor button, on the UI. That will then start the monitoring. And after every 2 minutes, a person's state can be displayed on the screen.

We can obviously increase the monitoring interval. Like if we want to get the data reading after every 10 minutes, or after an hour. That way data will be analyzed after that time.

4.3 MODEL CREATION

We created the model after testing various Ai techniques, by creating the live CSV files, and giving those files to different models. In The end, we selected the best model which gives us accurate results.

4.4 CODE FLOW

1. Run Wi-fi access Point first. To have a "StressAP" Wi-fi network, so that sensors can connect.

2- Turn on EEG and Accelerometer.

3- Run the main Python Server. Which will automatically connect to the wireless Network.

4.5 REAL-TIME PROJECT VALIDATION

We validated our results on different trains in Pakistan. The results help to categorize the comfortable level of different trains in Pakistan. This will not only help passengers to check, which train is more comfortable but it will also help the Pakistan Railway to validate the price tag on the individual train.

Fig 4.3 Pakistan Railway

CHAPTER 5

CONCLUSION AND FUTURE RECOMMENDATIONS

5.1 CONCLUSION

The goal of this research is to analyze the comfort level of trains in Pakistan. We are providing a solution that will not only analyse the railway ride comfort based on acceleration measurement but also acquire the brain signals, which exhibit the current comfort of passengers. This proposed instrumentation is comprised of EEG sensors and a train-mounted accelerometer module. The results are shown on the graphical user interface which is created by the team using HTML and VISUAL Studio Code. This Project will help Pakistan Railways to add the comfort ratings of trains in their current application.

5.2 ADVANTAGES

- Train comfort level analysis checks the comfort level of trains operating in Pakistan and based on their comfort level price tag on the ticket could be justified.
- This analysis helps Pakistan Railways to rate their trains based on the comfort states and identify and work on those trains which are not following the comfort standard.
- This project can also be integrated with the “Pakistan Railways Mobile Application” to show passengers the trains with a high comfort level to low with the mentioned price tag.

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