Cognitive Load Detection of Vision Impaired in the Inward Places using Bio-signal

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Dedication

We would like to dedicate this thesis to our loving parents.

Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

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Abstract

In this current world, approximately 290 millions of people are partially or fully blind. They can not roam around like the normal people. Visually Impaired People (VIP) have to face many obstacles everyday in inward and outward places. Moreover, it is pretty difficult for them to move for their daily works. They face difficulties when they try to move one place to another. Mobility in different environments in inward can be challenging and emotionally stressful tasks for VIPs when they are navigating in an unfamiliar environment. There are some navigation tools such as guide dog white cane but these aids are failed to uprootd key problems such as including route planning, discovering landmarks. It is matter of great sorrow that still in this era of technology we could not help them with a proper solution that includes all the key problem. These circumstances can be both psychological and social. Electroencephalogram (EEG) is a tool that records electrical activities over the scalp. This is a very useful technique which is used widely all over the world. In this paper, we will measure cognitive load through EEG signals for observing the usability test of navigating tools for determine whether these navigating tools are helpful or not . A classification accuracy of 77.35% for automated door,82.78%of accuracy for narrow space, 84.91% of accuracy for open space, 88.99% of accuracy for elevator, 79.19% of accuracy for stairs, 83.47% of accuracy for moving objects and 86.89% of accuracy for sound, which was achieved by this proposed model. In this paper observing usability test of navigating aids so that VIPs can feel confidence and comfortable when using any navigating tools for roaming around

Keywords: Assistive Navigation, Visual Impaired People, Route Planning, Mobility, Electroencephalogram, Cognitive Load

Acknowledgement

Firstly, all praise to the Great Allah for whom our thesis have been completed without any major interruption.
Secondly, to our advisor Dr Mohammad Zavid Parvez for his kind support and advice in our work. He helped us whenever we needed help.
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Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Motivation

According to WHO there are approximately 290 million people are visually impaired in the world[1]. They have a lot of restrictions in their daily life [2]. Wherever they go they face many obstacles as they don' t have any latest technologies to escort them properly. Yet there are different technologies like guide dog, visually impaired assistant etc. but they all are not properly efficient in terms of using in daily life. These technologies have some limitations also. Even the constitutional rights often violated due to the lack of accessibility, especially those who have more than one disabilities. Facing these types of obstacles in their daily basis life makes them less confident and lead them into depression.

There are a significant number of VIPs in worldwide who are not willing to go out or move here and there even in their home just to avoid these difficulties. In this paper, we are using EEG signals of vision impaired people to define cognitive load of them and to create an efficient system for them.

Our motive is to create such a system that will help these VIPs in their daily life with much more confidence they had in their life. Besides this we have reached as much accuracy level as we can in our research paper so that it is actually fruitful for VIPs. As our project is based on daily basis life and the users are visually impaired that' s why we are concern about our project quality and our accuracy level. In the era of modern technology it is very unusual that VIPs still didn' t have any fruitful technologies that we can call nearly perfect technology. For this, our goal is to contribute them with more up to date technologies that will help them in their daily life.

We implement our project in inward environment. So that we can understand how these things are work and how are the feed backs from our users. Our goal is to implement our ideas in both outward and inward environment in future.

1.2 Major Contribution

In our research, we have analyzed EEG signals captured from VIP to measure cognitive load based on signal processing and machine learning approaches. Measuring cognitive load is difficult due to abruptness phenomenon of EEG signals from VIPs. Therefore, we have analyzed the EEG signals from visually impaired in order measure the cognitive load using signal processing and learning methods. We have extracted one features based on well-known approaches which is Short Time Fourier Transformation(STFT).

1.3 Thesis Overview

The thesis is organized as follows:
In Chapter 2, a brief review is given on all the learnings and works from the past researches related to this study.

In Chapter 3, several techniques and strategies about the methods and algorithms used throughout the study is discussed. The methods were: (i) neurofeedback used for visual auditory or tactile modality, (ii) identifying bio-signal(EEG) and giving a brief description of different types of signal frequencies, voltage, shape of the waveform, recording process of EEG signals using EEG electrodes, how to place EEG electrodes, (iii) providing parts and functions of human brain, (iv) defining cognitive load theory and the process of executing cognitive load, (v) described Short Time Fourier Transformation (STFT) and its discrete function, (vi) defined Support Vector Machine(SVM) with related figure, (vii) provided Wigner Ville Distribution (WVD) for a single time series, (viii) described the process of Time Frequency Domain

In Chapter 4, a discussion of the proposed model for detecting cognitive load has given in details. Some other parts including, (i) brief description about collection process of data set with EPOC+, (ii) considering some band frequencies for detecting cognitive load through the process of band extraction, (iii) labeling process of ERS and EDS, (iv) providing extracted entropy feature based on time-frequency distributed signals, (v) classification of cognitive load through 5 fold method.

In Chapter 5, comprehensive result analysis using receiver operating characteristics (ROC) curve and related tables have provided, (i) provided related discussion about the graph according to the achieving results.

In Chapter 6, conclusion is given with references indicating possible future directions of the research.

Chapter 2

Literature Review

2.1 Related works

There are no reliable natural markers or physiological estimations for productively and viably dismembering the heterogeneity of Major Depressive Disorder (MDD). Two signals or examples are there to work with MDD, scalp electroencephalography (EEG) signals and a strong otherworldly spatial EEG highlight extractor called part Eigen-channel bank normal spatial example (KEFB-CSP). They are known as bio-signals. The KEFB-CSP first channels the multi-channel crude EEG signals into a lot of recurrence sub-groups covering the range from theta to gamma groups, at that point spatially changes the EEG signs of each sub-band from the first sensor space to another space where the new signals (i.e. CSPs) are ideal for the order among MDD and solid controls, lastly applies the piece head part examination (portion PCA) to change the vector containing the CSPs from all recurrence sub-groups to a lower-dimensional component vector called KEFB-CSP. EEG-based mind PC interface (BCI) framework which may, later on, assist specialists with giving individualized and compelling medicines to MDD patients [3].

The perplexing, nonlinear and non-stationary electroencephalogram (EEG) signals are monotonous to decipher outwardly and profoundly hard to extricate the note-worthy highlights from them. The direct and nonlinear strategies are successful in distinguishing the adjustments in EEG signals for the location of depression. Direct techniques don’t display the complex dynamical varieties in the EEG signals. Subsequently, tumult hypothesis and nonlinear unique strategies are generally utilized in separating the EEG signal highlights for PC helped conclusion of gloom. Thus, this article shows the ongoing endeavors on CAD of melancholy utilizing EEG signals with an attention on utilizing nonlinear techniques. Such a CAD framework is easy to utilize and might be utilized by the clinicians as a device to affirm their determination. It ought to be of a specific incentive to empower the early discovery of depression. [4].

Trans cranial direct current stimulation (tDCS) is a promising cure for MDD. Standard tDCS treatment includes various sessions running over half a month. Be that as it may, not all members react to this kind of treatment. This examination intends to explore the practicality of distinguishing MDD patients that react to tDCS treatment dependent on resting-state electroencephalography (EEG) recorded preceding treatment initiating. AI is utilized to anticipate perking up and cognizance during tDCS treatment from pattern EEG power spectra. In an examination ten members with a present conclusion of MDD were incorporated. Force phantom thickness was surveyed in five recurrence groups: delta (0.5 – 4 Hz), theta (4 – 8 Hz), alpha (8 – 12 Hz), beta (13 – 30 Hz) and gamma (30 – 100 Hz). Temperament marks were precisely anticipated in 8 out of 10 members utilizing EEG channels FC4-AF8 (accuracy=76% , p=0.034). Cognizance marks were precisely anticipated in 10 out of 10 members utilizing channels pair CPz-CP2 (accuracy=92% , p=0.004) [5].

Despite the fact that patients with MDD have dysfunctions in subjective practices and the guideline of feelings, the basic mind elements of the pathophysiology are hazy. Thusly, nonlinear procedures can be utilized to comprehend the dynamic conduct of the EEG signs of MDD patients. To research and explain the elements of MDD patients' minds during various passionate states, EEG accounts can be examined utilizing nonlinear procedures. The reason for the present examination was to evaluate whether there are diverse EEG complexities that segregate between MDD patients and sound controls during passionate handling. Along these lines, nonlinear parameters, for example, Katz fractal measurement (KFD), Higuchi fractal measurement (HFD), Shannon entropy (ShEn), Lempel-Ziv multifaceted nature (LZC) and Kolmogorov unpredictability (KC), were processed from the EEG signs of two gatherings under various exploratory states: clamor (negative enthusiastic substance) and music (positive passionate substance) periods [6].

EEG signals from scalp for brain activities used to identify the physiological in- dex that can lead to detecting cognitive load and emotional states. Examine nine participants in different indoor situation and recorded their brain activities signal through EPOC+ , which have 16 nodes or channels. Their activities were recorded through smart phones. Some features were extracted such as Permutation entropy, Cognitive index, Arousal and valence. Results were classified in some factors such as specificity, sensitivity and accuracy. This paper has achieved a result of 86.67% and has 10% of improvement compare to paper . Furthermore, 1% more accuracy in terms of corridor, we have noticed that all of them were commonly executed their works based on EEG signals in different situations such as indoor or outdoor. Their result accuracy or improvement percentage is not up to the mark to bring back VIP' s confidence[7].
Observing these papers, we have noticed that all of them were commonly executed their works based on EEG signals in different situations such as indoor or outdoor. Their result accuracy or improvement percentage is not up to the mark to bring back VIP' s confidence. In these research they have shown some existed method and

we are adding these method with time domain frequency by using STFT which is very useful method for processing audio signal frequency.

Chapter 3

Background Study

In this chapter, we will discuss about the methods and algorithms we have used throughout the study. We will divide this chapter into different sections. We will give basic idea about all the sections. We will use graphical representation, equations and statistics for the clear view of these topics. We will talk abut Neuro Feedback, EEG signal, Short Time Fourier Transformation, Support Vector Machine, Wigner Ville Distribution etc.

3.1 Neuro Feedback

Neuro Feedback (NF) is a self regulation system in which present parameters of EEG captured from the participant' s brain are presented to a subject through visual, auditory or tactile modality while the subject is supposed voluntary or involuntary alter these parameters to reach a more efficient mode of brain functioning.
The NF uses either amplitude itself or phase of the voltage fluctuation below 0.1 Hz. It is done in discrete and continuous forms. Basically NF is a process to train brain activity.

3.2 Bio Signal

The bio-sign or electroencephalogram (EEG) is an account of the electrical movement of the cerebrum from the brain. The captured wave structures mirror the electrical activity of human brain.
Signal power: EEG movement is very little, estimated in small scale volts (mV).
Signal recurrence: the principle frequencies of the human EEG waves (find in Figure 3.1) are: Delta, Gamma, Theta, Alpha, Beta.

Delta

It' s recurrence is from 3 Hz or underneath. It has the most noteworthy plentifulness and the slowest waves. It is common as the prevailing beat in newborn children as long as one year and in stages 3 and 4 of rest. It is generally most noticeable frontally in grown-ups (for example FIRDA - Frontal Intermittent Rhythmic Delta) and posteriorly in youngsters (for example OIRDA - Occipital Intermittent Rhythmic Delta).

To an extreme: Brain wounds, learning issues, powerlessness to think, serious ADHD

Excessively little: Inability to restore body, powerlessness to rejuvenate the cerebrum, poor rest

Ideal: Immune framework, common recuperating, remedial/profound rest

Increment delta waves: Depressants, rest [8].

Gamma

A gamma wave is an example of neural swaying in people with a recurrence somewhere in the range of 25 and 100 Hz, [9] however 40 Hz is commonplace. As per a mainstream hypothesis, gamma waves might be involved in making the solidarity of cognizant observation (the coupling problem)[10] [11] [12].
In any case, there is no concession to the hypothesis; as scientist C.H. Vanderwolf proposes:
Regardless of whether gamma wave movement is identified with abstract mindful- ness is an exceptionally troublesome inquiry which can't be replied with conviction at the present time.

To an extreme: Anxiety, high excitement, stress

Excessively little: ADHD, gloom, learning handicaps

Ideal: Binding detects, comprehension, data handling, learning, discernment, REM rest

Increment gamma waves: Meditation [8].

Theta

It has a recurrence of 3.5 to 7.5 Hz and is delegated "moderate" action. It appears in child age of 13 years and in rest however anomalous in wakeful grown-ups. It very well may be viewed as an indication of central sub-cortical injuries.

To an extreme: ADHD, discouragement, hyperactivity, impulsivity, distractedness

Excessively little: Anxiety, poor enthusiastic mindfulness, stress

Ideal: Creativity, enthusiastic association, instinct, unwinding

Increment theta waves: Depressants [8].

Alpha

It has a recurrence somewhere in the range of 7.5 and 13 Hz. It is normally best found in the back areas of the head on each side, being higher in adequacy on the prevailing side.
It is the significant beat found in ordinary loosened up grown-ups. It is available during the greater part of life particularly after the thirteenth year.

To an extreme: Daydreaming, powerlessness to center, too loose
Excessively little: Anxiety, high pressure, sleep deprivation, OCD
Ideal: Relaxation
Increment alpha waves: Alcohol, cannabis, relaxants, a few antidepressants

Beta

Beta recurrence is decides as " quick" errands. It' s recurrence is from 14 to more noteworthy Hz. It is typically noticied on every side in balanced dispersal and is most clear frontally. It is emphasizd by narcotic sleep inducing drugs particularly the benzodiazepines and the barbiturates.

To an extreme: Adrenaline, tension, high excitement, failure to unwind, stress
Excessively little: ADHD, wandering off in fantasy land, sadness, poor cognizance
Ideal: Conscious center, memory, critical thinking
Increment beta waves: Coffee, caffeinated drinks, different energizers [8].

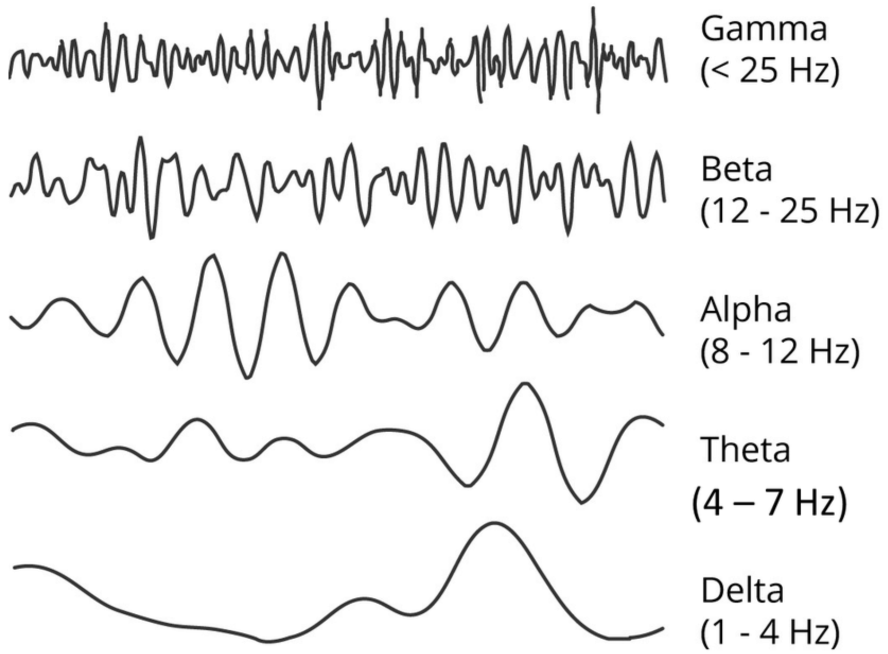

Figure 3.1: Different EEG Signals[13].

3.3 Human Brain

Human brain is one of the main organs of the human body (see in Figure 3.6). It controls the whole nervous system. It commands majority of the chores of the body such as processing, combining, and coordinating the details it accepts from the sense organs, and creating settlements as to the commands dispatch to the rest of the body.
There are mainly three parts of the brain –

- Cerebrum
- Brainstem
- Cerebellum

The most spacious part of the human brain is the cerebrum. Just under this lies the brainstem, and behind that we can see the cerebellum. Our Brain is connected with the spinal cord makes up the central nervous system [14].
The functions of the Brain are named as

- Motor control
- Sensory
- Regulation
- Language
- Lateralization
- Emotion
- Cognition

3.4 Cognitive load

Cognitive load theory (CLT) is utilize to evolve instructional procedure depend on the comprehension of human cognitive [16] design. It can decrease the load of working or active memory when dealing with previously organized information which is retrieved from long term memory [17]. Generally CLT is a theoretical framework depends upon human cognitive architecture of long term and working memory construct[16]. CLT compares or make a relations between these two following topics; working memory restrains to the usefulness of instruction. Learning process has limited capacity and duration as it can hold 7 (more or less 2) chunks of information of a given time [18]. In this process new details can reserve within 15 to 30 seconds [19]. There are three types of cognitive load, intrinsic, extraneous and germane ([20]). Demanding on working memory capacity implement by element interactivity are intrinsic to the material being learned . Event related synchronization and desynchronization (ERSD) are considered for calculating participants cognitive load.

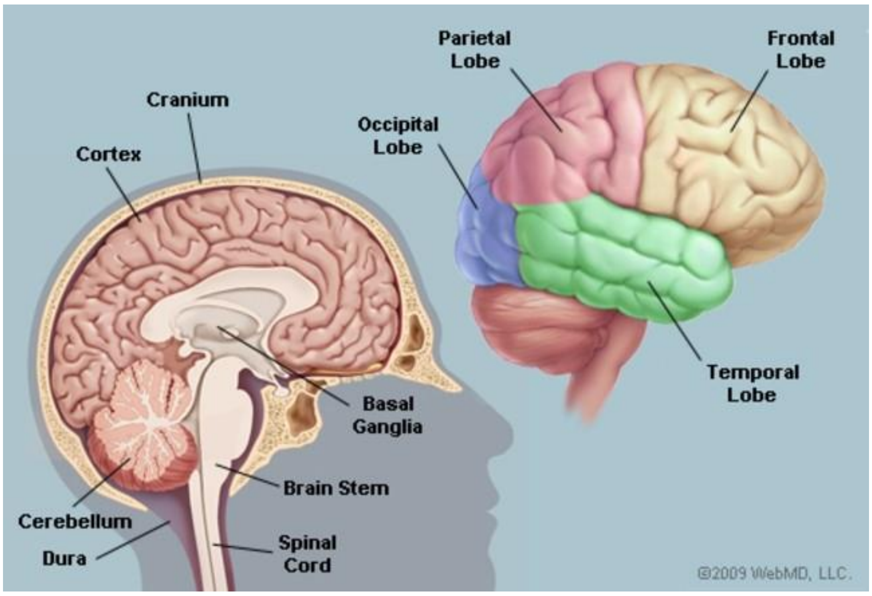

Figure 3.2: Human Brain[15].

3.5 Short-Time Fourier Transform (STFT)

The Short-Time Fourier Transform (STFT) is used to process audio signal as it changes frequently in different time (see in Figure 3.7). It is a very powerful general purpose tool for the processing of audio signal. This method, the longer signal is divided into short equal signals and then calculates the Fourier Transform separately for each signal. It characterizes an especially valuable class of time versus frequency conveyances which determine complex amplitude versus time and recurrence for any signal[21].

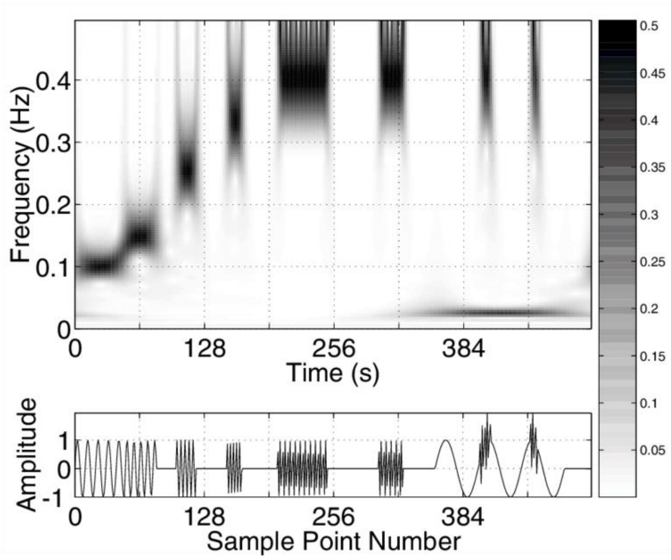

Figure 3.3: Example of STFT [22].

There are two types of STFT. One is continues and another is discrete.

3.5.1 Continues STFT window function:

$$F(\omega,t)=\int_{-\infty}^{+\infty} f(\tau)h(\tau-t)e^{-j\omega\tau}d\tau$$

Figure 3.4: Continues STFT window function [23].

3.5.2 Discrete STFT function:

$$\mathbf{STFT}\{x[n]\}(m,\omega) \equiv X(m,\omega) = \sum_{n=-\infty}^{\infty} x[n]w[n-m]e^{-j\omega n}$$

Figure 3.5: Discrete STFT window function [24].

3.6 Support Vector Machine (SVM)

The full meaning of SVM is Support Vector Machine. The usefulness of the SVM algorithm is to identify a hyper plane in an N-dimensional space that classifies the data set (see in Figure 3.10 and Figure 3.11) .

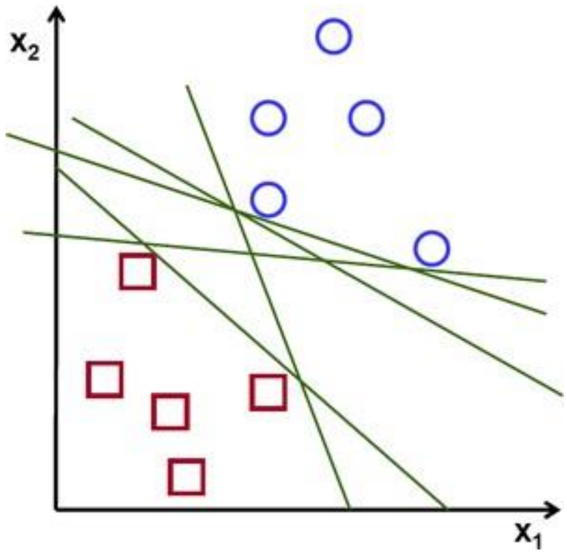

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Figure 3.6: Possible Hyper Plane [25].

To differentiate the two classes of data sets, there can be many hyper planes that could be taken. Increasing the margin distance provides some reinforcement so that

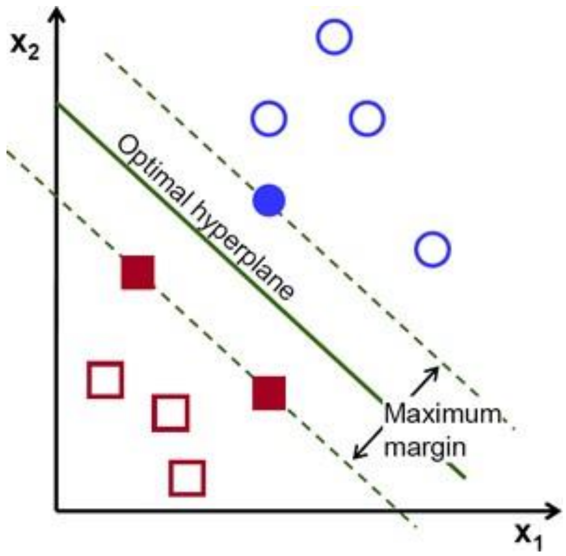

Figure 3.7: Optimal Hyper Plane [26].

future data sets can be classified easily.
Support vectors are data sets that are closer to the hyper plane and manipulate the position and orientation of the hyper plane. By using these support vectors we can increase the margin of the classifiers.

3.7 Wigner Ville Distributions

The WVD is a method that performs time frequency analysis.
It calculates the Fourier transform of the so called ambiguity function
(AF) [AF(tau) = x(t+tau/2)x (t-tau/2)]
AF is a general representation of the signal's auto correlation function. Wigner Ville Distribution gives the best spectral resolution. It basically does the correlation between the left and right folded parts of the signal to find the overlap between the past and future values of the signal. WVD has some nice properties such as marginal properties, energy preserved and support properties.

For a single (mean-zero) time series, the Wigner function is-

$$W_x(t,f) = \int_{-\infty}^{\infty} x\left(t+\frac{\tau}{2}\right) x^*\left(t-\frac{\tau}{2}\right) e^{-2\pi i \tau f}\, d\tau.$$

Figure 3.8: Wigner Ville Equation [27].

3.8 Time Frequency Domain

A time-domain graph is a graph that indicates how a signal changes over time and a frequency-domain graph shows that how much of the signal lies within each given frequency band over a range of frequencies (see in Figure 3.13 and Figure 3.14).

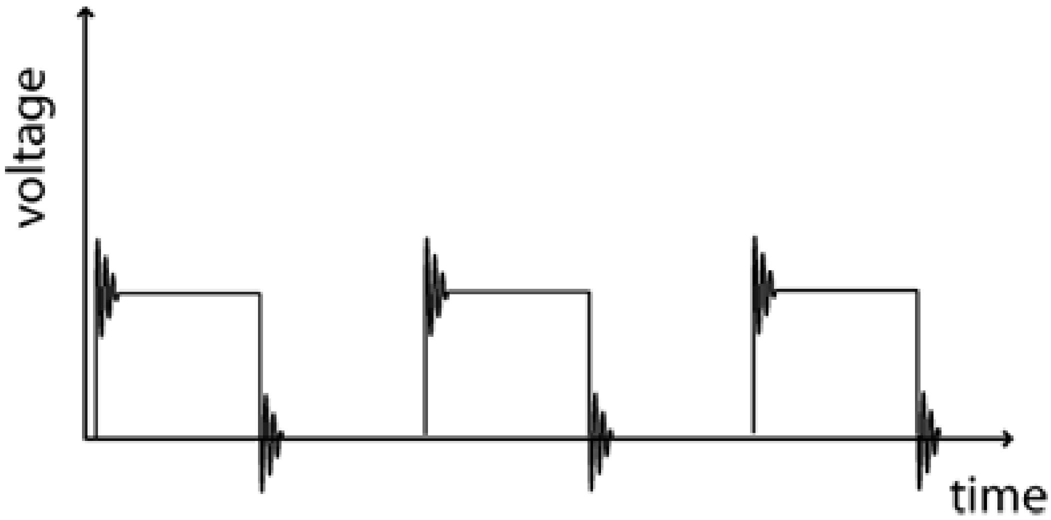

Figure 3.9: Voltage vs Time Graph [28].

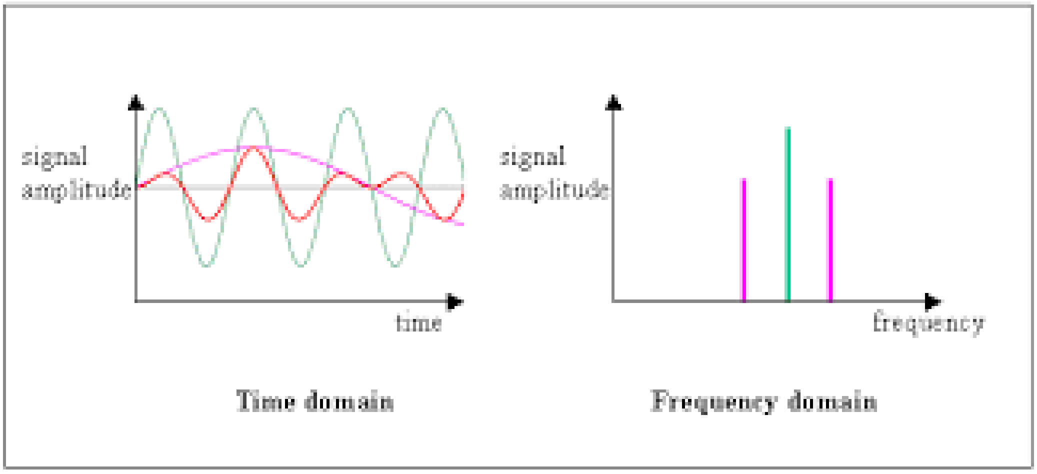

Figure 3.10: Time Domain versus Frequency Domain [29].

We have focused on the different methods and algorithms we have used throughout the research. We have divided this chapter into different parts. We have given basic knowledge about all the topics we have added. Moreover, we have used graphical representation, equations and statistics for the clear view of these topics. We have talked about Neuro Feedback, EEG signal, Short Time Fourier Transformation, Support Vector Machine, Wigner Ville Distribution etc.

In the next chapter, we will discuss about the proposed model of the research.

Chapter 4

Proposed Model

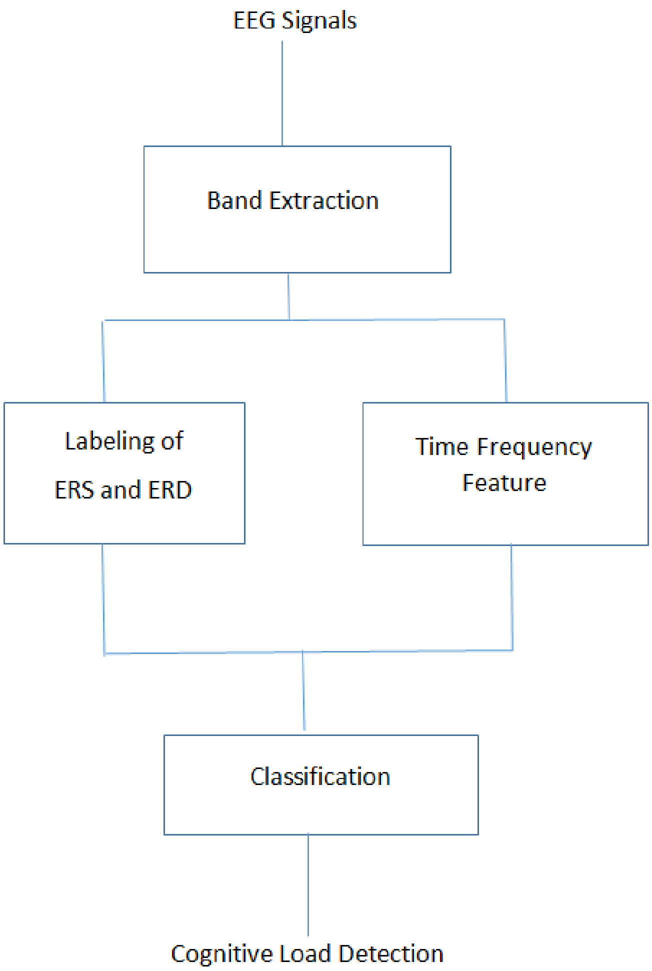

Figure 4.1: Proposed Model for detecting cognitive load.

This proposed model is presented details in later part. First we have discussed about the data-set and how the data were collected. Then we have talked about the different bands extraction and reasons. After that, labelling of ERS and ERD and time frequency features will be discussed. At the end of this chapter, will classify the bands and we will detect the cognitive load.

4.1 EEG Signal

4.1.1 Dataset Description

In this study, we have used a benchmark data set which was taken in the University of Iceland from university building. We have collected our dataset from European Union of Dataeset which is combination of 8 different organization. .The dataset we have is in numerical form and in EDF (Expected Default Frequency) format.
The house they used for research provide various service units such as a bookshop, two restaurants, classrooms, and reading rooms. The building has enough qualified inward places for the requirements of the study and with the use of VIP caretakers and O&M instructors, they planned a way to require the VIP to proceed through circumstances where totally individual levels of cognitive load were probable to occur (i.e. of varying complexity and hardness).The dataset we have is numerical form and in EDF (Expected Default Frequency) file.

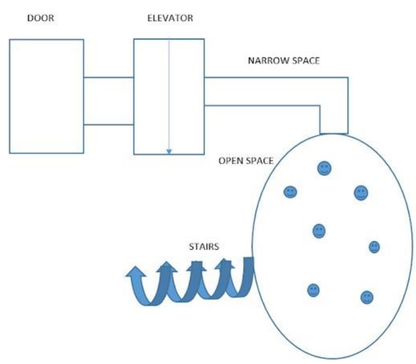

Figure 4.2: Indoor route map for recording EEG Signal

The way associated the entryway at the rear of the structure (START) to the most used appearance at its front (END) and involved five isolated situations ex-pressible of a scope of internal quality difficulties (see Table 4.1). In particular, members needed to enter through programmed entryways (situations An), utilization a partner lift (B), stroll around slender passage (C), continue over a bustling open house (D – principle entrance lobby), and stroll down an enormous winding stairway (E). The manner in which was pretty much 200 m long and was by and large 5 min to walk (go = 4 – 8 min). [7]
EEG was recorded through utilizing the Emotive EPOC+, a convenient headset with 16 dry cathodes enrolling over the 10-20 framework regions AF3, F7, F3, FC5, T7, P3, P7, P8, P4 (DRL), O1, O2, T8, FC6, F4, F8 and FC4. EPOC+ was picked as helpful objectives drew in with a portability study and it additionally gives great trade off among execution and usability concerning other business remote EEG frameworks. They pick EPOC+ in light of the fact that it has various channels and nature of the obtained EEG signals and simultaneously its compactness, planning time and client comfort-capacity.

Table 4.1: Descriptions and Mobility Challenges of the Different Inward Environments.

ID	Description	Challenges
A	Entering through automated doors (two hinged and one rotating)	Finding the push button (hinged doors only), finding where and when to enter the rotating door, other people going through the door at the same time
B	Using an elevator to move between doors	Finding the push buttons (calling the elevator, selecting door), other people existing or entering the elevator
C	Walking along a narrow corridor	Moving people, noise, classroom doors opening suddenly
D	Moving across an open space (in front of the classrooms and at the main entrance hall)	Moving people, standing people, tables, chairs, trash bins, pillars, people talking, loud noises
E	Using stairs to move between doors	Finding start of stairs, people using the stairs in the opposite direction, walk down a large spiral flight of stairs

At present E4 is the most straightforward business multi sensor device advanced dependent on broadened therapeutic examinations inside the zones of psycho physiology and mental registering. Also, this wristband planned as like a watch which is sans link. That is the reason it is increasingly adaptable to wear and extra stylishly wonderful to wear and in this manner higher to fit to use in ambulant estimations contrasted with various wearable bio signal gadgets. Those visual impeded grown-ups were mentioned to put on the wristband at the non-prevailing hand to restrain movement ancient rarities related with dealing with the white stick. Our members practices to strolled the graphed way multiple times as preliminary 1, 2 and 3. A few directions were provided to the members all through the essential stroll to help the VIP to acquaint with the course. They were told that they should get themselves far from futile head moves and hand signals just as addressing their O&M coach except if there was a crisis. Their development and all the assessment they were experiencing have been recorded both sound and video document through an advanced mobile phone camera to encourage realities comment and synchronization. After path 3 members have been approached to clarify awful minutes along the bearing.

4.2 Band Extraction

As mentioned earlier there are few types of signal frequencies in EEG signal and our research is about to detect cognitive load of VIPs. So, we consider 3 band frequencies among 5. They are Gamma band, Theta band and Beta band. We choose these bands because we know that Gamma band has a frequency from 40 to 100 Hz. It increase when separates who are mentally challenged, anxiety, high arousal and stress. The second one is Beta waves. We use this band because they are arouse in conscious thought, critical thinking and tend to have a invigorating affect. Having the perfect amount of beta waves permits us to focus and finish work based chores effortlessly. The third wave that we use for our paper is Theta waves. Too little amount of this wave causes anxiety, depression, hyperactivity, impulsivity and inattentiveness.

4.3 Labeling of ERS-ERD

According to Antonenko [30], the alpha band is increased when event related synchronization (ERS) and decreased when event related desynchronization (ERD) of the tusk interlude with baseline interlude. Based on this literature, we have extracted beta band from test interval and baseline interval of the EEG signals. Then we have applied beta bands to compute the ERS and ERD. Cognitive load of ERSD is calculated by the equation given below:

$$\beta = \frac{\rho_b - \rho_t}{\rho_b} * 100 \tag{4.1}$$

where β is determined as cognitive index, ρ_b is deermined as base line interval of band capacity, and ρ_t is determined as test interlude of band capacity.

4.4 Time-frequency feature

We have extracted entropy feature based on time-frequency distributed signals. For the time-frequency distribution, we have considered well-known signal processing algorithm namely STFT (see details in section 3.3 and 3.7). EEG EPOC+ has 16 channels (see details in section 4.1.1). We have Extracted feature for each sec (i.e., EPOC+) of EEG signal for all channels and also their corresponding annotations of their specific epoch in inward environments.

4.5 Classification

Cognitive load gives a significant calculation of the degrees of psychological attempt of the subject. It is used to calculate various degrees of level difficulty in a broad assortment of undertakings, extending from engine to cognitive chores. Cognitive index gives it’ s focus on computing the problem solving and reasoning of candidates in order to find the outcome. In this study, all subjects and their related thing trials are separated into N subsets, where N is 5. Five-fold cross validation is used during training to generate an optimal model of SVM classifier.

In this chapter we have talked about the proposed model we have used in this research. From the above discussion, we have seen that, there are total five steps which we have followed. Firstly, we have discussed about the data-set and how the data were collected.

Then we talked about the different bands extraction and reasons. After that, labelling of stress and time frequency features will be discussed. At the end we will classify the bands and we will detect the stress.

In the next chapter, we will focus on the result and discussion of our research.

Chapter 5

Results and Discussions

In this research, cognitive load is measured based on extracted features from permutation entropy. Each of the inward situation gives different results for nine participants. Total of two features extracted from each band and each channel of EPOC+ considering 1s window. In these situations there are three factors considered for results i.e. sensitivity, specificity, accuracy. The sensitivity, specificity and accuracy are measured from confusion matrix determined as-

Sensitivity refers or mean as True Positive Rate (TPR) or recall. Sensitivity is measured as the number of True Positive Rate (TPR) divided by the summation of True Positive (TP) and false-negative (FN). The best Sensitivity score is '100' and the worst score is '0'.

$$SN = TP/(TP + FN) \tag{5.1}$$

Specificity refers or mean as True Negative Rate (TNR). Specificity is measured as the number of True Negative Rate (TNR) divided by the summation of False Positive (FP) and True Negative (TN).The specificity score is better to have a higher value. The best score for specificity score is '100' and the worst is '0'.

$$SP = TN/(TN + FP) \tag{5.2}$$

Accuracy is computed by the ratio of all true predictions to the total data set.The best score for accuracy is '100' and the worst score is '0'

$$ACC = (TP + TN)/(TP + TN + FP + FN) \tag{5.3}$$

Table 5.1: Result of Different Inward Environments.

Obstacles	Sensitivity(%)	Specificity(%)	Accuracy(%)
Door	78.26	78.72	77.35
Narrow Space	84.55	81.55	82.78
Open Space	85.71	87.71	84.91
Elevator	92.35	86.36	88.99
Stair	79.91	78.40	79.19
Moving Object	87.72	84.62	83.47
Sound	87.10	88.89	86.89

We have found the sensitivity, specificity and accuracy for different inward obstacles like door, elevator, moving object, open space, sound, stairs, narrow space. We found the mean classification rate from which we have calculated the distinct classification measurement of sensitivity, specificity, and accuracy which is shown in the table.

From the Table 5.1, we can see that, in the door we got least amount of sensitivity, specificity and accuracy. The sensitivity, specificity and accuracy are very close to stair as door.However, in elevator participants mean sensitivity and accuracy are the highest. In terms of specificity sound got the highest and for accuracy participants mean highest is in elevator. For the moving object and sound, sensitivity, specificity and accuracy are pretty similar. Though the sensitivity is almost same for the open space and narrow space, the specificity is a bit different.

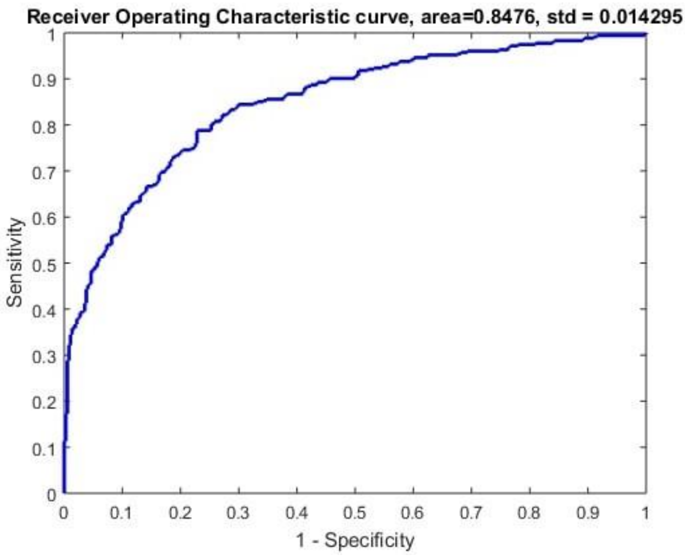

Figure 5.1: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of door.

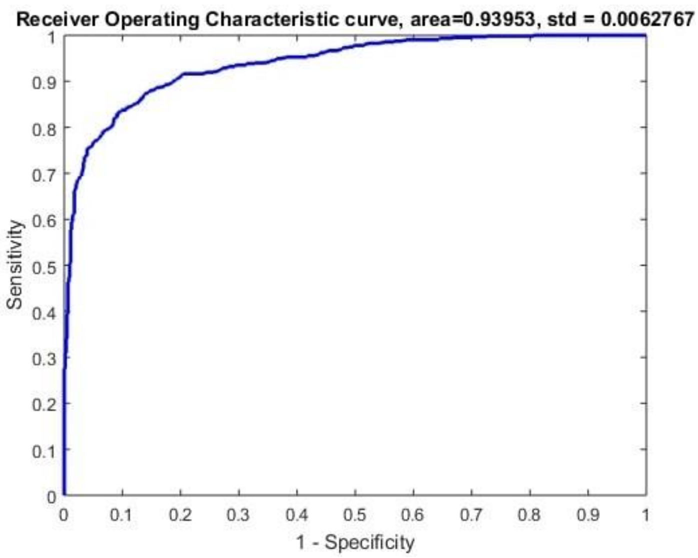

Figure 5.2: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of elevator.

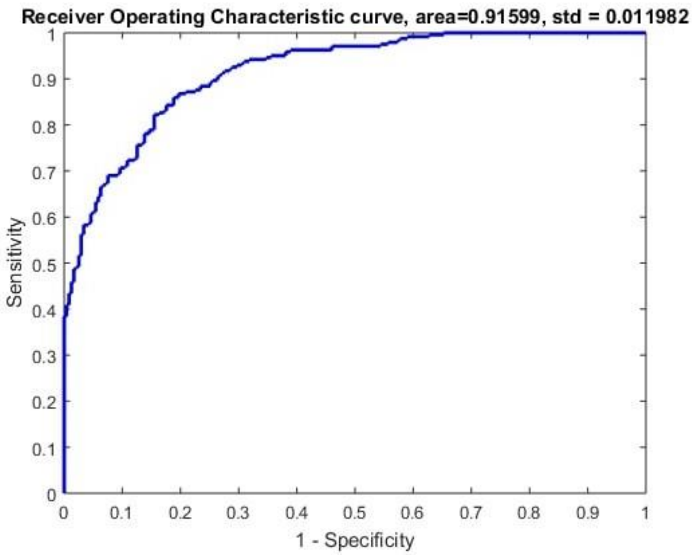

Figure 5.3: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of moving object.

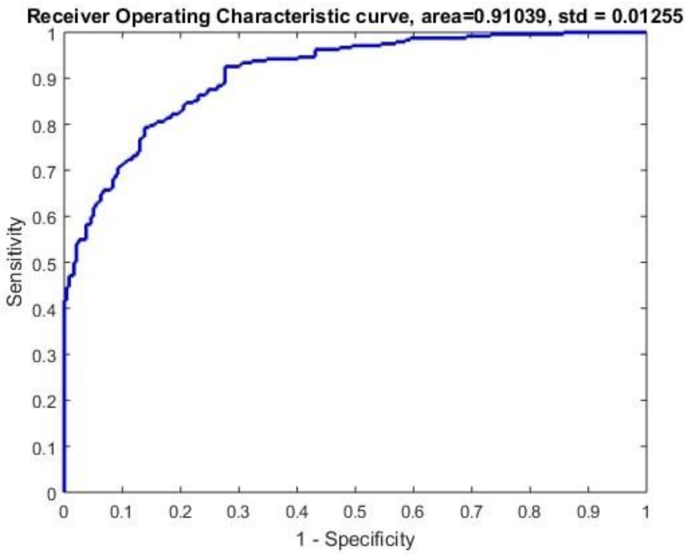

Figure 5.4: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of open space.

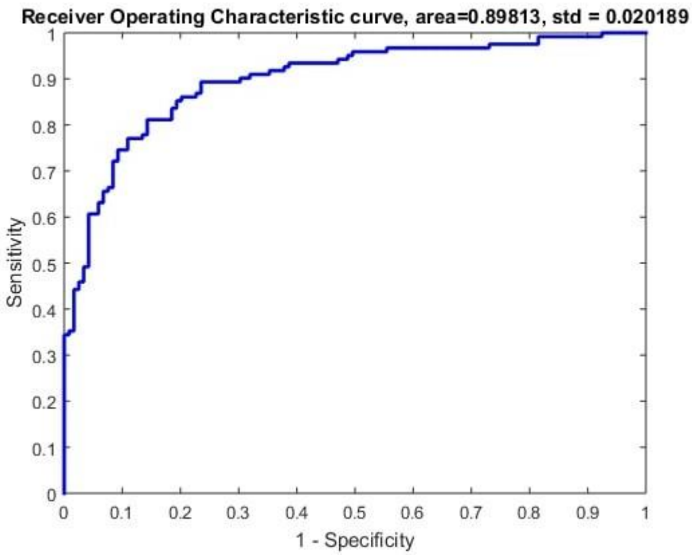

Figure 5.5: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of sound.

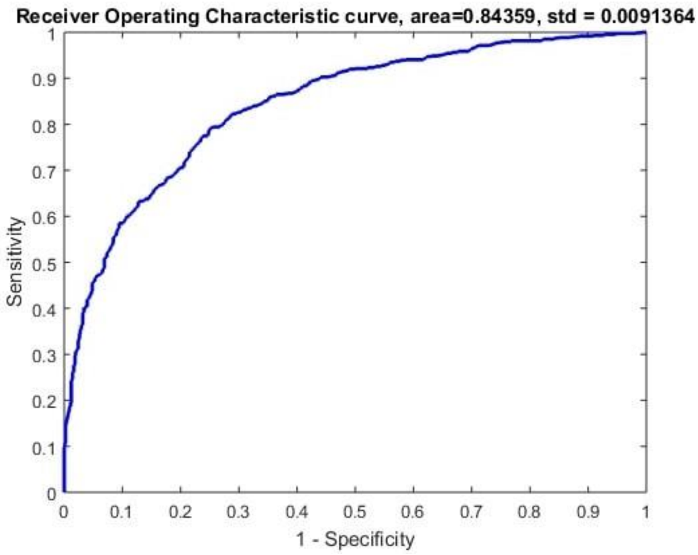

Figure 5.6: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of stairs.

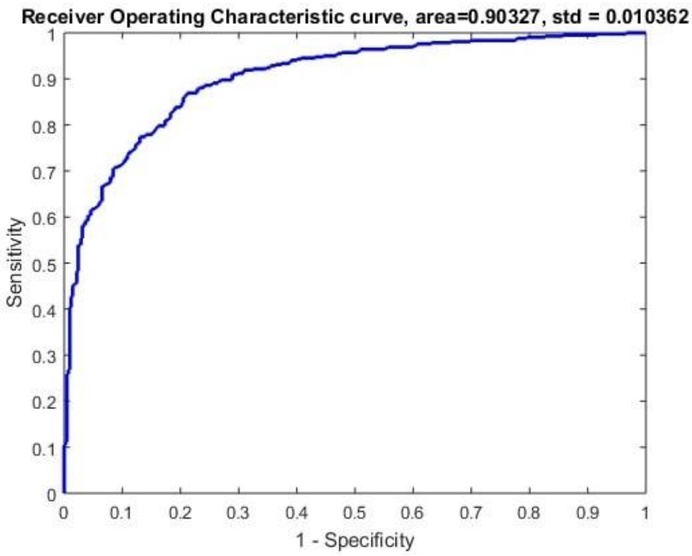

Figure 5.7: The ROC curve of the training and test EEG signals acquired from visually impaired in the obstacle of narrow space.

5.1 Discussions

All the graph from Figure 5.1 to Figure 5.7 are sequentially for automated door, elevator, moving object, open space, sound, stairs, narrow space. These graphs are based on sensitivity versus specificity for particular obstacles. Figure-5.1 is for automated door. It shows that, this graph has an area of 0.8416 and std is 0.014295 which is mean value of the participants.

Figure-5.2 is for elevator. It demonstrates that, this graph has an area of 0.93953 and std is 0.0062767 which is mean value of the participants. On the other hand, Figure-5.3 is for elevator. From this figure, we can see that this graph has an area of 0.91599 and std is 0.011982 which is mean value of the participants. Figure-5.4 is for elevator. It shows that, this graph has an area of 0.91039 and std is 0.01255 which is mean value of the participants.

Figure-5.5 is for elevator. It shows that, this graph has an area of 0.89813 and std is 0.020189 which is mean value of the participants. Figure-5.6 is for elevator. It shows that, this graph has an area of 0.84359 and std is 0.0091364 which is mean value of the participants. Figure-5.7 is for elevator. It shows that, this graph has an area of 0.90327 and std is 0.010362 which is mean value of the participants.

We use these results to observe the usability testing of navigating tools.These results indicates us that for sound the accuracy is higher and for using automated door the accuracy is the lowest. We can clearly determine that for automated door accuracy needs to be higher.

Chapter 6

Conclusion

Mobility aids for vision impaired people should have the capability of implied adaptation. To help the VIPs who are partially or fully blind making the mobility system can be considered as impressive and noticeable advantages. Considering cognitive load for making the mobility system can be good advantages also. People' s cognitive load can have quite good amount of noticeable impacts in the process of detecting cognitive load. EEG signals are used for determine cognitive load for the VIPs. EEG is a widely used tool for recording brains activity. EEG signals are recorded from participants who have separate degree of sight loss. Giving those participants some tasks and in that time, recording EEG signals from their brains activity. A classification accuracy of 77.35% for automated door (Sensitivity 78.26% and Specificity 78.72%), 82.78%of accuracy for narrow space (Sensitivity 84.55% and Specificity 81.55%), 84.91% of accuracy for open space(Sensitivity 85.71% and Specificity 87.71%), 88.99% of accuracy for elevator (Sensitivity 92.35% and Specificity 86.36%), 79.19% of accuracy for stairs (Sensitivity 79.91% and Specificity 78.40%), 83.47% of accuracy for moving objects (Sensitivity 87.72% and Specificity 84.62%) and 86.89% of accuracy for sound (Sensitivity 87.10% and Specificity 88.89%), which was achieved by the proposed model. Results shows that cognitive load is significantly upgraded regarding different types for environmental situations in inward environment.

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