

DETECTION AND PREVENTION OF ATTENTION DEFICIT HYPERACTIVITY DISORDER USING IMAGE PROCESSING

Submitted in partial fulfillment of the requirements for the award of

Master of Technology degree in Medical Instrumentation

by

Hemalatha.M (41440006)



**DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MAY– 2023



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project report is the bonafide work of **Hemalatha. M** (Reg. No. **41440006**) who carried out the project entitled "**Detection and Prevention of Attention Deficit Hyperactivity Disorder using Image processing**" under my supervision from **November 2022 to April 2023**.

Dr. S. Krishnakumar M.Sc., Ph.D.,
Guide

Dr. T. SUDHAKAR, M.Sc., Ph.D.,
HEAD OF THE DEPARTMENT
Head of the Department
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
K. J. Somaiya Nagar, Rajiv Gandhi Salil
Chennai - 600 079

Submitted for Viva-voce Examination held on **05-05-2023**

05/05/23
Internal Examiner
R. M. S. S. S.
External Examiner

DECLARATION

I, **Hemalatha. M** (Reg. No. **41440006**) hereby declare that the Project report entitled **“Detection and Prevention of Attention Deficit Hyperactivity Disorder using Image processing”** done by me under the guidance of Dr. S. Krishnakumar M.Sc., Ph.D., Department of Biomedical Engineering is submitted in partial fulfillment of the requirements for the award of **Master of Technology** degree in **Medical Instrumentation**.

DATE: 05.05.23

PLACE: CHENNAI

M. Hemalatha.

SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to the **Board of Management of SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to Dr. **T. Sudhakar**, M.Sc., Ph.D., Head of the Department, Department of Biomedical Engineering for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide Dr. **S. Krishnakumar**, M.Sc., Ph.D., for her valuable guidance, suggestions, and constant encouragement that paved way for the successful completion of my project work.

I wish to express my thanks to all **Teaching and Non-teaching staff** of the Department of Biomedical Engineering who were helpful in many ways for the completion of the project.

I want to extend my sincerest thanks to all my **Family members and Friends** for their encouragement and support during my project work.

ABSTRACT

Attention Deficit Hyperactivity Disorder is one of the most prevalent neurodevelopmental disorders of childhood. It frequently persists into adulthood and is typically first identified in childhood. ADHD develops as a result of the structure and function of the brain, genetics and heredity, head injuries, alcohol and toxin exposure, etc. Children with ADHD may struggle to focus, manage impulsive behaviour, or be extremely active. Drugs or therapy are both effective ways to manage ADHD. The entire world has changed since COVID-19, stress, sadness and anxiety are now a part of everyday life. Human stress is a state of imbalance within an individual. A stressor is defined as any stimulus that threatens an individual's homeostasis state. Stressors can be physical or psychological in nature. If people are aware of their stress levels, they may feel empowered to take some preventative measures to reduce stress and achieve stress balance before it causes serious health problems. This project aims to provide a non-invasive therapy solution for individuals with ADHD. It involves using facial emotion detection using Python and comparing the facial emotion with restlessness detection using an accelerometer sensor and sweat detection using a water sensor. The threshold values for these parameters are connected to an Arduino Mega microcontroller. If any two conditions exceed their respective threshold values, non-invasive therapy will be activated using vibration motors. Additionally, an emergency button is integrated to send an SMS alert to the caregiver in case of any uneasiness. The facial emotion detection will be carried out using a pre-trained deep learning model that can detect emotions from facial expressions. The accelerometer sensor will be attached to the individual's wrist to detect restlessness, while the water sensor will be placed on the individual's skin to detect sweat. The EEG sensor will be used for monitoring purposes only, and its parameter values will be visualized in the Arduino serial plotter. This will enable the caregiver to monitor the individual's brain activity and adjust the therapy accordingly. Due to changes in lifestyle, this tool will benefit regular people. It can also be primarily utilised by rape victims and train drivers, who are going through a very difficult period and could benefit from these tactics to help them heal.

KEYWORDS: ADHD, stress, EEG, non-invasive therapy, Image processing.

CONTENT

CHAPTER	TITLE	PAGE NO.
	Abstract	v
	List of Abbreviations	viii
	List of Figures	x
	List of Tables	xii
1	INTRODUCTION	1
2	LITERATURE SURVEY	4
3	AIM AND SCOPE	11
	3.1 Aim	11
	3.2 Scope	11
	3.3 Existing system	11
	3.3.1 Disadvantages	11
	3.4 Proposed system	11
	3.4.1 Advantages	12
4	MATERIALS AND METHODS	13
	4.1 Block diagram	13
	4.2 Circuit diagram	14
	4.3 Flow diagram	15
	4.4 Hardware requirements	15
	4.4.1 Arduino Microcontroller	15

	4.4.2 EEG	19
	4.4.3 Sweat detection sensor	20
	4.4.4 Accelerometer	21
	4.4.5 GSM	24
	4.4.6 Bluetooth module	27
	4.4.7 Vibration motor	28
	4.4.8 SMPS	29
	4.4.9 LCD	31
	4.4.10 Push Button	34
	4.5 Software requirements	34
	4.5.1 Arduino IDE	34
	4.5.1.1 Steps to create and run	34
	4.5.2 Image Processing	37
	4.5.2.1 To create and run	38
5	RESULTS AND DISCUSSION	41
	5.1 Results	41
	5.2 Discussion	44
6	SUMMARY AND CONCLUSION	45
	6.1 Summary	45
	6.2 Conclusion	46
	6.3 Future scope	46
	REFERENCES	47

LIST OF ABBREVIATIONS

SWA	-	Slow Wave Activity
EOG	-	Electrooculogram
ANN	-	Artificial Neural Network
Fmri	-	Functional Magnetic Resonance Imaging
DMN	-	Default Mode Network
TBR	-	Theta to Beta Ratio
CNN	-	Convolutional Neural Network
LCD	-	Liquid Crystal Display
SW LORETA	-	Standardized Low Resolution Brain Electromagnetic Tomography
ERP	-	Event Related Potential
QEEG	-	Quantitative Electroencephalogram
FD	-	Fractal Dimensions
ML	-	Machine Learning
DL	-	Deep Learning
MRI	-	Magnetic Resonance Imaging
rTMS	-	Repetitive Transcranial Magnetic Stimulation
tDCS	-	Transcranial Direct Current Stimulation
NE	-	Norepinephrine
LC	-	Locus Coeruleus
NHS	-	National Health Service

EMD	-	Empirical Mode Decomposition
DWT	-	Discrete Wavelet Transform
SPP	-	Serial Port Protocol
DMP	-	Digital Monitor Processor
SCL	-	Serial Clock
SDA	-	Serial Data
XDA	-	Auxiliary Serial Data
XCL	-	Auxiliary Serial Clock
INT	-	Interrupt
PSU	-	Power Supply Unit
CRT	-	Cathode Ray Tube
VCC	-	Voltage Common Collector
SMPS	-	Switched Mode Power Supply
UART	-	Universal Asynchronous Receiver-Transmitter
V _{in}	-	Input Voltage
EEPROM	-	Electrically Erasable Programmable Read Only Memory
SRAM	-	Static Random Access Memory
TWI	-	Two Wire Interface
TTL	-	Transistor-Transistor Logic
DTR	-	Dynamic Thermal Rating
MEMS	-	Micro Electro Mechanical System
MPU	-	Memory Protection Unit

LIST OF FIGURES

FIGURE NO.	DESCRIPTION	PAGE NO.
4.1	Block diagram of attention deficit therapeutic device	13
4.2	Circuit diagram of attention deficit therapeutic device	14
4.3	Flow diagram of attention deficit non-invasive therapy	15
4.4	Arduino layout	16
4.5	Accelerometer layout	22
4.6	Working principle of accelerometer	23
4.7	Top view of GSM	25
4.8	Bluetooth layout	27
4.9	Parts of bar type vibration motor	28
4.10	Block diagram of SMPS	29
4.11	LCD layout	32
4.12	Connection of Arduino using USB cable	35
4.13	Device manager	35
4.14	Select board	35
4.15	EEG mode activated	36
4.16	EEG sensor is placed in the forehead	36
4.17	Select the serial monitor icon	36
4.18	Graph in serial plotter	37

4.19	EEG mode OFF	37
4.20	Connection of USB cable to Arduino	38
4.21	Select SHOW MORE option	39
4.22	Select EDIT with 3.10(64 bit) option	39
4.23	Python code	39
4.24	Select RUN module	40
4.25	Detection of facial emotions	40
5.1	Outputs of Sweat sensor and accelerometer	41
5.2	Output of EEG sensor	41
5.3	Detection of facial emotion for happy	42
5.4	Detection of facial emotion for sad	42
5.5	Detection of facial emotion for neutral	42
5.6	Detection of facial emotion for angry	42
5.7	Detection of facial emotion for surprise	43
5.8	Detection of facial emotion for disgust	43
5.9	Mobile showing alert message	43

LIST OF TABLES

S.NO	DESCRIPTION	PAGE NO.
1.	Pin Description	33

CHAPTER – 1

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neurobiological disorder that first occurs in childhood and has the potential to last a person's entire life (Alves et. al., 2020). The prevalence of ADHD is estimated to be 7.2% globally in children between the ages of 6 and 17 and it is a complex, chronic, and potentially crippling disorder of the brain, behaviour, and development (Bokovza et. al., 2020). Inattentiveness, lack of focus, poor time management, lack of impulse control, heightened emotions, hyperfocus, hyperactivity, and executive dysfunction are all typical symptoms of ADHD. A combination of psychological and psychiatric therapeutic interventions may be used to treat ADHD, but it is frequently ignored (Camp et. al., 2021). In order to create effective teaching and treatment methods, clinical researchers have concentrated their efforts on ADHDs, which pose significant challenges to educators (Cazzato et. al., 2019). Untreated ADHD has negative long-term effects on people and their families and has a negative impact on family dynamics, educational outcomes, and financial burdens for both children and adults. Lack of treatment affects one's ability to function in social and professional settings and increases the risk of comorbid disorders like heightened anxiety, depression, personality disorders, and antisocial behaviour (Das et. al., 2021).

There are three main categories of ADHD including: combined type of ADHD: This form of ADHD, which is the most prevalent, is distinguished by impulsive and hyperactive behaviours in addition to inattention and distractibility. Impulsive/hyperactive type of ADHD: This form of ADHD, which is the least common, is distinguished by impulsive and hyperactive behaviours without inattention or distractibility. Type inattentive and easily distracted with ADHD: Inattention and distractibility without hyperactivity are the main features of this type of ADHD. ADHD can be caused due to brain structure and operation: ADHD may be accompanied by a decrease in activity in the regions of the brain that regulate attention and level of activity. Heredity and genes: It's common for ADHD to run in families. A child's chance of having an ADHD parent is one in four. It's also likely that a sibling or other close relative will

also have ADHD. In some cases, severe head injuries can result in ADHD. ADHD is more likely to develop in premature children. Alcohol and nicotine from smoking during pregnancy are two prenatal exposures that raise the risk of ADHD.

The most typical signs and symptoms of ADHD are listed below. However, each child may present with different symptoms. The following are the 3 categories of ADHD symptoms: Inattention: low age-appropriate attention span (difficulty sustaining attention), having trouble listening to others, trouble paying attention to details, prone to distraction, Forgetfulness, Age-related lack of organizational skills, inadequate academic skills for one's age. Impulsivity: interrupts people a lot, has trouble waiting for their turn in social games or at school, tends to respond immediately rather than waiting to be questioned, frequently takes risks and frequently acts without thinking. Hyperactivity: seems to be moving constantly; occasionally climbs or runs with no apparent purpose other than movement, possesses issues staying seated, even when it is expected, squirms or fidgets with hands while seated; excessive fidgeting, talks too much, has trouble concentrating during quiet activities, frequently and repeatedly forgets or loses things, Lack of focus; shifts from one task to another without finishing any of them (Demirci et. al., 2021).

Children with ADHD are typically diagnosed by a pediatrician, child psychiatrist, or other qualified mental health specialist. The diagnosis of ADHD is based on a thorough history of the child's behavior from parents and teachers, observations of the child's behavior, and psychoeducational testing (Freismuth et.al., 2022). Since ADHD is a collection of symptoms, a diagnosis is made by combining information from various tests, including physiological, neurological, and psychological ones. Some of the ADHD treatments are medications, central nervous system stimulants, non-stimulant medications, psychotherapy, behavior therapy, cognitive behavioral therapy. Research opportunities in the ADHD treatment phase are immense, and computer technologies have a bright future in this area (Bokovza et. al., 2020). The common ADHD triggers are stress, poor sleep, over stimulation and certain food and additives. Stress management can be complicated and confusing because there are different types of stress — acute stress, episodic acute stress, and chronic stress. It comes from

demands and pressures of the recent past and anticipated demands and pressures of the near future. Most people experience acute stress during their everyday life. It is a primal flight-or-fight response to immediate stress factors and is not considered harmful. When the frequency of these occurrences increase, physiological symptoms might occur. stress is a pattern of negative physiological states and psychological responses occurring in situations where individuals perceive threats to their well-being, which they may be unable to meet When we perceive a threat, our nervous system responds by releasing a flood of stress hormones, including adrenaline and cortisol. These hormones rouse the body for emergency action(Jiang et. al., 2020). In some cases, it is necessary to collect feedback in order to control this symptom because it can become dangerous in certain situations. Therefore, it is necessary to build a device to detect stress. Wearable smart sensors are widely used nowadays to capture the physiological and behavioral data in our day-today lives to correlate with stress. But there are hardly any clinical-grade physiological monitors that can accurately quantify stress levels across individuals. Elevated cortisol and adrenaline levels are almost always present in patients with chronic stress. The patient experiences constant anxiety, finds it difficult to kick back, and may even start to develop anxiety disorders as a result of these feelings. Typically, chronic stress is a reaction to one or more long-term triggers.

When a person exhibits particular symptoms after a particularly stressful event, it is considered an acute stress. The term "acute" refers to symptoms that appear suddenly but pass quickly. After an unexpected life crisis, the events are typically very severe, and an acute stress reaction will include. A person with episodic acute stress reacts to relatively insignificant stressors with extreme stress and life-or-death feelings. Additionally, the person who has the disorder experiences real stress, which could lead them to believe that these circumstances are life-or-death. Children with attention deficit hyperactivity disorder have been found to process emotions differently, especially anger and other negative expressions. The brain is impacted by attention deficit hyperactivity disorder (ADHD). In the past, electroencephalography (EEG) has been used primarily to evaluate neural function in children with attention deficit hyperactivity disorder (ADHD).

CHAPTER – 2

LITERATURE SURVEY

Renato Montaleao Brum Alves et. al., (2020) developed a mobile application due to distance or mobility concerns, receiving psychotherapeutic treatment in some places is practically impossible. By using this application, some patients may receive treatment exclusively through mobile technology and online resources. ADHD has been treated using IT systems. The treatment of ADHD with mobile EEG technology and serious games has been successful.

Carlo Biancardi et. al., (2021) discussed Electroencephalographic (EEG) microstructural sleep markers are indicators of abnormal cortical development in ADHD. Early childhood had much higher slow wave activity (SWA) than late childhood or adolescence, and vice versa. SWA and CAP-A1 alterations were identified by this analysis as trustworthy indicators of variations in sleep microarchitecture in ADHD. In context of the cognitive and behavioral abnormalities associated with the condition, they can aid in evaluating changes in cortical development.

Lihi Bokovza et. al., (2020) developed a tool for assessing ADHD. The validated tasks in the Mindstreams battery can be used to test a variety of cognitive domains. It includes activities that call for continuous performance, information processing, response inhibition, memory, executive functioning, and attention. All of the usual suspects are performing poorly in adult subjects with ADHD. Accuracy, reaction time, and reaction time standard deviation are computed for each task. Based on a sample of 28 ADHD and 49 healthy men, the construct validity of Mindstreams as a tool for assessing ADHD was confirmed.

Allyson Camp et. al., (2021) developed a therapeutic treatment by interfering the current understanding of the condition, with a focus on early detection and creative therapeutic approaches. ADHD individuals show notable differences in colour perception. Retinal dopaminergic neurons, which regulate the system of photoreceptor

neurons that convert light into neurological signals, have a role in the sense of colour. Other neurological conditions including Parkinson's disease and Tourette syndrome, which entail altered dopaminergic transmission, are linked to a deficiency of retinal dopamine and a blue-yellow colour vision impairment.

Catherine Joy et. al., (2021) discussed about an effective computer-aided technological approach based on different nonlinear entropy estimators and an artificial neural network classifier for detecting ADHD from the recorded electroencephalography (EEG) signals. The ability to distinguish ADHD patients from the control group using features derived through fuzzy entropy, log energy entropy, permutation entropy, SURE entropy, and Shannon entropy is examined. The test findings show the strategies may accurately identify and categorise ADHD patients.

Dario Cazzato et. al., (2019) created a helper tool for those with ADHD. The system consists of a screen with a circle that flashes on and off in predetermined locations and a camera that can detect the user's gaze at any given moment. For people with ADHD, the tool represents a legitimate exercise to maintain a high level of focus and attention.

William Das et. al., (2021) discussed about a full pupillometric feature engineering and visualization pipeline with cutting-edge binary classification algorithms and univariate feature selection. An average accuracy of 85.6% was attained by the support vector machine classifier. A declassified dataset of 50 patients was used, and the results showed an area under the receiver operating characteristic (AUROC), 77.3% sensitivity, and 75.3% specificity. 218 of the 783 designed features, such as consecutive quantile, absolute energy, and Fourier transform metrics changes, approximative entropy, aggregated linear trends, and pupil-size dilation velocity were discovered to be statistically significant differentiators ($p < 0.05$), and they offer new behavioural insights into correlations between pupil-size dynamics and the prevalence of ADHD.

Esra Demirci et. al., (2021) discussed about the patient with ADHD and healthy subject underwent a visual stimulus follow-up test, and electrooculogram (EOG) signals were simultaneously recorded. Artificial Neural Networks (ANN) were used to classify patients and healthy individuals using the features derived from EOG signals, and it was found that the classification of ADHD and the healthy group could be discriminated by 81.76% performance. Consequently, the results will support an impartial diagnosis of ADHD.

Senuri De Silva et. al., (2021) discussed about the process of identifying ADHD uses a decision support system. Eye movement data and functional magnetic resonance imaging (fMRI) data are both employed. The feature extraction, feature selection, and pre-processing procedures used in the classification processes are part of upgraded pipelines. In order to process fMRI data, aggregated characteristics of fixations and saccades are used to derive seed-based correlation features from default mode network (DMN) and eye movement features from eye movement data. An ensemble model is produced for the categorization utilising eye movement data with an overall accuracy of 81%. A convolutional neural network (CNN) is employed with 82% accuracy for the fMRI classification to identify ADHD.

David Freismuth et. al., (2022) discussed about the Theta-to-Beta Ratio (TBR) as a diagnostic tool for ADHD and it samples this ratio. while being exposed to various stimuli (such as a resting condition, focusing on a sound, or photo, etc.). The diagnosis is obtained by comparing this dataset to a norm. In adults with ADHD, the brain areas in charge of visual pre-processing are impaired. Traditionally, ERP has been used to quantify this discrepancy. Applying standardised weighted low-resolution electromagnetic tomography can also reveal this shortcoming (swLORETA). By examining EEG signals, this method enables the localisation of current densities. As a result, the brain's spatial resolution is enabled.

Harini et. al., (2021) developed a portable device consist of pulse, sweat and accelerometer sensors and their outputs are displayed on the LCD screen. The therapy

is then administered with the aid of vibration motors to enhance body blood circulation and promote relaxation with minimal expense and technical expertise, this device serves as a supportive therapy that aids in the quick recovery of ADHD patients.

Ruchi Holker et. al., (2022) discussed about the Quantitative electroencephalogram (QEEG) to identify ADHD in youngsters. A 19-channel EEG signal is utilised to extract the spectral, amplitude, functional connectivity and Range EEG (EEG) properties from five frequency bands to identify ADHD youngsters. The QEEG characteristics are ranked according to their relative significance to the classification job using four feature selection techniques: ANOVA, Chi-square, Gini Index, and Information Gain. The top 600 discriminative features are then supplied as input to a variety of classifiers once the feature ranks are averaged. The Random Forest classifier achieves the best accuracy of 81.82% on the ADHD dataset.

Pham Thi Viet Huong et. al., (2021) discussed about examining EEG in order to identify human ADHD. the Fractal Dimensions (FD), which are non-linear features chosen using various criteria. Finally, using group learning as a classifier to separate children with ADHD from a healthy group. When compared to cutting-edge studies, the outcome is more accurate.

Jatin Satoskar et. al., (2022) discussed about an efficient method for diagnosing early-stage of ADHD using resting-state functional magnetic resonance imaging data. The functional connection of seeds to every other brain voxel. Categorization is based on seed correlations taken from multiple default mode network (DMN) regions and executed using a convolutional neural network.

Xinlong Jiang et. al., (2020) discussed about a scale-driven diagnostic assessment system's design concepts and WeDA is a prototype system that combines an interactive screen, interactive objects, and wearable sensors. WeDA is used as a technical test to assess the practical utility of such a system. Utilizing a dataset of 100 school-age children, to assist in realising the auxiliary diagnosis of ADHD (with 50

ADHD children). In particular, the system is capable of achieving high-precision ADHD recognition as well as comprehensive coverage of all ADHD-related symptoms in the DSM-5.

Vinod Rao et. al., (2021) discussed about the medication for ADHD and better retention in both short- and long-term SUD treatments, with a strong correlation. Its discovery due to the small sample size, the assessment of nonstimulants is limited. Mainly reflects the use of stimulants for ADHD. The findings confirm prior calls for early identification and pharmacologic treatment of ADHD in adults with SUD, even though these data are constrained by the retrospective, nonrandomized, naturalistic study design.

Amandeep Kaur et. al., (2022) discussed statistical characteristics were obtained from the pre-processing of motor activity data from persons with ADHD and clinical controls. Principal component analysis was used to determine essential characteristics for precise categorisation. These features are used as input into six different machine learning methods for classification, including C4.5, kNN, Random Forest, LogitBoost, SVM, and Naive Bayes. With accuracy of 98.43%, F-measure of 98.42%, sensitivity of 98.33%, specificity of 98.56%, and AUC of 0.983, SVM beats other classifiers, according to the 10-fold cross-validation. Therefore, employing real-time analysis of activity data, a PCA-based SVM technique looks to be a good option for accurately identifying ADHD patients among other clinical controls.

Huiwen Loh et. al., (2022) discussed about the two most popular methods for diagnosing ADHD in the ML and DL models are MRI and EEG signals. The two features that are most frequently employed to diagnose ADHD in these two modalities: functional connectivity features and power spectral features for MRI and EEG, respectively. These are the common ADHD evaluation forms that have been effective in assisting ML models to obtain good diagnostic performance.

Mridul Makkar et. al., (2021) discussed about the benefits of rTMS and tDCS for treating ADHD. When two tDCS placements were compared (F3 and F4 vs. F4 and Fp2), it was

discovered that using the right supra-orbital area as the cathodal site produced better results than on the IDLPFC. tDCS is effective in reducing impulsive symptoms as well as improving inhibitory control and executive function. rDLPFC(F4) has been consistently used as the anodal site of stimulation for ADHD. Cathodal stimulation tDCS and rTMS are effective in treating ADHD.

Sou Nobukawa et. al., (2021) discussed about the pupil diameter, which is controlled by the parasympathetic and sympathetic pathways. The complexity and symmetry are physiologically inherent in neuronal dynamics. Pupil diameter size, complexity and symmetry were compared between the TD and ADHD groups. It was larger in diameter, less complex and symmetrical in the ADHD group. The results of the ROC evaluation showed that the combination of pupil diameter size/complexity and size/symmetry was associated with higher accuracy.

Rohit Kale (2019) discussed about Machine Learning Algorithm. Four different types of input parameters, which are taken from brain pictures, are provided for the system. The radiologist's recommendations guide the choice of features. Then, using a dataset of around k-means classification technique is used to divide the data into two groups, one for ADHD patients and the other for normal people, using information from 1000 individuals, including MRIs of both ADHD patients and healthy individuals to determine if a person has ADHD or not.

Aya Shirama et. al., (2020) discussed about size of the pupil is a reflection of the activity of norepinephrine (NE) neurons in the locus coeruleus (LC), and ADHD may result in malfunction of the LC-NE neuromodulatory system that controls alertness. During an auditory continuous performance test, the kinetics of pupil diameter in response to stimuli is monitored and compared between people with ADHD ($n = 17$) and normally developing (TD) adults ($n = 23$). In comparison to individuals in the TD group, those with ADHD showed a considerably greater tonic pupil diameter and inhibited stimulus-evoked phasic pupil dilation. These results lend credence to the hypothesis that the

abnormal regulatory control of pupil diameter in ADHD adults may be associated with a reduced level of alertness brought on by a hyperactive LC-NE system.

Ilias Tachmazidis et. al., (2021) discussed AI technologies combined a machine learning model that was taught using domain knowledge gathered from clinical professionals and clinical data from previous cases provided by an NHS Trust. The AI system generates three alternative results based on the same clinical data that is typically collected by the NHS upon referral: has ADHD, does not have ADHD, or consults a medical expert.

Hui Tian Tor et. al., (2021) discussed a novel automated system (AS) can be utilised as a cloud-based web tool to assist in the clinical diagnosis of CD and/or ADHD using brain signals. The electroencephalogram (EEG) data were divided using the empirical mode decomposition (EMD) and discrete wavelet transform (DWT) methods. After that, the signals relative wavelet energy and autoregressive modelling coefficients were calculated. The decomposed coefficients were used to extract a number of nonlinear characteristics. To balance the dataset, adaptive synthetic sampling (ADASYN) was used. The sequential forward selection method was used to choose the important features for diagnosis of ADHD.

Samuel et. al., (2021) developed a non-invasive brain stimulation for children and adults with attention-deficit/hyperactivity disorder. rTMS or tDCS of the dlPFC as an alternate neurotherapy for ADHD. Heterogeneity in stimulation protocols, sample age, and cognitive outcome measures hindered rTMS and tDCS research as well as meta-analysis of tDCS studies in ADHD. To better understand clinical and cognitive consequences and to offer clear direction on the best stimulation protocols, larger, double-blind, randomised controlled trials with homogenous protocols and systematic testing for optimal designs are required.

CHAPTER – 3

AIM AND SCOPE

3.1 AIM

- To detect the hypertension and restlessness in human using sensors and facial expression.
- To detect attention level using EEG.
- To provide therapeutic based treatment for non-invasive therapy.

3.2 SCOPE

This device will help common people with lifetime changes and it could also be mainly used for rape victims and train drivers as they go through very tough phase which will help them to recover.

3.3 EXISTING SYSTEM

In Existing system, heavy medications and strong injections are given to the subject to keep them in drowsiness state and using invasive methods for long term affects our body, brain and nervous system.

3.3.1 Disadvantages

- Usage of heavy medications.
- Usage of injections.
- Cost

3.4 PROPOSED SYSTEM

In Proposed system, to overcome the existing problem we employ non-invasive techniques to assist them in overcoming their hypertension and restlessness, and therapeutic solutions that gradually assist them in emerging from the trauma state and prevent suicide(s), as well as triggering Emergency Notifications to Care Taker to enable prompt action to assist them.

3.4.1 Advantages

- Portable.
- Non-invasive method.
- It can be used anywhere.

CHAPTER – 4

MATERIALS AND METHODS

4.1 BLOCK DIAGRAM

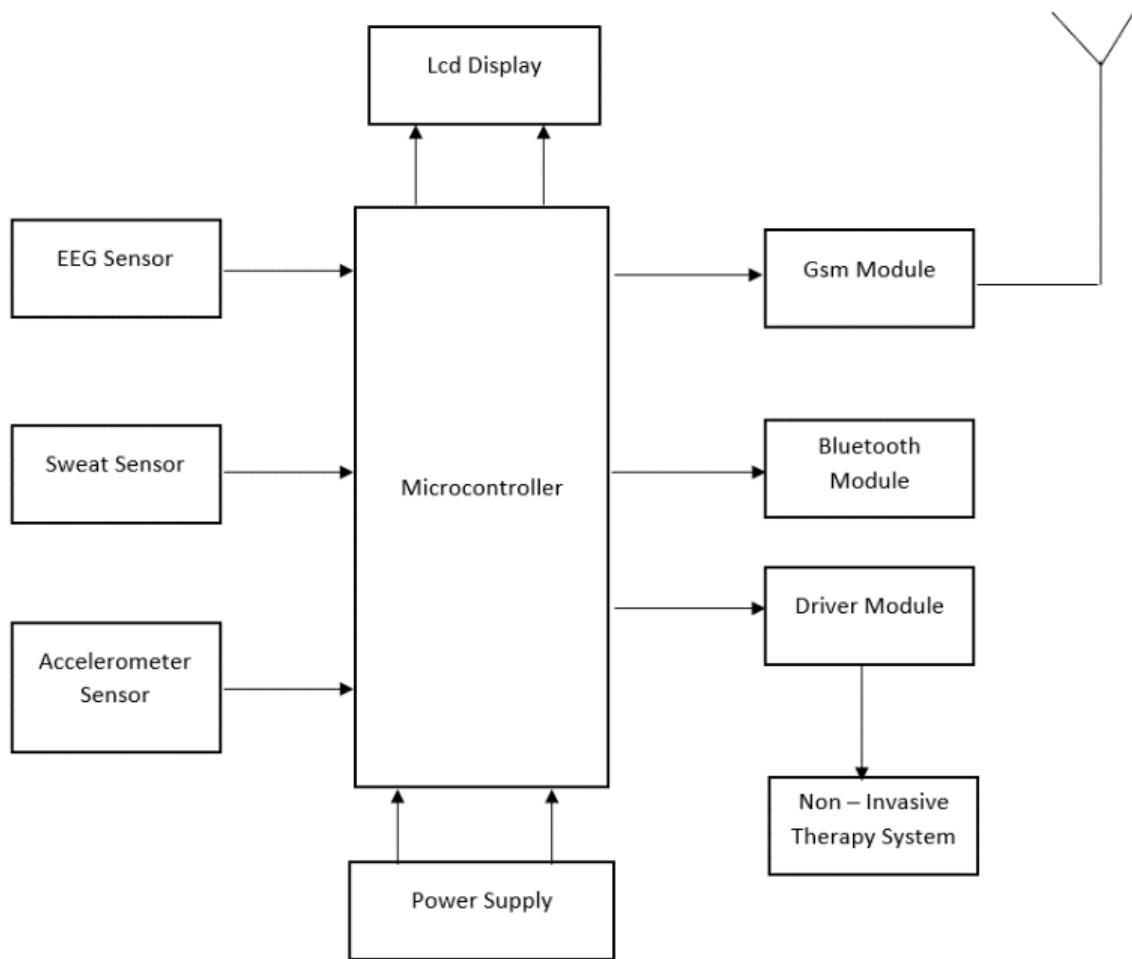


Fig. 4.1: Block diagram of attention deficit therapeutic device

ATmega microcontroller has been taken as the core of the article following device which is associated with an EEG sensor, sweat sensor and accelerometer sensor, each depicting various items which is shown in the Fig. 4.1 is made and remaining parts are fixed. An alert message is sent to the neighbor's mobile using the GSM module.

4.2 CIRCUIT DIAGRAM

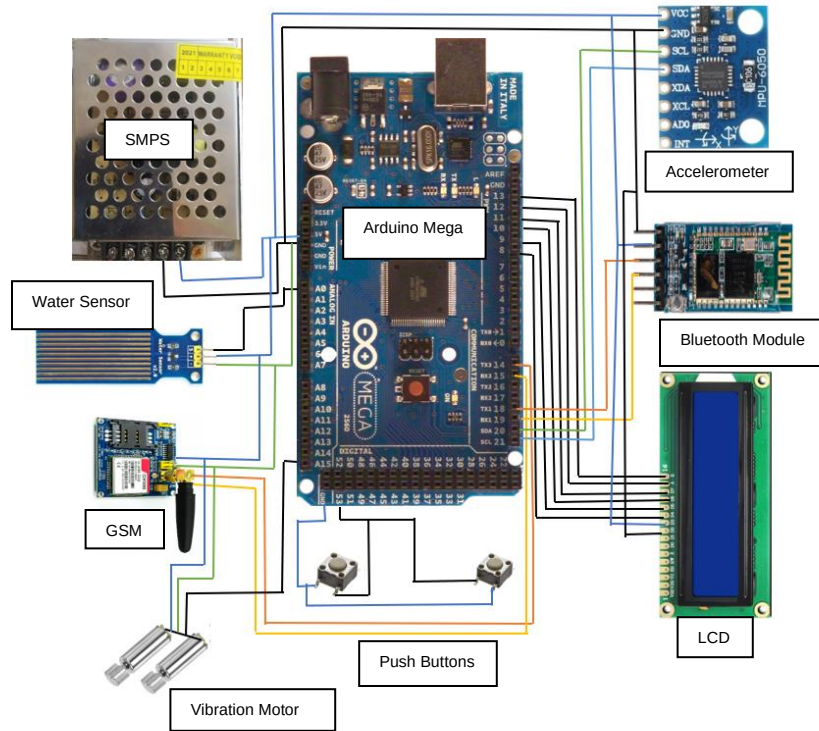


Fig. 4.2: Circuit diagram of attention deficit therapeutic device

The power supply pins of SMPS are connected to 5V and GND of arduino. A0 pin of arduino is connected to the S of the sweat sensor. '+' to the 5V and '-' to the GND of the arduino. Accelerometer sensor pins of VCC and GND are connected to 5V, GND and SDA of the arduino to the SCL of the accelerometer and SCL of the arduino to the SDA of the accelerometer sensor. VCC pin of the Bluetooth module is connected to the 5V of arduino. GND pin of bluetooth module is connected to the ground of the arduino. The Tx and Rx pins of the bluetooth module is connected to the Rx1 and Tx1 of the arduino. VCC and GND of the GSM module is connected to the 5V and GND of the arduino. TXD and RXD pins of the GSM module is connected to the Tx3 AND Rx3 of the arduino. The pins of RS to D7 in LCD is connected to the 8th to 13th pins of the arduino and the VCC is connected to the 5V and GND of the LCD to the GND of the arduino. The push buttons are connected to the 51th pin and ground of the arduino. The vibration motor is connected to the 5V, GND and A15th pin of the arduino. Fig. 4.2 shows the wiring circuit of the therapeutic device and Fig. 4.3 shows the flow diagram of the non invasive therapy.

4.3 FLOW DIAGRAM

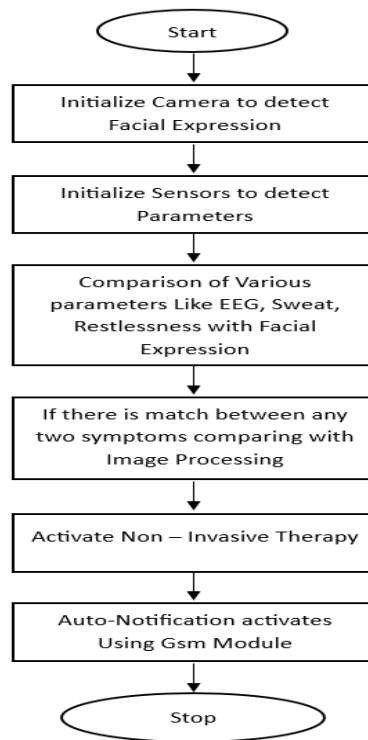


Fig. 4.3: Flow diagram of attention deficit non-invasive therapy

4.4 HARDWARE REQUIREMENTS

- Arduino Microcontroller
- EEG Sensor
- Sweat Detection Sensor
- Accelerometer Sensor
- GSM (Global System for Mobile Communication)
- Bluetooth Module
- Vibration motor
- SMPS
- LCD
- Push Button

4.4.1 ARDUINO MICROCONTROLLER

The microcontroller board known as the Arduino Mega 2560 is based on the ATmega2560. It has a 16 MHz crystal oscillator, a 16 MHz digital input/output

converter, 54 digital input/output pins (14 of which can be used as PWM outputs), 16 analogue inputs, 4 hardware serial ports (UARTs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; to get started, just use a USB cable to connect it to a computer, or an AC-to-DC adapter or battery to power it. Most shields made for the Arduino Duemilanove or Diecimila can be used with the Mega.

SPECIFICATIONS

Microcontroller : ATmega2560

Operating Voltage : 5V

Input Voltage (recommended) : 7-12V

Digital I/O Pins : 54 (14 provide PWM output)

Analog Input Pins : 16

DC Current (3.3V Pin) : 50 mA

SRAM : 8 KB

EEPROM : 4 KB

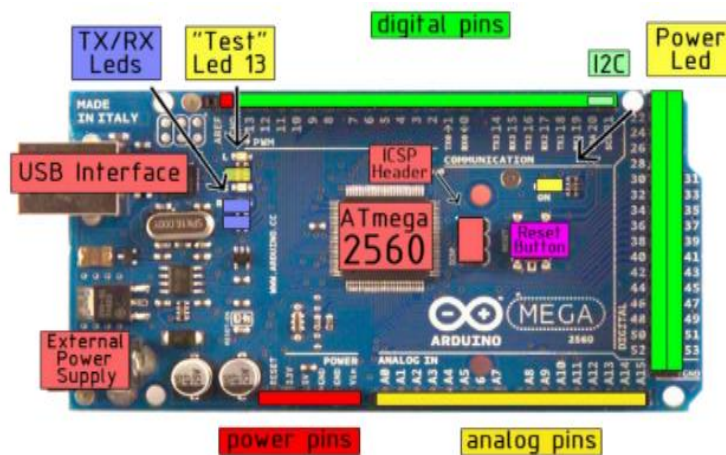


Fig. 4.4: Arduino layout

A USB connection or an external power source can be used to power the Arduino Mega2560. Fig. 4.4 shows the Arduino layout. It automatically chooses the power source. Power from an AC-to-DC adapter (wall wart) or a battery can be used for external (non-USB) devices. A 2.1mm centre-positive plug must be inserted into the board's power jack in order to connect the adapter. In the Gnd and Vin pin headers of

the POWER connector, battery leads can be inserted. The board can be powered by a 6 to 20 volt external supply. The 5V pin, however, may supply less than five volts if supplied with less than seven volts, and the board may become unstable. The voltage regulator could overheat and harm the board if more than 12V is used. The suggested range is between 7 and 12 volts. The Mega2560 differs from all earlier boards in that it does not make use of the FTDI USB-to-serial driver chip. Instead, it has an Atmega8U2 that has been configured to function as a USB to serial converter.

These are the power pins:

- VIN. The Arduino board's input voltage when using an external power supply (as opposed to 5 volts from the USB connection or other regulated power source). This pin can be used to access voltage that has been supplied via the power jack or to supply voltage to it.
- The regulated power supply that supplies 5V to the board's microcontroller and other components. This can be supplied by USB or another regulated 5V source, such as VIN via an on-board regulator.
- 3.3 volts produced by the on-board regulator, or 3V3. There is a 50mA maximum current draw.
- Ground pins, also known as GND.

The ATmega2560 has 256 KB of flash memory for code storage (of which 8 KB is used for the bootloader), 8 KB of SRAM, and 4 KB of EEPROM (which can be read and written with the EEPROM library). Using the `pinMode()`, `digitalWrite()`, and `digitalRead()` functions, each of the Mega's 54 digital pins can be used as an input or an output. They use 5 volts to function. Each pin has a 20–50 Kohm internal pull-up resistor that is by default disconnected and has a maximum current capacity of 40 mA. Additionally, some pins have unique uses.

Serial 0 (RX) and Serial 1 (TX) are followed by Serial 1 (19 RX and 18 TX), Serial 2 (17 RX and 16 TX), and Serial 3 (15 RX and 14 TX) (TX) utilised for sending and receiving TTL serial data (RX and TX). The corresponding pins of the ATmega8U2 USB-to-TTL Serial chip are also connected to pins 0 and 1.

External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be set up to initiate an interrupt in response to low values, rising or falling edges, or value changes.

PWM: 0 to 13. The `analogWrite()` function can produce 8-bit PWM output.

52 (SCK), 53 (MISO), 51 (MOSI), and 50 (SPI) (SS). These pins enable SPI communication, which the underlying hardware supports but is not yet supported by the Arduino language. The ICSP header, which is physically compatible with the Duemilanove and Diecimila, is also divided into SPI pins.

LED: 13. Digital pin 13 is wired to a built-in LED. The LED is on when the pin has a HIGH value; it is off when the pin has a LOW value.

I2C: 20 (SDA) and 21 (SCL). I2C (TWI) communication support using the Wire library.

The Mega2560 has 16 analogue inputs with a resolution of 10 bits each (i.e. 1024 different values). They measure from ground to 5 volts by default, but the AREF pin and `analogReference()` function allow you to change the upper limit of their range. There are a few additional pins on the board: AREF for the analogue inputs, a reference voltage used with `analogReference()`. Reset. To restart the microcontroller, turn this line LOW. Shields that block the reset button on the board are frequently added with this feature.

The Arduino Mega2560 has a variety of features for interacting with a computer, another Arduino, or other microcontrollers. The ATmega2560 offers four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual COM port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. Simple textual data can be sent to and received from the board using the serial monitor found in the Arduino software.

ARDUINO SOFTWARE

The Arduino software can be used to programme the Arduino Mega2560. The bootloader that comes preburned with the ATmega2560 on the Arduino Mega enables you to upload new code to it without using an external hardware programmer. It uses the original STK500 protocol for communication. Bypass the bootloader and use the ICSP (In-Circuit Serial Programming) header to programme the microcontroller.

AUTOMATED RESETTING

The Arduino Mega2560 is made in a way that enables it to be reset by software running on a connected computer, as opposed to needing a physical press of the reset button before an upload. A 100 nanofarad capacitor is used to connect one of the ATmega8U2's hardware flow control lines (DTR) to the ATmega2560's reset line. The reset line drops for a long enough period of time when this line is asserted (taken low) to reset the chip. You can upload code using the upload button in the Arduino environment by using this feature of the Arduino software. As a result, the bootloader's timeout can be shortened because the upload's beginning and the lowering of DTR can be perfectly timed.

This configuration has additional effects. The Mega2560 resets each time a connection is made to it from software when it is connected to a computer running either Mac OS X or Linux (via USB). The Mega2560's bootloader then starts to run for about a half-second. The first few bytes of data sent to the board after a connection is established will be intercepted, despite the fact that it is programmed to ignore invalid data (i.e., anything other than an upload of new code). Make sure that the software with which it communicates waits a second after opening the connection and before sending any configuration or other data when a sketch running on the board initially receives it.

A trace on the Mega can be cut to turn off the auto-reset. To make the trace functional again, solder the pads on either side of it together. It is marked "RESET-EN." A 110 ohm resistor connected to the reset line from 5V may also be able to disable the auto-reset.

The USB ports on computer are safeguarded against shorts and overcurrent by a resettable polyfuse built into the Arduino Mega. The fuse offers an additional layer of protection even though the majority of computers have their own internal safeguards. The fuse will automatically cut off the connection if more than 500 mA is applied to the USB port until the short or overload is resolved.

4.4.2 EEG

The MindLink EEG sensor is a device designed to measure brain activity by detecting and analysing the electrical signals generated by the brain. The device uses a set of sensors, usually placed on the scalp, to detect these electrical signals, which

are then transmitted wirelessly to a computer or other device for analysis. The MindLink EEG sensor operates on the principle of electroencephalography (EEG), which is a non-invasive method of measuring brain activity. The sensors are designed to detect the electrical signals generated by the neurons in the brain, which are then amplified and digitized by the device. Once the signals are digitized, they are transmitted wirelessly to a computer or other device for analysis. The analysis software can then be used to visualize and interpret the brain activity, providing insights into cognitive and emotional states, as well as providing diagnostic information for conditions such as epilepsy or sleep disorders. Overall, the MindLink EEG sensor is a powerful tool for measuring brain activity and provides a non-invasive and convenient way to monitor and analyse brain function. Additionally, the training of ADHD treatments can be done using Mindlink.

SPECIFICATIONS

Weight: 45g

Support System: Android /iOS

Connection Method: Bluetooth

Connection Battery Type: Lithium battery 160mAH

Duration of Use: about 120 min (depends on actual usage condition)

4.4.3 SWEAT DETECTION SENSOR

The water sensor brick was created for the purpose of detecting water and can be used to detect leaks in liquid as well as rainfall and water levels. Three components make up the bulk of the brick: an electronic brick connector, a 1 M Ω resistor, and a number of lines of bare conducting wires.

The sensing traces are interlaced between a number of exposed traces that are connected to ground in order for this sensor to function. A 1 M Ω weak pull-up resistor is present on the sensor trace. The sensor trace value will be pulled high by the resistor until a water drop shorts the sensor trace to the grounded trace. Unbelievably, you can use this circuit to measure the amount of water-induced contact between the grounded and sensor traces with the analogue pins of your Arduino or the digital I/O pins.

It uses a number of exposed parallel wires stitched together to measure the size of the water droplets to determine the water level. This item makes it simple to convert water volume to an analogue signal, and the output analogue value can be used directly in programme functionality to implement the water level alarm function. The main characteristics of this module are its high sensitivity and low power consumption. This sensor module includes a 300mm 3 Pin Dual-female Jumper Wire.

SPECIFICATIONS

Working voltage: 5V

Working Current: <20ma

Interface: Analog

Width of detection: 40mm×16mm

Working Temperature: 10°C~30°C

Size: 65mm×20mm×8mm

Output voltage signal: 0~4.2V

PIN DESCRIPTION

"S" stands for signal input

"+" stands for power supply

"-" stands for GND

4.4.4 ACCELEROMETER SENSOR

The MPU6050 module is a Micro Electro-Mechanical Systems (MEMS) that includes a 3-axis accelerometer and 3-axis gyroscope inside it as shown in the Fig. 4.5. This assists in measuring a system's or object's acceleration, velocity, orientation, displacement, and many other motion-related parameters. Additionally, this module contains a (DMP) Digital Motion Processor, which is strong enough to handle complex calculations and free up the Microcontroller's time. The MPU-6050 components are the first Motion Tracking devices in the world made for the low power, low cost, and high-performance needs of mobile devices like smartphones and tablets as well as wearable sensors.

SPECIFICATIONS

Operating Voltage : 5V (typical)

Accelerometer Range : $\pm 2g$, $\pm 4g$, $\pm 8g$, $\pm 16g$

Gyroscope Range : $\pm 250^\circ/s$, $\pm 500^\circ/s$, $\pm 1000^\circ/s$, $\pm 2000^\circ/s$

Temperature Range : -40 to $+85^\circ C$

Absolute Maximum Acceleration : Up to $10,000g$

A 3.3V voltage regulator on the MPU6050 breakout board enables simple 3.3V and 5V computer interface. As a result, connecting MPU6050 to platforms like Arduino, Raspberry Pi, ESP32, and many other microcontrollers and SBCs is simple.

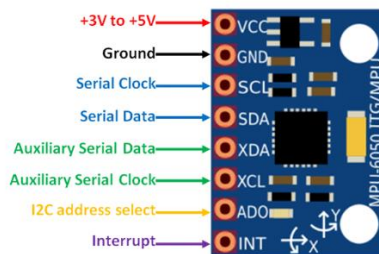


Fig. 4.5: Accelerometer layout

Vcc : Provides power for the module, can be +3V to +5V. Typically +5V is used

Ground : Connected to Ground system

Serial Clock (SCL) : Used for providing clock pulse for I2C Communication

Serial Data (SDA) : Used for transferring Data through I2C communication

Auxiliary Serial Data (XDA) : Can be used to interface other I2C modules with MPU6050.

Auxiliary Serial Clock (XCL) : Can be used to interface other I2C modules with MPU6050.

AD0 : If more than one MPU6050 is used a single MCU, then this pin can be used to vary the address

Interrupt (INT) : Interrupt pin to indicate that data is available for MCU to read.

Robotics, gesture recognition, vehicle stabilisation, position control in drones and quadcopters, pointing devices, game controllers, and fitness trackers are a few examples of applications that use motion tracking sensors. MPU6050 is one of the

widely used motion tracking sensors. It is a six-axis MEMS motion tracking sensor with a MEMS gyroscope and a MEMS accelerometer. The sensor also includes a built-in temperature sensor, and the accelerometer and gyroscope can be adjusted using the temperature reading. Additionally, the MPU6050 sensor can be extended to 9 DOF by connecting it to an external magnetometer using an internal I2C channel (Degree of Freedom). A controller or computer is able to precisely track the movement of the MPU6050 when an external magnetometer is connected to it.

WORKING OF ACCELEROMETER

The detection of linear acceleration is done using accelerometers. In one, two, or three dimensions, these sensors are capable of detecting linear acceleration. Within a reference frame, an accelerometer has a proof mass suspended by springs as shown in the Fig.4.6. A one-dimensional accelerometer has one degree of freedom for the proof mass. The proof mass in a two-dimensional and three-dimensional accelerometer, respectively, has 2 DOF and 3 DOF within the reference frame. Within a cubical frame, the proof mass behaves like a suspended ball that is free to move. A force acting in the opposite direction acts on the suspended proof-mass when the sensor moves along a particular axis.

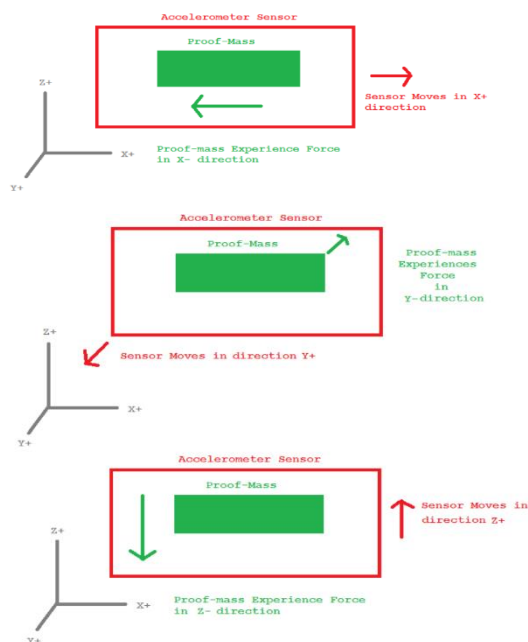


Fig. 4.6: Working principle of accelerometer

An embedded micro-machined structure on a silicon wafer makes up a MEMS accelerometer. Polysilicon springs suspend a proof mass, which is free to deflect in any direction when subjected to external force in one, two, or three dimensions. The proof mass moves back and forth between stationary plates that serve as the electrodes of a capacitor. The distance between the proof mass and the fixed plates is altered by an axis' deflection in proportion to the acceleration along that axis. The capacitance of the fixed plates is impacted proportionally as a result. A highly accurate sensor produces a proportional analogue voltage after detecting the difference in capacitance.

4.4.5 GSM (Global System for Mobile Communication)

The smallest and least expensive GSM/GPRS communication module is the SIM900A GSM Module. This module can also be used to create embedded applications and IOT (Internet of Things) applications. A dual-band GSM/GPRS engine called SIM900A operates at EGSM 900MHz and DCS 1800MHz. In order to communicate using a mobile sim, the module offers GPRS/GSM technology. SMS and mobile calls can be received and sent using the 900 and 1800MHz frequency bands. The keypad and display interface enable the creation of specialized applications by the developers. Additionally, it has data mode and command mode. Different GPRS/GSM protocols and operating frequencies are used in every nation. The developers can modify the default setting to meet their needs with the aid of command mode.

SPECIFICATIONS

Supply voltage: 3.4V – 4.5V

Power saving mode: Power consumption in SLEEP mode is 1.5mA

Frequency bands:SIM900A Dual-band: EGSM900, DCS1800.

GSM class: Small MS

GPRS connectivity : GPRS multi-slot class 10 (default)

Transmitting power: Class 4 (2W) at EGSM 900, Class 1 (1W) at DCS 1800

Operating Temperature: -30°C to +80°C

Storage Temperature: -5°C to +90°C

The Module SIM900A appears to be a single chip as shown in the Fig. 4.7, but it has a variety of features that can be used to create a wide range of commercial applications. Despite this, using the 68 pins on the SIM900A allows for the development of applications. However, using a module to interface with Arduino will only require a small number of pins.

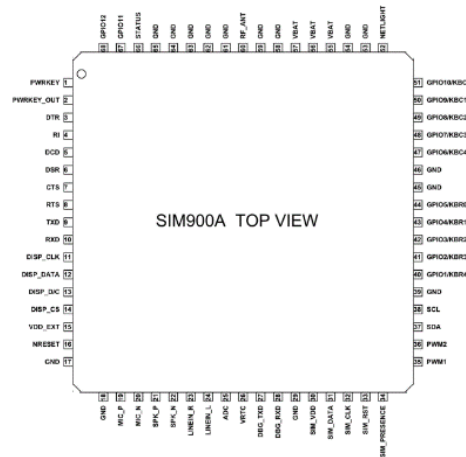


Fig. 4.7: Top view of GSM

PINOUT CONFIGURATIONS

PWRKEY : Voltage input for PWRKEY. PWRKEY should be pulled low to power on or power off the system. The user should keep pressing the key for a short time when power on or power off the system because the system needs margin time in order to assert the software.

PWRKEY_OUT : Connecting PWRKEY and PWRKEY_OUT for a short time then release also can power on or power off the module.

DTR : Data terminal Ready

RI : Ring indicator

DCD : Data carry detect

DSR : Data Set Ready

CTS : Clear to send

RTS : Request to send

TXD : Transmit data

RXD : Receive data

DISP_CLK : Clock for display

DISP_DATA : Display data output

DISP_D/C : Display data or command select
DISP_CS : Display Enable
VDD_EXT : 2.8V output power supply
NRESET : External reset input
GND : Ground
MIC_P : Microphone Positive
MIC_N : Microphone Negative
SPK_P : Speaker Positive
SPK_N : Speaker Negative
LINEIN_R : Right Channel input
LINEIN_L : Left Channel Input
ADC : General purpose analog to digital converter.
DBG_TXD : Transmit pin [Serial interface for debugging and firmware upgrade]
DBG_RXD : Receive pin [Serial interface for debugging and firmware upgrade]
VRTC : Current input for RTC when the battery is not supplied for the system. Current output for backup battery when the main battery is present and the backup battery is in low voltage state.
SIM_VDD : Voltage supply for SIM card
SIM_DATA : SIM data output
SIM_CLK : SIM clock
SIM_RST : SIM reset
SIM_PRESENCE : SIM detect
PWM1 : PWM Output
PWM2 : PWM Output
SDA : Serial Data [I2C]
SCL : Serial Clock [I2C]
KBR0 to KBR4 & KBC4 to KBC0 : Keypad interface [ROWS & COLUMNS]
NETLIGHT : Indicate net status
VBAT : Three VBAT pins are dedicated to connect the supply voltage. The power supply of SIM900A has to be a single voltage source of VBAT= 3.4V to 4.5V.
RF_ANT : Antenna connection

STATUS : Indicate working status

GPIO 11 : General Purpose Input/output

GPIO 12 : General Purpose Input/output

This module can be communicated with using an RS232 or UART interface. Usually, the module is connected to a standard +4.0V power supply. Any voltage above +4.5V may cause damage to the module, and it can operate on regulated power only. And a 2A peak current should be feasible from the power source. Connect the module's RXD to the Arduino's TXD, and the Arduino's RXD to the module's TXD. For voltage reference, the ground of the controller and module must be connected. After that, the module must be equipped with a functional GSM SIM card. Once all connections are complete, create a programme to allow the microcontroller to communicate with the module. Utilize libraries created specifically for the module because the data exchange sequence between the controller and module is extremely complex. Obtain the libraries, then use them in programmes. To instruct the controller to send or receive data after the header file has been included, use short commands in the programme. Using a UART Interface and a protocol set up in libraries, the controller transmits data to the module. This information is sent by the module over a cellular network to another GSM user. The module will send any data it receives via UART serial communication to the controller if it comes from the cellular network (or another GSM user). In this manner, cellular can be established using the GSM900A module.

4.4.6 BLUETOOTH MODULE

The HC-05 Bluetooth Module is an intuitive Bluetooth SPP (Serial Port Protocol) module made for setting up transparent wireless serial connections as shown in the Fig. 4.8. It communicates via serial communication, which makes interacting with a controller or PC simple. The HC-05 Bluetooth module offers switching between master and slave mode, which means it is unable to use either receiving or transmitting data.

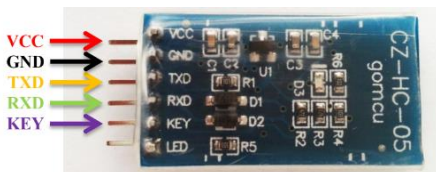


Fig. 4.8: Bluetooth layout

SPECIFICATIONS

Model : HC-05

Input Voltage : DC 5V

Communication Method : Serial Communication

VCC : Connect to +5V

GND : Connect to Ground

TXD : Connect with the MCU's (Microcontroller and etc) RXD PIN.

RXD : Connect with the MCU's (Microcontroller and etc) TXD PIN.

KEY : Connect to the air for communication mode.

4.4.7 VIBRATION MOTOR

A vibration motor is a small, coreless DC motor that vibrates to alert users to the presence of a signal. Vibration motors are widely used in many different applications, such as pagers, cell phones, and other devices. The permanent magnet coreless DC motor, which will always have its magnetic properties, has one of the primary characteristics of a vibration motor. The noise and the power consumption of the motor is low. The motor's performance is very dependable as a result of those characteristics.

BAR TYPE VIBRATION MOTORS

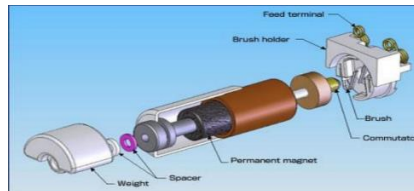


Fig. 4.9: Parts of bar type vibration motor

The bar-type vibration motor is another name for the cylinder shape is shown in the Fig. 4.9. In essence, the motor that is causing this vibration is unbalanced. In other words, the motor's rotational shaft is attached to a weight that is off-center and rotates while exerting centrifugal force. The motor is displaced by this unbalanced force. Vibrating is the term for the motor's wobbling caused by its high-speed displacement. The wobble can be altered by adding weight, adjusting the weight's proximity to the shaft, and changing the motor's rotational speed. In addition, the motor vibrates in two axes due to the centrifugal force produced by the rotating unbalanced weight (Z axis and X axis). Additionally, using the equations, the centrifugal force can be calculated.

The relationship between each component in this equation makes it clear that a heavier weight mass offset from the shaft will produce more force, and consequently more vibration amplitude. In addition, increasing the voltage fed to the motor will increase its speed, and as a result, the vibration frequency and amplitude.

$$f_{\text{vibration}} = \frac{\text{Motor RPM}}{60}$$

$$F_{\text{vibration}} = m * r * \omega^2$$

m = the mass of eccentric weight

r = mass offset distance

ω = speed of the motor(rads^{-1})

$$\omega = 2 \pi f$$

The relationship between each component in the equation makes it clear that a heavier weight mass offset from the shaft will produce more force, and consequently more vibration amplitude. In addition, increasing the voltage fed to the motor will increase its speed, and as a result, the vibration frequency and amplitude.

4.4.8 SMPS

Switched-Mode Power Supply is referred to as SMPS. It is an electronic power source that effectively converts electrical power using a switching regulator. The Switching Mode Power Supply is another name for it. Computers typically use a power supply unit (PSU) to convert voltage into a range that is acceptable to the device.

The following are the main elements that make up SMPS:

- Input rectifier and Filter (Diode rectifier and capacitor filter)
- High-frequency switch (Power transistor or MOSFET)
- Power transformer
- Output rectifier and Filter (Diode rectifier and capacitor filter)
- Control circuit (comparator and pulse width modulator)

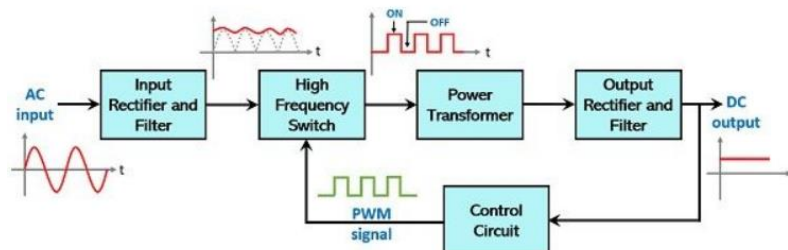


Fig. 4.10: Block diagram of SMPS

The input rectifier and filter circuit receive the unregulated ac input signal from the source at first. Here, the ac input signal is rectified in order to produce a dc signal, and it is then further smoothed in order to remove the high-frequency noise component. The power transistor, which serves as a high-frequency switch, receives the dc output (still in unregulated form). The dc signal is chopped in this place (switching). When the power transistor (chopper circuit) is turned on, current flows through it with a negligible voltage drop, and a dc signal is obtained at the output terminal of the transistor as shown in the Fig. 4.10. This circuit then functions as an ideal switch. However, when the power transistor is turned off, no current flows through it, causing a maximum voltage drop inside of it. As a result, there won't be any voltage on the output side.

As a result, the power transistor's output side will produce dc voltage in accordance with how it switches. In order to keep the desired dc voltage level, the chopping frequency is crucial. The high-frequency power transformer's primary winding is then fed the obtained direct current signal at the chopper circuit's output. In this case, the step-down transformer lowers the high voltage signal to a level that can be used as an input by the output rectifier and filter unit. To produce a controlled dc signal as the output, this merely filters out the signal's undesirable residuals. The feedback circuit for the entire unit is served by the control circuitry that is currently in place. A comparator and a pulse width modulator are used in this (PWM). The error amplifier, which functions as a comparator, compares the obtained dc voltage with the reference value using the dc output from the rectifier and filter that is fed into the control circuit. Minimizing the chopping frequency is necessary if the dc output is higher than the reference value. The output power and dc output voltage will both decrease with a decrease in chopping frequency. In contrast, the chopping frequency is increased if the dc output is lower than the reference value. Increased chopping frequency causes an increase in dc output voltage. The pulse width modulator creates a pulse width modulated waveform with a fixed frequency, where the duty cycle determines the frequency of the chopping.

The duty ratio is essentially the proportion of on-time to total cycle time. Therefore, the chopping frequency can be adjusted by making the necessary changes to the pulse width, which results in regulated dc output.

4.3.9 LCD (*Liquid Crystal Display*)

Materials used in liquid crystal displays (LCDs) combine the characteristics of crystals and liquids. Instead of a melting point, they have a range of temperatures where the molecules are almost as mobile as they would be in a liquid but are arranged in a structure akin to a crystal.

The liquid crystal material is sandwiched between two glass panels that make up an LCD. Transparent electrodes that define the characters, symbols, or patterns to be displayed are coated on the inner surface of the glass plates. Polymeric layers are present between the electrodes and the liquid crystal, causing the liquid crystal molecules to maintain a specific orientation angle.

The two glass panels have polarizers pasted outside of them, one of each. These polarizers would cause the light rays to pass through them to rotate at a specific angle and in a specific direction.

When the LCD is turned off, the two polarizers and liquid crystal rotate the light rays so they exit the LCD with no orientation, giving the LCD its transparent appearance. The liquid crystal molecules would align in a particular direction once the electrodes received a sufficient voltage. The polarizers would rotate the light rays as they passed through the LCD, activating or highlighting the desired characters as a result. The LCDs are thin and light, measuring only a few millimeters. Since LCDs use less energy, they can be powered for extended periods of time and are compatible with low power electronic circuits.

Since LCD displays don't produce light, light is required to read the display. Reading in the dark is made possible by the use of backlighting. The LCDs have a long lifespan and a broad temperature range of operation. The LCDs are more user-friendly because it is relatively easy to change the layout or display size.

Simple seven-segment LCDs with a small amount of numeric data are the only LCDs used in watches, calculators, and measuring instruments as shown in the Fig. 4.11. Recent technological developments have improved legibility, increased information display capacity, and expanded the temperature range. These have led to LCDs being widely used in electronics for telecommunication and entertainment. Even

the cathode ray tubes (CRTs) used for text and graphic display as well as in small TV applications have begun to be replaced by LCDs.

The principle underlying LCDs states that when an electrical flow is applied to a fluid atom, the particle will typically untwist. In addition to changing the point of the largest polarizing channel, this changes the point of light that is passing through the spellbound glass particle. As a result, a small amount of light can pass through a specific area of the LCD's energized glass. So, in comparison to other areas, that one will become dull. The standard of obstructing light is handled by the LCD. A reflected mirror is arranged at the back while the LCDs are developing.

On top of the device, an indium-tin oxide cathode plane is kept, and the bottom of the device also has an electric glass with a polarizing film added to it. An average cathode, or more likely fluid material, must surround the entire area of the LCD. the second piece of glass, which has another polarizing film on top and a terminal with a square shape on the bottom. It should be taken into account that both pieces are placed in the proper locations. The light will pass through the front of the LCD when there is no current, be reflected by the mirror, and then bounce back. The square-shaped liquid jewels between the cathode and anode in the fundamental plane will untwist as the cathode is connected to a battery by the current from it. This makes it appear as though there is no barriers preventing light from entering the specified rectangular domain. The Pin description of LCD is shown in the Table 4.1.

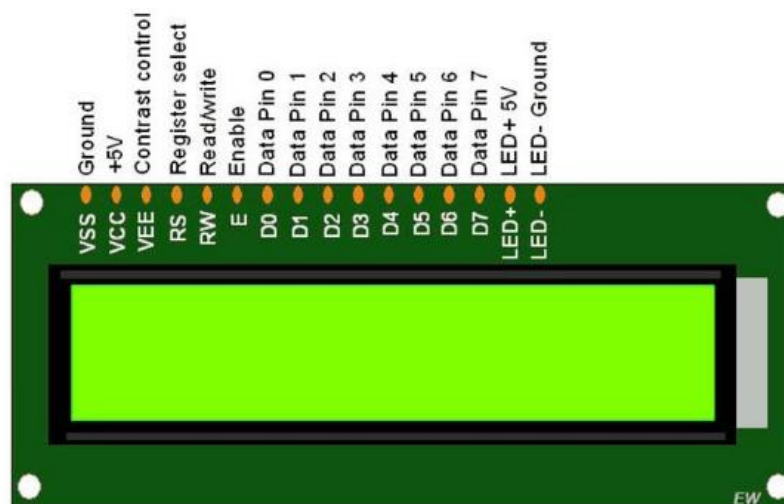


Fig. 4.11: LCD layout

Table 4.1 : Pin Description of LCD

S.NO	PIN NO.	Pin Name	Pin Type	Pin Description	Pin Connection
1.	Pin 1	Ground	Source Pin	This is a ground pin of LCD	Connected to the ground of the MCU/Power source
2.	Pin 2	VCC	Source Pin	This is the supply voltage pin of LCD	Connected to the supply pin of Power source
3.	Pin 3	V0/VEE	Control Pin	Adjusts the contrast of the LCD	Connected to a variable POT that can source 0-5V
4.	Pin 4	Register Select	Control Pin	Toggles between command or data register	Connected to a MCU pin and gets either 0 or 1. 0 - command mode 1 - data mode
5.	Pin 5	Read/Write	Control Pin	Toggles the LCD between read or write operation	Connected to a MCU pin and gets either 0 or 1. 0-Write Mode 1-Read Mode
6.	Pin 6	Enable	Control Pin	Must be held high to perform Read or Write operation	Connected to a MCU and always held high
7.	Pin 7-14	Data Bits (0-7)	Data/ Command Pin	Pins used to send command or data to the LCD	In 4-wire Mode, 4 pins (0-3) are connected to MCU. In 8-wire Mode, All 8 pins(0-7) are connected to MCU.

8.	Pin 15	LED Positive	LED Pin	LED-like operation typical for LCD illumination	Connected to +5V
9.	Pin 16	LED Negative	LED Pin	Connected to a MCU pin and gets either 0 or 1. 0-command mode 1-data mode	Connected to ground

4.4.10 PUSH BUTTON

Press Buttons are frequently operated material switches. When we press the button, the press gets give us the ability to turn on the circuit or form a specific affiliation. It merely connects the circuit when pressed and disconnects it when conveyed. Additionally, the SCR's entryway terminal is activated by pressing a button. These are the most notable features that we frequently encounter in electronic devices.

4.5 SOFTWARE REQUIREMENTS

- Arduino IDE

4.5.1 ARDUINO IDE

The Arduino Software (IDE), also known as the Arduino Integrated Development Environment (IDE), has a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a number of menus. For uploading and interacting with programmes, it establishes a connection with the Arduino hardware.

4.5.1.1 STEPS TO CREATE AND RUN

STEP1: Install the latest version of Arduino IDE.

STEP2: Connect the Arduino board and PC using USB cable as shown in Fig. 4.12.

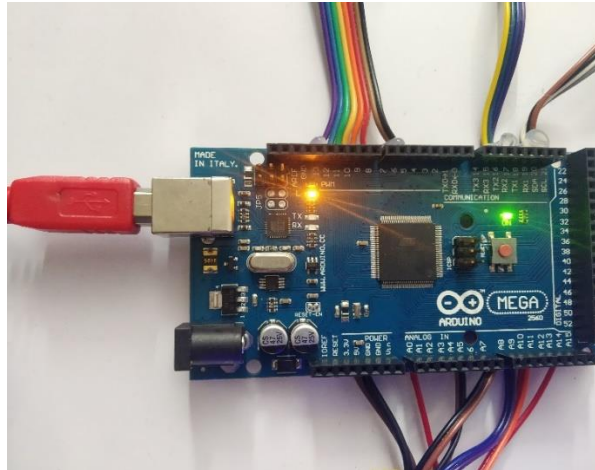


Fig. 4.12: Connection of Arduino using USB cable

STEP3: Open device manager and check whether the required port is shown in the Fig. 4.13.

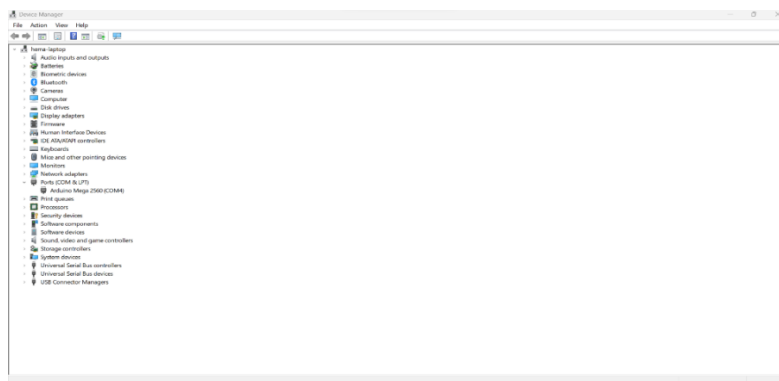


Fig. 4.13: device manager

STEP4: Open ARDUINO IDE

STEP5: Select board as shown in the Fig. 4.14.

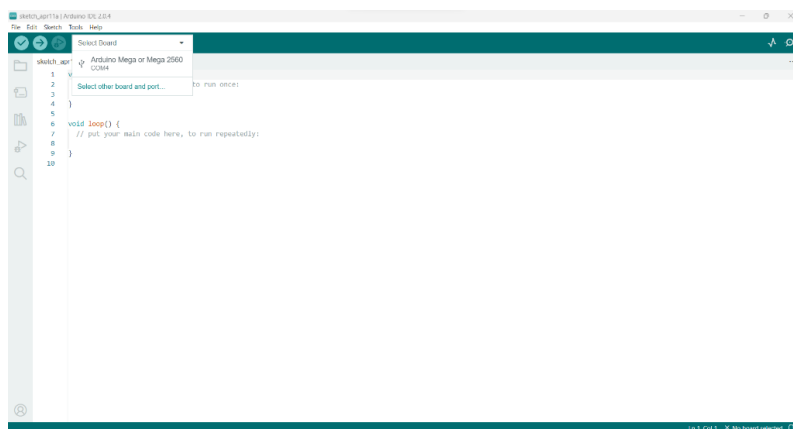


Fig. 4.14: Select Board

STEP6: Program is already stored in the Arduino board.

STEP7: Switch ON the EEG sensor then EEG MODE will be activated as shown in the Fig. 4.15.

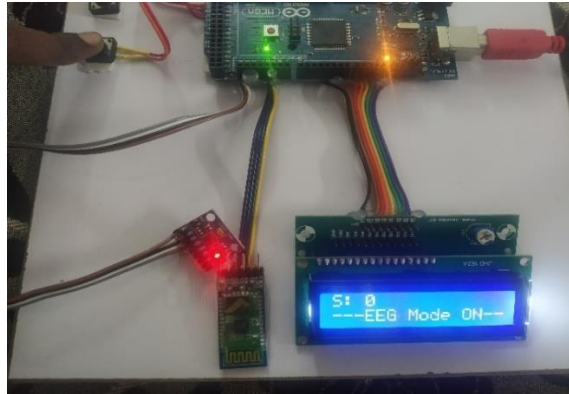


Fig. 4.15:EEG Mode activated

STEP8: EEG Sensor should be in placed properly in the forehead as shown in the Fig. 4.16.



Fig. 4.16: EEG sensor is placed in the forehead

STEP7: Click serial plotter at the top right corner as shown in the Fig. 4.17.

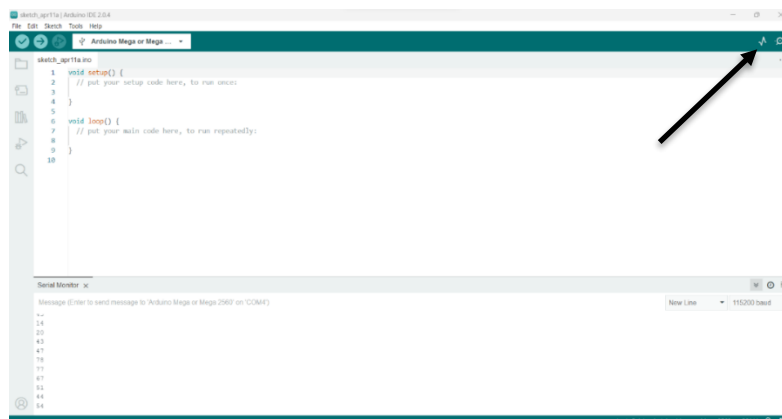


Fig. 4.17: Select serial monitor icon

STEP8: View the graph in the serial plotter as shown in the Fig. 4.18.

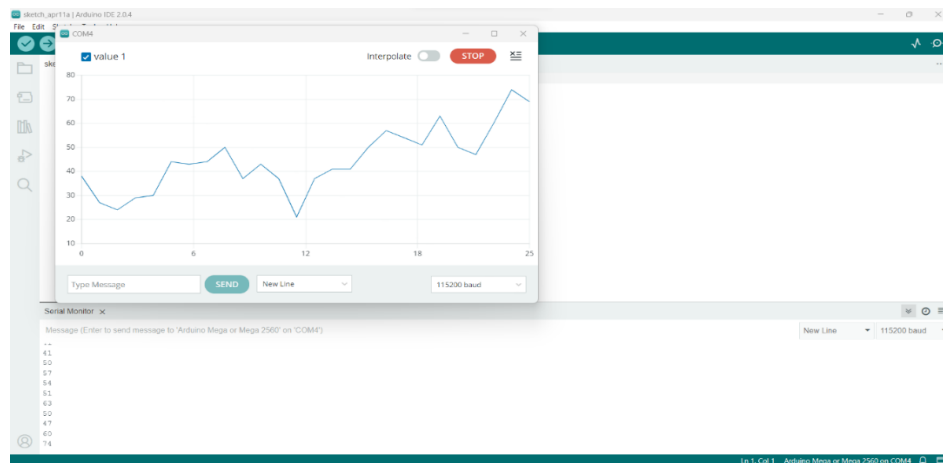


Fig. 4.18: Graph in serial plotter

STEP9: Switch off the EEG sensor as shown in the Fig. 4.19.



Fig. 4.19: EEG mode off

4.5.2 IMAGE PROCESSING

Image processing is the process of converting an image into a digital format and applying specific operations to it in order to extract some useful information. If certain predetermined signal processing techniques are used, the image processing system typically treats all images as 2D signals.

Image processing can be divided into five categories:

1. Visualization : Seek out objects that are hidden in the image.
2. Recognition : Identifying or detecting objects in the image.

3. Sharpening and restoration : Create an improved version of the original Image.
4. Pattern recognition : Calculate the different patterns that surround the objects in the picture.
5. Retrieval : Browse and search through thousands of digital pictures that are similar to the original picture.

METHOD OF DETECTING FACIAL EMOTIONS:

Python is used for the recognition of facial emotion in Image processing.

The major dependencies include:

- 1) Facial Expression Model : Python Package used to Detect Facial Expression.
- 2) NumPy : Python Library used for Mathematical Functions.
- 3) OpenCV : Python Library for Computer Vision.

The main concept used to predict the Emotion of Adhd affected Childrens/adults. The flow of the project is as follows:

- First using read the image from Camera by using OpenCV
- Then, the haar cascade method is used to detect faces in each frame of the webcam feed.
- The region of image containing the face is resized to 48x48 and is passed as input to the CNN.
- The emotion with maximum score is displayed on the screen.

4.5.2.1 TO CREATE AND RUN

Step1: Connect the Arduino board to the PC using a USB cable as shown in the Fig. 4.20.



Fig. 4.20: Connection of USB cable to Arduino

Step2: Open the program folder and right click on the main option and select show more options as shown in the Fig. 4.21.

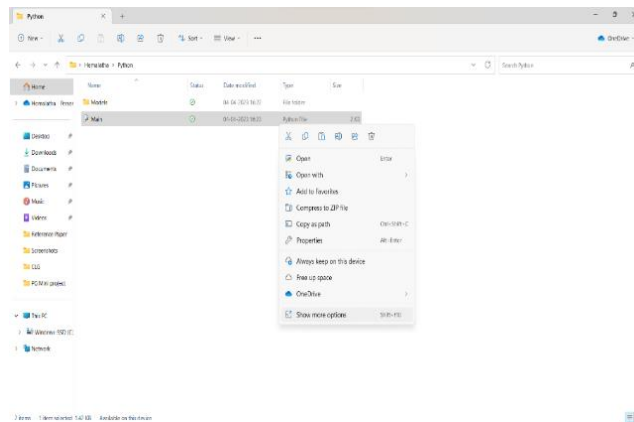


Fig. 4.21: Select show more options

Step3: Select edit with IDLE option and click edit with 3.10(64 bit) as shown in the Fig. 4.22.

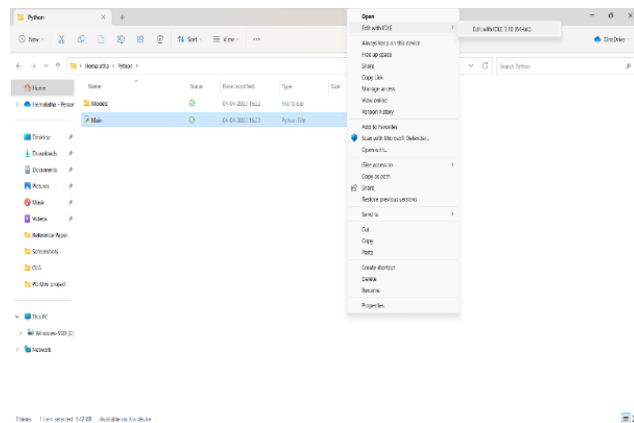


Fig. 4.22: select edit with 3.10(64 bit) option

Step4: The code is opened as shown in the Fig. 4.23.



Step5: Select Run module option in RUN as shown in the Fig. 4.24.



Fig. 4.24: Select RUN module

Step6: Camera is turned ON and detects the facial emotion as shown in the Fig. 4.25.

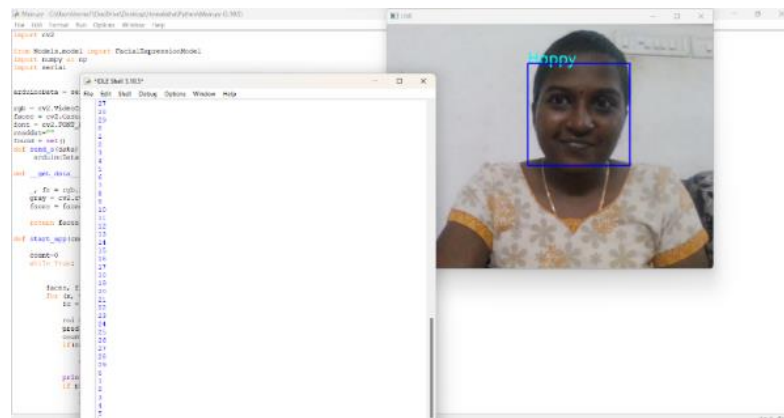


Fig. 4.25: Detection of facial emotion

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 RESULTS

This is a simple device that focuses on the therapeutic treatment for the ADHD patient when they have high sweat rate, nervousness and sad facial emotion, the vibration motors will automatically turn ON, which improves blood circulation and make them feel relaxed.



Fig. 5.1: Outputs of sweat sensor and accelerometer

Figure 5.1 describes the outputs of Sweat sensor and accelerometer are displayed in the LCD.

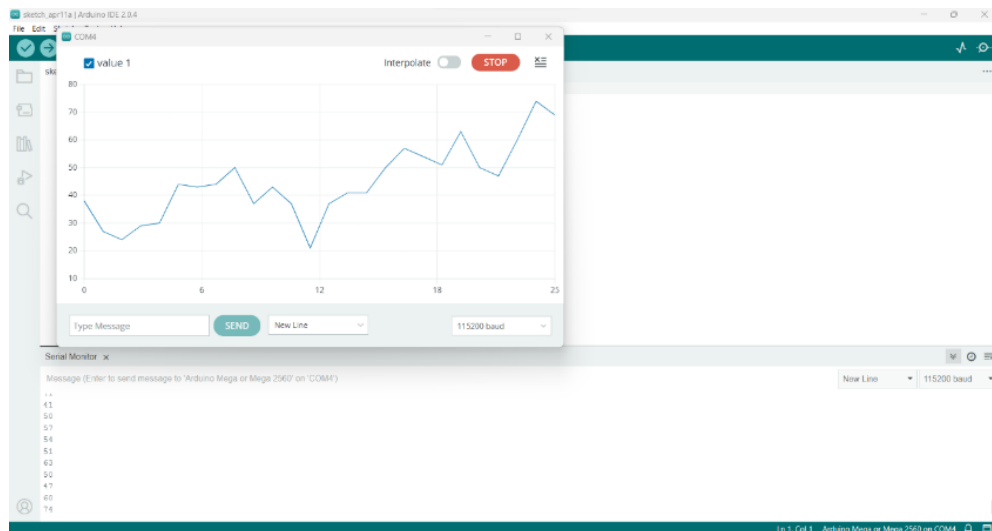


Fig. 5.2: Output of EEG sensor

Figure 5.2 describes the obtained graph in the serial plotter in Arduino IDE.

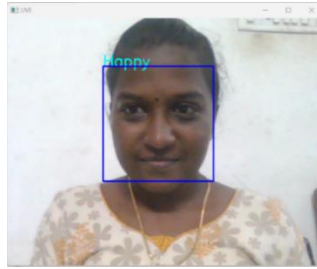


Fig: 5.3: Detection of facial emotion for happy

Figure 5.3 describes the detection of facial emotion for happy

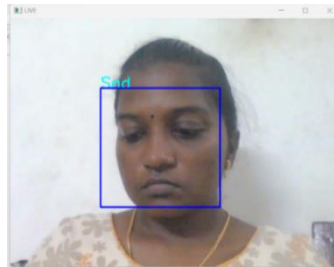


Fig: 5.4: Detection of facial emotion for sad

Figure 5.4 describes the detection of facial emotion for sad

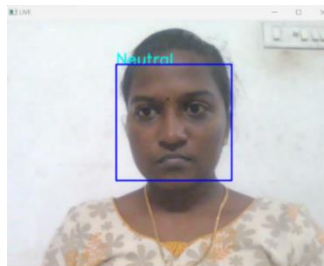


Fig: 5.5: Detection of facial emotion for neutral

Figure 5.5 describes the detection of facial emotion for neutral



Fig: 5.6: Detection of facial emotion for angry

Figure 5.6 describes the detection of facial emotion for angry



Fig: 5.7: Detection of facial emotion for surprise

Figure 5.7 describes the detection of facial emotion for surprise



Fig: 5.8: Detection of facial emotion for disgust

Figure 5.8 describes the detection of facial emotion for disgust



Fig: 5.9: Mobile showing alert message

Figure 5.9 describes that when a person is not feeling calm after the therapy session, panic button is pressed and an alert message has been sent to the neighbor's mobile.

5.2 DISCUSSION

Westwood et. al., (2021) discussed about the detection of emotions using image processing in Python, OpenCV & (CK and CK+) Database to detect facial emotions. The proposed method uses Python, OpenCV & dataset was taken from Kaggle to detect the facial emotions. In the above statements, database from Kaggle gives the best result than own database. Harini et. al., (2021) discussed about the sensors like accelerometer and sweat sensor to detect the hypertension and restlessness in human and the alert message has been sent using IOT. In the proposed method, EEG sensor, accelerometer and sweat sensor is used to detect attention level, hypertension and restlessness. The alert message has been sent using GSM. In the above statements, alert message using IOT gives the accurate result. Langley et. al., (2018) discussed about the detection of emotions using the Facial Emotion Recognition task, consisting of 60 faces from the Ekman and Friesen facial affect battery, representing four basic emotions (happiness, anger, fear, sadness) and neutral. In the proposed method, facial emotions are detected using Haar cascade method and CNN. In the above statements, CNN and Haar cascade methods shows the accurate facial emotions. Catherine Joy et. al., (2022) discussed to detect adhd using electroencephalography (EEG) signals based on different nonlinear entropy estimators and an artificial neural network classifier. David Freismuth et. al., (2022) discussed about the diagnosis of ADHD using EEG, neuro feedback method is used. Pham Thi Viet Huong et. al., (2021) discussed about examining EEG in order to detect ADHD children by utilizing the non-linear features of EEG signal. Jaya Jeswani et. al., (2022) CNN algorithm was used to detect ADHD syndrome using fMRI image data. In the proposed method, EEG signals are based on Convolutional neural network. In the above statements, CNN method gives the greater accuracy.

CHAPTER – 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The main aim of the project is to detect hypertension, stress and restlessness in human. Here, EEG sensor, sweat sensor and accelerometer sensor are used to detect the hypertension and restlessness. Sweat sensors, accelerometers, and facial expression detection can aid in the detection and prevention of ADHD. Sweat sensors can measure the levels of neurotransmitters and other biomarkers in sweat, which can provide valuable information about the chemical imbalances associated with ADHD. Accelerometers can measure movement and activity levels, providing insights into hyperactivity and impulsivity symptoms. The output of the Accelerometer sensor and sweat sensor are displayed in the LCD. Sweat sensor output is displayed as “S” and the output of the accelerometer will be counted till five. Facial expression detection can detect emotional dysregulation and other behavioral symptoms associated with ADHD. The image from the camera is read by OpenCV and then the haar cascade method is used to detect faces and the detected image is given as the input to the CNN and the emotion with maximum score is displayed on the screen. EEG is used to detect whether the person is attentive or not. EEG should be connected properly to forehead and it will detect the activity of brainwaves. When the sensor value is more than the threshold value, the vibration motor will turn ON automatically. These motors will make the patient calm by improving the blood circulation. When the patient becomes calm, it will stop automatically. When the patient is not feeling relaxed or in tensed state, panic button should be pressed. When the panic button is pressed, Alert message has been sent to the neighbor's mobile with the location of the patient. By combining these technologies, comprehensive assessments of ADHD symptoms are developed and an effective prevention and treatment strategies are developed. These technologies provide non-invasive and objective measurements, which can improve accuracy and reduce subjectivity in the diagnosis and management of ADHD. This is a non-invasive portable device used to speedy recovery ADHD patients with minimal knowledge.

6.2 CONCLUSION

This project gives non-invasive therapeutic treatment for the ADHD patient using vibration motor. Stress, depression and anxiety has become a part of our life, statistics says many people have taken their life during lockdown, unable to cope-up with stress during tough times and it has forced them to take their lives which affects their whole family. People with stress, anxiety, nervousness and restlessness can use this portable device which will keep them calm and relaxed. This tool will help common people because of life style changes and it could also be mainly used for Rape victims and train drivers as they go through very tough phase which will help them recover by using these techniques. This device is portable and can be used anytime. Anyone with a basic understanding of technology can handle it.

6.3 FUTURE SCOPE

In future, this therapy can be introduced in rehabilitation centers as a session which will help the ADHD people to overcome the disorder. This is a slow recovering process and it will give the best result by using it continuously. Many people will start to smoke or drink due to stress. To stop this kind of habits, this therapy will be helpful. This therapy will help the people to get rid of negative thoughts. Additionally, Music can be added to this therapy. According to the patient's mood, it will play the music. This will also help the people to feel relaxed.

REFERENCES

- 1) Airdrie JN, Langley K, Thapar A, van Goozen SHM. "Facial Emotion Recognition and Eye Gaze in Attention-Deficit/Hyperactivity Disorder with and without Comorbid Conduct Disorder". *J Am Acad Child Adolesc Psychiatry*. 2018 Aug;57(8):561-570.
- 2) Alves, Renato Montaleão Brum, Mônica Ferreira da Silva, Eber Assis Schmitz, and Antonio Juarez Alencar. "Mobile Devices and Systems in ADHD Treatment." In *WEBIST*, 2020, pp. 141-146.
- 3) Biancardi, Carlo, Gianluca Sesso, Gabriele Masi, Ugo Faraguna, and Federico Sicca. "Sleep EEG microstructure in children and adolescents with attention deficit hyperactivity disorder: a systematic review and meta-analysis." *Sleep* 44, no. 7 (2021).
- 4) Bokovza, Lihi, Guy Baz, and Hadar Shalev. "Effects of Non-Invasive Right Prefrontal Stimulation on Cognitive Performance of ADHD Patients." *Journal of Psychiatry and Psychiatric Disorders* 4, no. 6 (2020), pp. 400-414.
- 5) Camp, Allyson, Amanda Pastrano, Valeria Gomez, Kathleen Stephenson, William Delatte, Brianna Perez, Hunter Syas, and Anthony Guiseppi-Elie. "Understanding ADHD: Toward an innovative therapeutic intervention." *Bioengineering* 8, no. 5 (2021): 56.
- 6) Catherine Joy, R., S. Thomas George, A. Albert Rajan, and M. S. P. Subathra. "Detection of ADHD from EEG signals using different entropy measures and ANN." *Clinical EEG and Neuroscience* 53, no. 1 (2022): 12-23.
- 7) Cazzato, Dario, Silvia M. Castro, Osvaldo Agamennoni, Gerardo Fernández, and Holger Voos. "A non-invasive tool for attention-deficit disorder analysis based on gaze tracks." In *Proceedings of the 2nd International Conference on Applications of Intelligent Systems*, 2019, pp. 1-6.
- 8) Das, William, and Shubh Khanna. "A robust machine learning based framework for the automated detection of ADHD using pupillometric biomarkers and time series analysis." *Scientific reports* 11, no. 1 (2021): 16370.
- 9) De Silva, Senuri, Sanuwani Dayarathna, Gangani Ariyaratne, Dulani Meedeniya, Sampath Jayarathna, and Anne MP Michalek. "Computational decision support system for ADHD identification." *International Journal of Automation and Computing* 18, no. 2 (2021): 233-255.

- 10) Demirci, Esra, Mustafa Yasin Esas, Çiğdem Gülüzar Altıntop, Neslihan Taştepe, and Fatma Latifoğlu. "Diagnostic Support System for the Detection of Attention Deficit Hyperactivity Disorder Using EOG Signals." (2021).
- 11) Freismuth, David, and Nima TaheriNejad. "On the treatment and diagnosis of attention deficit hyperactivity disorder with eeg assistance." *Electronics* 11, no. 4 (2022): 606.
- 12) Harini, K. "Attention Deficit Hyperactivity Disorder (ADHD) Detection and Providing Therapeutic Treatment Using." *Journal of Research Proceedings* 1, no. 2 (2021): 31-40.
- 13) Holker, Ruchi, and Seba Susan. "Computer-Aided Diagnosis Framework for ADHD Detection Using Quantitative EEG." *International Conference on Brain Informatics*. Springer, Cham, 2022.
- 14) Huong, Pham Thi Viet, Nguyen Anh Tu, and Tran Anh Vu. "Ensemble learning in detecting ADHD children by utilizing the non-linear features of EEG signal." In *Proceedings of the 2nd International Conference on Human-centered Artificial Intelligence (Computing4Human 2021)*. CEUR Workshop Proceedings, Da Nang, Vietnam (Oct 2021).
- 15) Jaya Jeswani, Priya Soni, Iqra Khatri, Jatin Satoskar." Detecting Attention Deficit Hyperactivity Disorder (ADHD) Inflicted Humans using Convolutional Neural Network (CNN)." *IOSR Journal of Computer Engineering (IOSR-JCE)* Volume 24, Issue 2, Ser. II (Mar. –Apr. 2022), e-ISSN: 2278-066, p-ISSN: 2278-8727.
- 16) Jiang, Xinlong, Yiqiang Chen, Wuliang Huang, Teng Zhang, Chenlong Gao, Yunbing Xing, and Yi Zheng. "WeDA: Designing and evaluating a scale-driven wearable diagnostic assessment system for children with ADHD." In *Proceedings of the 2020 CHI conference on human factors in computing systems*, 2020, pp.1-12.
- 17) Kast, Kristopher A., Vinod Rao, and Timothy E. Wilens. "Pharmacotherapy for attention-deficit/hyperactivity disorder and retention in outpatient substance use disorder treatment: a retrospective cohort study." *The Journal of clinical psychiatry* 82, no. 2 (2021): 28164.
- 18) Kaur, Amandeep, and Karanjeet Singh Kahlon. "Accurate Identification of ADHD among Adults Using Real-Time Activity Data." *Brain Sciences* 12, no. 7 (2022): 831.

- 19) Loh, Hui Wen, Chui Ping Ooi, Prabal Datta Barua, Elizabeth E. Palmer, Filippo Molinari, and URajendra Acharya. "Automated detection of ADHD: Current trends and future perspective." *Computers in Biology and Medicine* (2022): 105525.
- 20) Makkar, Mridul, Narkeesh Arumugam, and Divya Midha. "Winning over ADHD by charging the brain non-invasive stimulation methods in ADHD: A systematic." *IJAR* 7, no. 2 (2021): 384-390.
- 21) Nobukawa, Sou, Aya Shirama, Tetsuya Takahashi, Toshinobu Takeda, Haruhisa Ohta, Mitsuru Kikuchi, Akira Iwanami, Nobumasa Kato, and Shigenobu Toda. "Identification of attention-deficit hyperactivity disorder based on the complexity and symmetry of pupil diameter." *Scientific Reports* 11, no. 1 (2021): 8439.
- 22) Puri, Raghav, Archit Gupta, Manas Sikri, Mohit Tiwari, Nitish Pathak, and Shivendra Goel. "Emotion detection using image processing in python." *arXiv preprint arXiv:2012.00659* (2020).
- 23) Rohit Kale. "Detection of ADHD using Machine Learning Algorithms." *International Journal of Science and Research (IJSR)* ISSN: 2319-7064.
- 24) Shirama, Aya, Toshinobu Takeda, Haruhisa Ohta, Akira Iwanami, Shigenobu Toda, and Nobumasa Kato. "Atypical alert state control in adult patients with ADHD: A pupillometry study." *PloS one* 15, no. 12 (2020): e0244662.
- 25) Tachmazidis, Ilias, Tianhua Chen, Marios Adamou, and Grigoris Antoniou. "A hybrid AI approach for supporting clinical diagnosis of attention deficit hyperactivity disorder (ADHD) in adults." *Health Information Science and Systems* 9 (2021): 1-8.
- 26) Tor, Hui Tian, Chui Ping Ooi, Nikki SJ Lim-Ashworth, Joel Koh En Wei, V. Jahmunah, Shu Lih Oh, U. Rajendra Acharya, and Daniel Shuen Sheng Fung. "Automated detection of conduct disorder and attention deficit hyperactivity disorder using decomposition and nonlinear techniques with EEG signals." *Computer Methods and Programs in Biomedicine* 200 (2021): 105941.
- 27) Westwood, Samuel J., Joaquim Radua, and Katya Rubia. "Noninvasive brain stimulation in children and adults with attention-deficit/hyperactivity disorder: a systematic review and meta-analysis." *Journal of Psychiatry and Neuroscience* 46, no. 1 (2021): E14-E33.