

BRAIN AUTOMATION SYSTEM

Session: 2013-2017



SUBMITTED BY

Abdul Rahman	BSSE-14337
M.Bilal Khan	BSSE-14339
Umer Mehmood	BSSE-14343
Shahbaz Javed	BSSE-14345
Taimour Hamayoun	BSSE-14349

Submission Date: 27 November, 2017

Program

BS Software Engineering

Computer Science & Information Technology,

Superior University, Lahore

CERTIFICATE

It is certified that **M.Bilal Khan** (Registration No. BSSE-14339), **Abdul Rehman** (Registration No. BSSE-14337), **Shahbaz Javaid** (Registration No. BSSE-14345), **Taimour Hamayoun** (Registration No. BSSE-14349), **Umer Mehmood** (Registration No. BSSE-14343) has carried out all the work related to this project under my supervision at the Faculty of Computer Science and Information Technology, Superior University, Lahore, Pakistan and the work fulfills the requirements for award of Master of Information Technology degree.

Date: 8th November, 2017

Supervisor

Mr. Talha Irfan
Lecturer, Faculty of CS &IT

Head of Department

Dr. Nadeem
Ahmed
HOD, Faculty of CS
&IT

ABSTRACT

In human brain, either in the state of wakefulness or sleeping, different frequency changes are observable in the spectrum of measured electric signals of the brain [1]. Regarding the frequency components of these signals that occur as a consequence of this electric activity, different brain waves can be distinguished. The electric impulse alternations that generated during the operation of neurons can be measured by the EEG (Electroencephalography) device. In the past, devices that could measure these brain signal alterations were mainly used in medicine. However, in the past few years cheaper and user friendly brainwave signal processing units have become available and the use of this technology has expanded. As a result, a prototype has been implemented that comprises analysis, transformation, and classification through a linear discriminant analysis of the recorded signals and that allows device control through the means of brain signals. In addition to the evaluation whether the concept is working, a number of possible further improvements and considerations are given in order to achieve a more mature state [1][2].

DEDICATION

DEDICATE

To

Our Parents, Teachers and Paralyzed People

ACKNOWLEDGEMENTS

Alhamdulillah, all praises to Allah Almighty, the most Merciful and the most Gracious, for the strengths and His blessings in completing this Project. Working on this project was indeed a challenging task that demanded immense efforts. But we feel proud to express our deepest sense of gratitude and appreciation to our Supervisor **Mr. Talha Irfan** for his kind help, advice, inspired guidance, unlimited support, sympathetic attitude and sincere personal involvement throughout the development of project.

Special thanks to **Miss. Amna Khan** and **Mr. Khurram Jilani** who provided us all the guidance throughout the project.

We would never have been able to reach this stage but for the prayers and great support of our families. Thanks and best wishes for all those who have made this learning experience
so
wonderful for us.

Table of Contents

CERTIFICATE	2
ABSTRACT	3
DEDICATION	4
ACKNOWLEDGEMENTS	5
List of Tables	9
List of Figures	10
List of Abbreviations	11
.....	12
CHAPTER 1	12
1.1 Introduction to the problem	13
.....	15
CHAPTER 2	15
2.1 Literature Review.....	16
2.1.1 Introduction to BCI.....	16
2.1.2 History of BCI.....	16
2.1.3 Types of BCI.....	17
2.1.4 Invasive BCI	17
2.1.5 Partially invasive BCIs	17
2.1.6 Feature of ECOG	18
2.1.7 Non Invasive BCI	18
2.1.8 Application of BCI.....	19
2.1.9 Medical	19
2.1.10 Games and Entertainment	19
2.1.11 P300	19
2.1.12 P300 Components	20
2.1.13 Introduction to EEG.....	20
.....	21
2.1.14 History of EEG	21
2.1.15 Types OF EEG.....	22
2.2 Existing Solutions	23
2.3 Proposed Solution	23
.....	24
CHAPTER 3	24
3.1 Feature Extraction Algorithms.....	25

3.1.1 SVM.....	25
.....	25
.....	28
3.1.2 Introduction of Fourier Transformation.....	28
3.1.3 Discrete Fourier Transformation.....	29
3.1.5 Regression Analysis.....	33
3.1.6 PCA.....	38
3.1.7 Wavelet Transform	41
3.2 Languages	52
3.2.1 Matlab Programming	52
3.2.2 C Language	52
3.2.3 Python	53
3.3 Applications	53
3.3.1 Matlab R2016.....	53
3.3.2 IDLE 2.7	53
3.4 Libraries	54
3.4.1 Thinkgear	54
3.4.2 Svmlibs	54
3.4.3 Scikit	54
3.4.4 Numpy.....	54
3.4.5 Nled.....	54
.....	55
CHAPTER 4	55
4.1 Summary.....	56
4.2 Conclusion	56
.....	58
CHAPTER 5	58
5.1 User Manual.....	59
5.1.1 Introduction.....	59
5.1.2 System overview	59
5.1.3 Trouble shooting	59
5.1.4 Usage of Mindwave	60
.....	62
CHAPTER 6	62
6.1 Lessons Learnt and Future Work / Enhancements	63
6.1.1 Lesson Learnt.....	63
6.1.2 Future Work / Enhancements.....	64

.....66

CHAPTER 766

 7.1 Bibliography67

 7.1.1 References67

Appendices.....71

 8.1 Appendix A71

 8.1.1 Team Structure71

 8.1.2 Roles & Responsibilities71

 8.1.3 Time Table73

 8.1.4 Budgeting74

 8.1.5 Experimental Results74

 8.2 Appendix B76

 8.2.1 References76

 8.3 Appendix C80

 8.3.1 Indexes80

List of Tables

Table 1: Logistic function.....	37
Table 2: Roles & Responsibilities.....	71
Table 3: Time Table.....	73
Table 4: Budgeting.....	74
Table 5: Experimental Results 1	74
Table 6: Experimental Results 2	75

List of Figures

Figure 1 man with a wheel chair.....	13
Figure 2 BCI	16
Figure 3 types of bci	17
Figure 4 BCI	19
Figure 5 Showing decesion choice	20
Figure 6 Man with Electrodes on his scul.....	21
Figure 7 recording EEG signals	22
Figure 8 SVM classification	25
Figure 9 Best hyper plan	25
Figure 10 find the best hyper plan	26
Figure 11 hyper plan	26
Figure 12 classes with Outlier.....	27
Figure 13 SVM with Z-axis	27
Figure 14 SVM with nom-linear classification.....	28
Figure 15 Example of Fourier transform	29
Figure 16 Discrete Fourier transform	30
Figure 17 Example of Fourier series.....	31
Figure 18 Example of Fast fourier transform	31
Figure 19 Example of DST	33
Figure 20 interpolation & extrapolation	34
Figure 21 linear regression.....	35
Figure 22 Logistics regression model.....	36
Figure 23 Logistics regression probability analysis.....	37
Figure 24 PCA reducing 2D data into 1D.....	38
Figure 25 This is how PCA works	40
Figure 26 Wavelet representation	42
Figure 27 wavelet and fourier transform representation on time domain.....	43
Figure 28 Wavelet vs fourier transformation.....	44
Figure 29 Time frequency domains	44
Figure 30 Wavelet Compression for transient signals	45
Figure 31 Continuous wavelet transform with positive scale factor.....	46
Figure 32 De Noising process.....	47
Figure 33 Malaat example	50
Figure 34 Malaat	50
Figure 35 Orignal image with no noise.....	51
Figure 36 one with noised and on is De noised image	52
Figure 37 Mindwave wearing method	60
Figure 38 Telling wearing method.....	60
Figure 39 Adjust Ear clip.....	60
Figure 40 Should be closes to left eye	61

List of Abbreviations

Sr.No	Abbreviations	Page Number
1	Brain computer interface (BCI)	16
2	Eastern Cooperative Oncology Group (ECOG)	18
3	Event Related Potential (ERP)	19
4	Electroencephalogram (EEG)	21
5	Support Vector Machine (SVM)	25
6	Discrete Fourier transformation (DFT)	29
7	Fast Fourier Transformation (FFT)	30
8	Discrete Sine Transform (DST)	32
9	Principal component analysis (PCA)	37
10	Brain Automation System (BAS)	55



CHAPTER 1

1.1 Introduction to the problem

Millions of the people around the globe are facing physical challenge in form of physically disabilities such as paralysis, bone diseases and join disorder, Tumors, Brain disorder, sleep disorder. People with such physically challenges are unable to even, enjoy most common activities of a living being such as movements, speaking or doing any normal physical activities. Such people are always dependent on other individuals just to carry out simple task of daily life. Till this date minor research and development has been published or seen in context to brain computer interaction and brain interfacing (BCI).

We believe you are not dead till your brain is functional. What if we handover the control of a physically challenge person who cannot control his/her body but he/she may control general daily activities of a normal person such as controlling appliances, wheel chair or even the bed they lay on just by their thoughts.



Figure 1 man with a wheel chair

Many institutions around the globe are working on brain computer interaction (BCI) but very few institutions or individuals are doing actual development in this vary context.

We wish to develop a unique and easy to use solution for such individuals who are facing the great challenge of physical disabilities.

Our project BAS (Brain Automation System) is going to refine the EEG signals and with those refine signals we will perform some action. The trend is moving towards the smart technology, people want solutions in smart way and want to have access to their solution in easiest and relaxing. Our project is catering the solution for those people also who are disable. This is completely research based project and for future aspects we want to control everything with brain to serve the humanity. Now a days, most of the research is being happening on BCI(brain computer interface) in different universities of the world like in China and United States for different purposes, we want to continue this research in Pakistan Because we want Pakistan to be stand in the list of such countries which are now a days serving people through technology.



CHAPTER 2

2.1 Literature Review

2.1.1 Introduction to BCI

Brain computer interface helps to provide a transmission way among human brain and the computer system. The main purpose of BCI work is to establish a system that allows paralyzed people to collaborate with the outside environment and helps to interact with the third person. In the 1970s the research on BCI began at University of California, Los Angeles under the allocation from the National Science Foundation. After their great work in BCI research their paper publication is considered the first presence remarks Brain Computer Interface in the history of scientific literature. The field of BCI research has mainly focus on application called Neuroprosthetics and in this application it main focus on recovered injured sight, hearing movement [1] [2].



Figure 2 BCI

2.1.2 History of BCI

The history of BCI began with psychiatrist named Hans Berger invention of EEG Signals. In 1924 Hans Berger was the first person that able to record EEG signal. He has used the silver foil wires and that attached to the patient head with rubber bandage and used Siemens double coil galvanometer for recording and found some compact alteration in his EEG wave diagram. So EEG acceptable a new capabilities for the research of human brain activities. This was the great achievement of Hans Berger and it will be benefit for the scientist in the field of human brain research work. Jacques Vidal was the professor of University of California Los Angeles develop the first peer writing on the Brain Computer Interface. In BCI community Vidal was known as the Inventor of BCI and their article was mostly reviewing and explain in the fields. After their contribution Vidal Gave lecture in Graz, Austria on this topic and got the standing

ovation from the audience. Everyone their like their work and paper about BCI. In 1977 Vidal presented an experiment which was displayed on a maze and based on noninvasive EEG. This EEG noninvasive was control on a cursor which is similar to graphical object on a computer screen. In 1988 the experiment on physical object, a robot was given and it bases on noninvasive that control the physical object. In this experiment EEG describe the control of the robot movement like start, stop and restart. Along an arbitrary which defined by a line drawn on a floor. The behavior of line-following was the default robot behavior and autonomous source of energy [3].

2.1.3 Types of BCI

- 1) Invasive BCI
- 2) Non Invasive BCI

2.1.4 Invasive BCI

Invasive BCI is provided a new process for paralyzed people and also focused on recovered the damage sight of paralyzed people. During neurosurgery of brain the invasive are fix straightly into the grey matter. Because they exist in the grey matter, highest quality of signals are produced by invasive device of a BCI device but are flat scar tissue made up, generate the signal to become weaker, or even the negative and as foreign object in the brain react with the body [4] [5] .

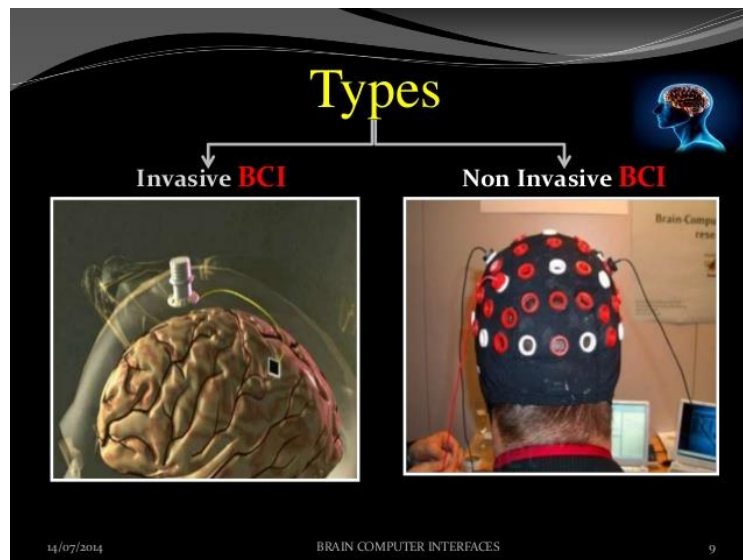


Figure 3 types of bci

2.1.5 Partially invasive BCIs

Partially Invasive BCI are fix inside the skull and quiet outside the brain instead of slightly with in the grey matter and produce the better determination signal than non-

invasive. Partially Invasive BCI have a low possibilities of organize scar-tissue when it analyze with invasive BCI which have high possibilities of organize scar-tissue where the bones tissue of the cranium changes and scarred signal. Electrocorticography and non-invasive have same process to record electrical movement of the brain seized under the skull. Under the dura mater and above the cortex electrodes are joined in a thin plastic pad. In 2004 Eric Leuthardt and Daniel Moran from Washington University in St Louis were first analyze ECOG technology in humans [6].

2.1.6 Feature of ECOG

It has higher dimensional resolutions, good signal for noise to ratio, broader frequency range, scalp recorded EEG require more training requirement but it required less training than the scalp recorded EEG, there is less chance of technical fault, having less clinical risk it also have possibility to retain long term than recording of signal neuron the so that why ECOG is very talented BCI medium process Domain. In the domain of theory the develop BCI are fix and would engaged to fix a laser inside the skull. Single neuron is trained by the laser and separate sensor are required for the measure the reflectance of neurons. The wavelength and laser light it reflect would lightly change when the neurons are fire. This would help the researcher to supervise the signal neurons but it need less connection with tissue and overcome the possibilities of made up the scar tissue [7] [8].

2.1.7 Non Invasive BCI

Non Invasive BCI based on the EEG based Interface. Noninvasive EEG do not required any surgery and it's easy to wear. Non Invasive are just like to wearable virtual reality devices. Due to the skull has sprinkle signal, scattered and darken the electromagnetic generated by neurons so that why they cannot used higher frequency signal and have approximately poor dimensional resolution. Noninvasive required the training and also some time to complete the training without training Noninvasive does not work well and does not produced the result well and in Invasive does not required the training first. The best BCI depend on their feature. When it compare it is the most save than the other types [9].



Figure 4 BCI

2.1.8 Application of BCI

BCI have a variety of application in the field of research and they are concerned in games and entertainment, medical, educational and security [10] [11].

2.1.9 Medical

There are number of application in medical field that could take advantage an use of brain signal in affiliate phases include detection, restoration , diagnoses , prevention and rehabilitation [12].

2.1.10 Games and Entertainment

In games and Entertainment field BCI pay an important role. In Football game two player can play game and score the goals by connecting the two BCI devices and move the player by imagine left and right hand movement. Brain Ball have been explain by Tan and Nijholt and this game include to control their stress level and by relaxing their stress level the player can move the ball if one player will be more peaceful then the other player so he can will the game and so the player would able to control their stress level until when the stress level will divert. This game is fully based on EEG.

2.1.11 P300

P300 wave is a component of ERP (Event Related Potential) and in the process of decision making P300 is obtained. It is mostly obtain by using the oddball paradigm. In oddball paradigm lower possibilities target components are united with high possibilities non-target. During recorded by EEG it cover like positive deviation in the voltage with a delay of approximately 250 to 500ms. Covering the parietal lobe the

signal is usually strongly measured by the electrodes. Cognitive function used as a metrics in the decision making process because of the magnitude and timing of signals.

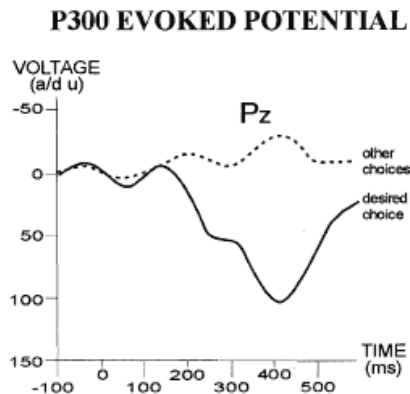


Figure 5 Showing decesion choice

This ERP components for neural substrates should be hold unclear, the universality and regenerate of this signal make usual selection for the psychologist test and also used both in the laboratory and clinic.

2.1.12 P300 Components

1- P3a

It show maximum amplitude across the central electrodes sites so that's why it has a positive going amplitude and have range with delay between the 250- 280ms. With the brain activity P3a has been affiliated relevant to the going out of attention.

2- P3b

It also have a positive going amplitude also have different peak delay of 250-500ms or more depend upon the work and P3a have peak of 300ms. Across the parietal brain areas the amplitude mostly highest on the scalp. For the study of cognitive processes P3b is the most extended tools used [13] [14].

2.1.13 Introduction to EEG

EEG is the process of recording the electrical movement of the brain from the scalp. The waveforms which were recorded are assumed to display the movement of the shallow of the brain, the cortex. This movement is change by the electrical movement from the brain network lower the cortex. The Brian contains nerve cell which produced the signals that are called action potential and these action potential moves form one cell to another over the gaps called synapse. Neurotransmitters are playing an important

role and move the signals over the gaps. Neurotransmitters have two types one will allow the action potential to move to the next cell and second does not allow to move the next cell it will stop the movement. It's difficult for brain to hold the same quantity of each of these neurotransmitters. EEG has approximately frequency 30 Hertz (Hz) because EEG is quite very small and measured in microvolts [15] [16].



Figure 6 Man with Electrodes on his scul

2.1.14 History of EEG

The history of EEG was started in 1875 a physician named Richard Caton doing their work in Liverpool and presents their work and his finding about electrical process of the discover of analytical division of rabbits and monkey in the British Medical Journal. In 1924 a German Physiologists name Hans Berger was the first person to record the EEG activity and also took the work of previously done physician Richard Caton operates on animals. The discovery of Richard carton was the motivation of Hans Berger.

The discovery of EEG was the major breakthrough I n the history of researchers and recorded human brain movement. By evaluate EEG element Berger was successful to described oscillatory movement and he gave the name of Berger wave also called the alpha wave having frequency (8-13) Hz. Firstly Berger recording device was simple and this process was not give the accurate value after he put silver wires inside the scalp of his patients. After those silver wires were replaced by silver foils for more accurate result and silver foils were connected to the patients head with rubber bandage. Berger used Lippmann Capillary Electrometer and connects this sensor with it and he found that the result was not accurate and not satisfy their requirements then he used more accurate measuring device which show electric voltage as small as one tenth thousands of voltage name Siemens. Siemens have double coiled galvanometer and this time

Berger was led to success and found some alternation in waveform and which is how in his EEG wave diagram [17] [18].

2.1.15 Types OF EEG

1- Routine EEG

A routine EEG recording mostly 20-30 minutes and it's also include the operation time and used scalp electrodes for recording. Routine EEG also used in to determine the epileptic seizures such as syncope from other types of spells. For brain death test it's also used as appendage. At times, especially when it is essential to record he or she is having a seizures then a routine EEG is not enough. In this situation patient should grant to hospital for few days and for one week and EEG recording will be continue along with time integration video and audio recording. This recording will give the accurate information about epileptic seizures and show there is a spell occurs in it or not and also identifies the point where seizures activity emerges.



Figure 7 recording EEG signals

2- Prolonged EEG

Prolonged EEG recording takes 1-2 hours and it will be done with video and also done without video [19] [20].

3- Ambulatory EEG

Ambulatory EEG recording take place at sick person home without patient admitted in the hospital. This is usually taken 1-3 hours for recording the EEG. The recording length will be different using the video or without using the video [19] [20].

2.2 Existing Solutions

Many people around the world worked on EEG signals. They used the EEG signals got from a person's mind and make them useful by performing some actions through them. Like people used mind signals for turning LED on or off. But no one noticed that in our skull there are huge number of signals that are travelling because a human can think many things at a single time so that every signal has different frequency and they acts like noise for the signals which are considered to be used for performing some action. No one worked on the filtration of the mind signals till now.

2.3 Proposed Solution

The BAS team took an initiate to fill this gap. The aim of BAS is to provide revolutionary change and consultancy to customers on their door steps. We structured our services flexibly, innovatively and responsively around the needs of customers.

We have designed a headset which will interpret EEG waves of human mind. Then we applied feature extraction algorithms to remove noise and get the required EEG signals and will trigger actions against the purified signals. Our headset will read thoughts of the user through EEG waves and will perform desired action i.e. moving wheelchair, controlling appliances etc.

Our major focus is to remove or ignore that signals which acts like noise for the useful signals. We have done it with feature extraction algorithms for perfection of commands through EEG signals. It is more convenient to control something with your mind instead of performing some physical action to control.

Brain is only one thing that can work even after death of the person. This thing give us idea that disabled person have active brain and they can use it for performing those actions which they cannot perform physically.

Actually we focused on the disabled people who cannot perform some actions because of their weaknesses and they dishearten themselves by looking at the normal people who are living their lives happily. We are giving opportunity to the disabled people to live their lives normally. We worked on removing the flaws of the disabled people so that they can enjoy each and every aspect of their lives. Our moto is to serve humanity.



CHAPTER 3

3.1 Feature Extraction Algorithms

3.1.1 SVM

Support Vector Machine (SVM) is an algorithm which is used in machine learning for classification and regression problems. Mostly it is used for classification. In this algorithm, we put each data component in terms of point in a space which has n -dimensions (where n denotes the number of features) with each feature's value of actual coordinates. Then classification is done by finding a plane called hyper plane that divides the two classes.

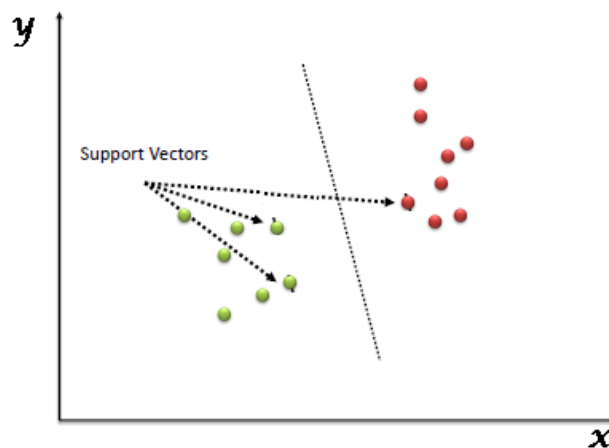


Figure 8 SVM classification

Working

3.1.1.1 Find the Best Hyper Plane

Consider the following diagram, It has three hyper planes denoted with A, B and C. Now SVM have to select a hyper plane which divides star and circle. The rule for selecting the right hyper plane in SVM is to select that plane which divides them properly. In this diagram the plane B separates them properly.

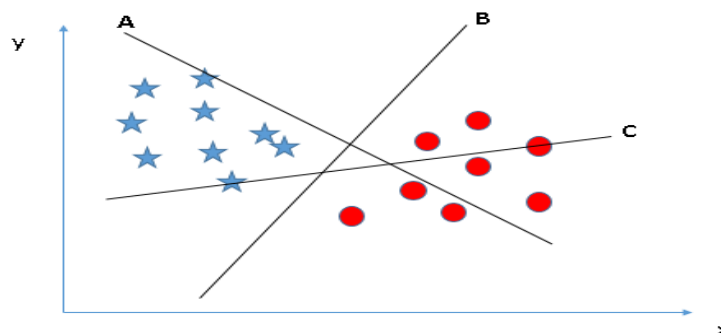


Figure 9 Best hyper plan

3.1.1.2 Find the Best Hyper Plan

Consider the following diagram, It has three hyper planes denoted with A, B and C. In this example all the planes are dividing them well. But SVM have to identify which is best among those three.

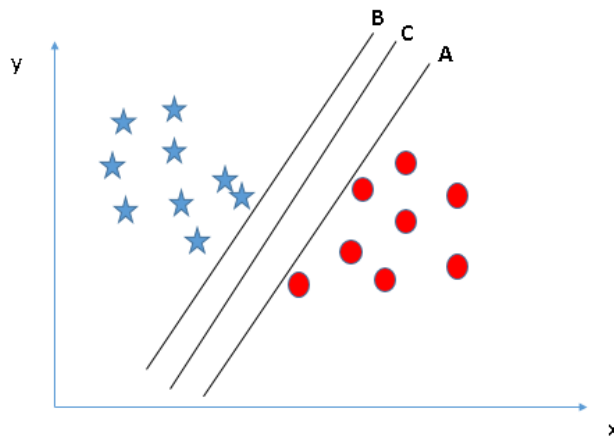


Figure 10 find the best hyper plan

In this situation SVM identifies the margins of the planes to their nearest data point and selects the plane which has maximum distance from the nearest point.

In above diagram hyper plane C has maximum distance from the nearest point meanwhile A and B has minimum distance. If a hyper plane is selected which has low margin so it may cause miss-classification.

3.1.1.3 Find the Best Hyper Plane

Consider the following example

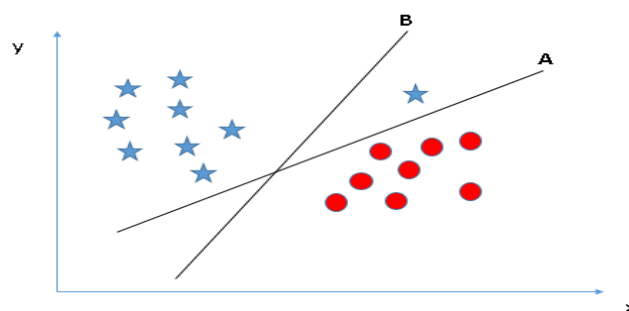


Figure 11 hyper plan

In this diagram, plane B has maximum distance from the nearest data point as compared to plane A. SVM choose the hyper plane which separate the classes in a way that

classifying the classes perfectly has high priority than having maximum margin. In this diagram plane B does not separate both classes perfectly while plane A does, regarding plane B has maximum margin. So, SVM will select plane A which separates them accurately.

3.1.1.4 Find the Best Hyper Plane

In the following diagram we can see that other end has one star which does not belongs to his class. This type of data points (star) are called outliers. SVM ignores those type of outliers and identifies the hyper-plane with maximum margin from the nearest data point. This shows that SVM is firm to outliers.

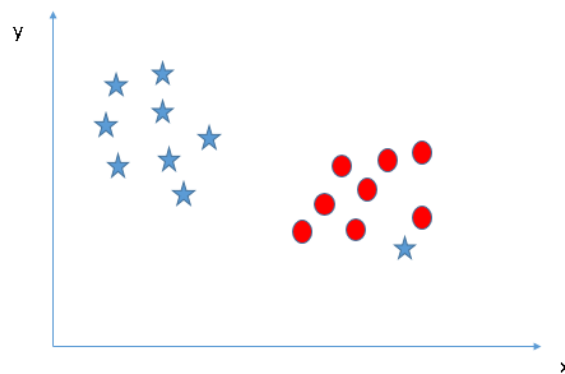


Figure 12 classes with Outlier

3.1.1.5 Find the Best Hyper Plane

In this example we can see that it is very difficult to classify these classes. We have done linear classification above but now we need another method for classification of these type of problems. SVM solves this problem in a very smooth way. SVM adds a new coordinate z along with x and y-axis. After adding z-axis we will get this data in the following form

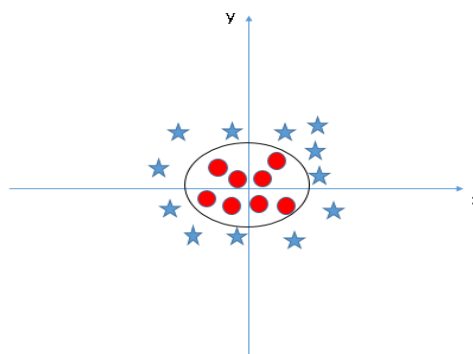


Figure 13 SVM with Z-axis

Classification of these classes is very easy for linear hyper plane but for non-linear classification we need a strong algorithm. SVM has an algorithm called **kernel trick** which performs non-linear classification. Actually kernel trick takes a space with low dimensions as an input and convert it to a high dimensional space. After applying kernel trick on above data we will get the following data as output. We can easily see that the hyper plane we get in this example is a circle due to high dimension spacing.

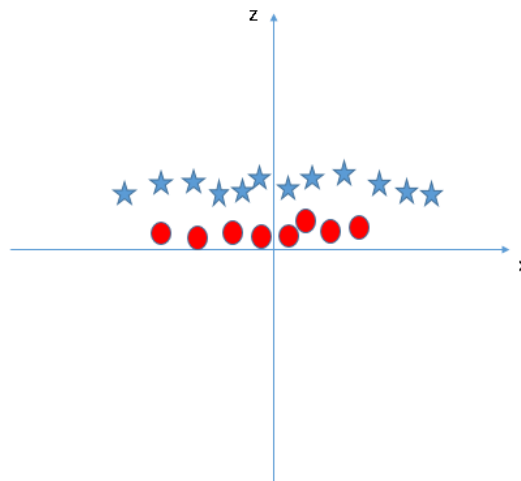


Figure 14 SVM with non-linear classification

3.1.2 Introduction of Fourier Transformation

The Fourier transformation converts the signal domain into frequency domain. Fourier transformation derived from Fourier series. The Fourier series are complex but in term of periodic function can be represented as sum of simple wave and mathematically periodic function can be represented by sine and cosine. Fourier transformation is a delay of Fourier series so that's why at a time representation function result is expand and allowed to achieve the infinity. Using an integral function it's difficult to retain the amplitude of each wave in Fourier series this is due to the properties of sine and cosine. For function f Fourier transformation and Fourier series have close definition between them which have zero present outside the interval. For these function include the point where f is not zero we have to calculate its Fourier series on any interval. For this condition Fourier Transformation also defined. On which we count the Fourier series if we increase the length of the interval, then the result of Fourier series coefficients start to occur the Fourier transform and the result of sum of the Fourier series of f start to occur the inverse Fourier transform.

Fourier transformation of function $g(t)$ is given as:

$$f(g(t)) = G(f) = \int_{-\infty}^{\infty} g(t) e^{-2\pi i f t} dt$$

This equation shows that a function of f , or the frequency, $G(f)$ allows how much power $g(t)$ held at the frequency f [21] [22].

3.1.2.1 Example of Fourier Transformation [23]

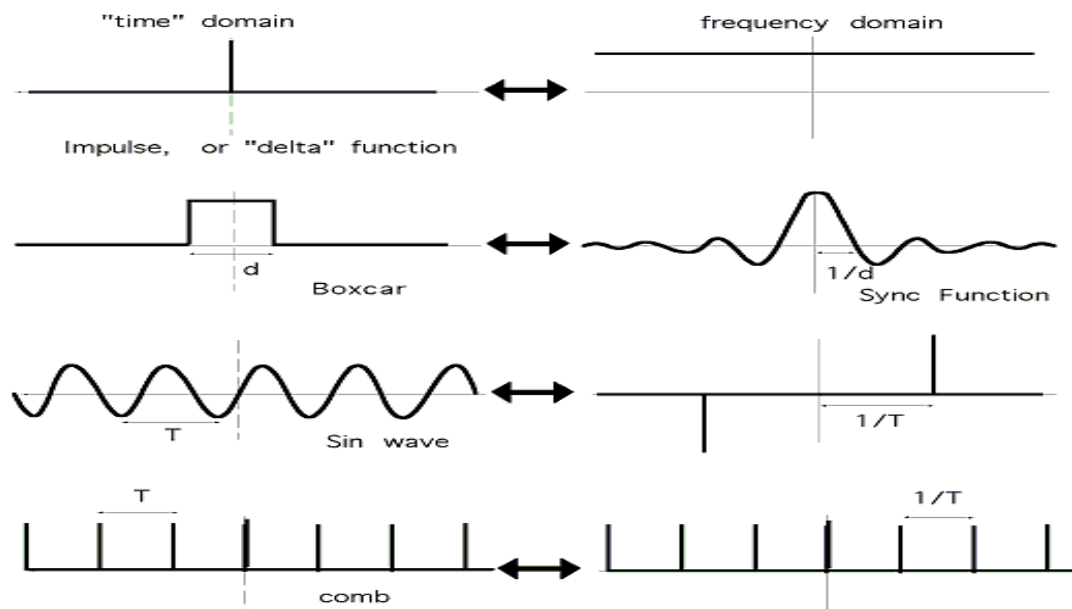


Figure 15 Example of Fourier transform

3.1.3 Discrete Fourier Transformation

The discrete Fourier transform (DFT) changes a finite sequence of uniformly-spaced samples of a function into a same-length sequence of uniformly-spaced samples of the discrete-time Fourier transform (DTFT), which is a complicated-valued function of frequency.

The discrete Fourier Transformation defines as:

$$X_k = \sum_{n=0}^{N-1} X_n \cdot e^{i2\pi kn/N}$$

Using Euler theorem

$$\sum_{n=0}^{N-1} X_n \left[\cos\left(\frac{2\pi kn}{N}\right) - i \sin\left(\frac{2\pi kn}{N}\right) \right]$$

In many application for the completion of Fourier analysis the discrete Fourier Transform is used that's why the DFT is the essential discrete transform. Any volume of function or over the time signals are different in digital signal processing, like, a radio signal, the force of a sound wave or reading of every day temperature, pattern finished a designation time delay. For the raster image in image processing, the pattern will be the bundle of pixels as well as a row or column. To solve partial differential equations efficiently the DFT is also used, and for the operation perform like multiplying large integers or convolutions [24] [25].

Example of Discrete Fourier Transformation

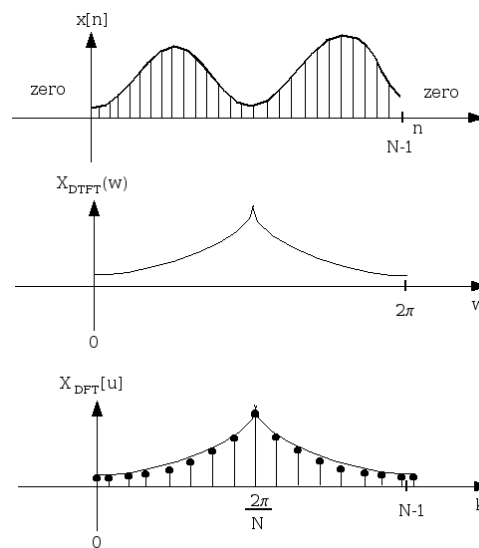


Figure 16 Discrete Fourier transform

3.1.3.1 Fourier series

For the analysis of periodic function Fourier series are used and it also show a function as sum of simple sine waves. It break down any periodic function or periodic signal into the sum of a set of simple oscillating functions, namely sines and cosines. Mostly in the description of Fourier series the discrete-time Fourier transform is periodic function. [26]

Example of Fourier series

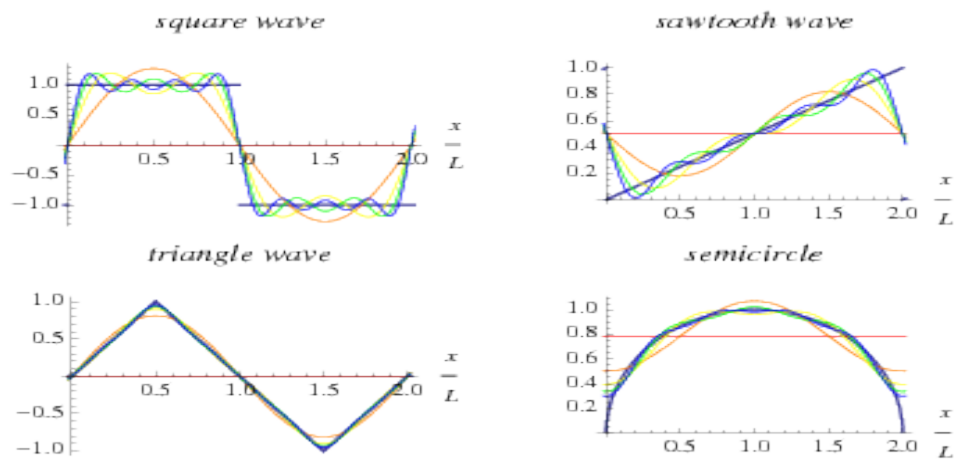


Figure 17 Example of Fourier series

3.1.3.2 Fast Fourier Transformation

Fast Fourier Transformation is used to estimate the discrete Fourier transformation of an array or its inverse. It mostly estimates by factorization the discrete Fourier transformation matrix into a sparse matrix product. By this process it easy to calculate DFT and reduced its complexity for $O(n^2)$ which can begin if one implement the definition of DFT to $O(n \log n)$ n shows the size of data.

FFT used in many application like engineering science mathematics. FFT is faster than DFT because it generate same value and result while calculating then DFT and more accurate than DFT [27] [28].

FFT define by formula

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-i2\pi kn/N} \quad \text{Where } k = 0 \dots\dots\dots N-1$$

Example FFT

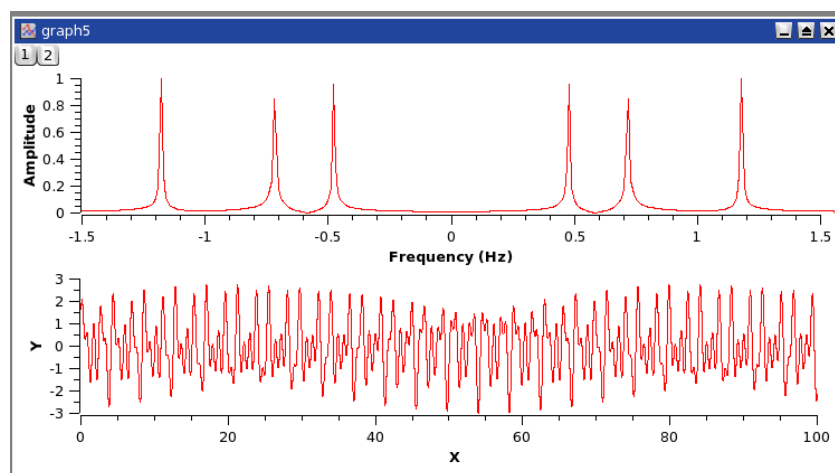


Figure 18 Example of Fast fourier transform

3.1.3.3 Multidimensional FFTs

The discrete multidimensional Fourier Transformation can be defined as follows:

$$X(k) = \sum_{n=0}^{N-1} e^{-i2\pi k.(n/N)} X_n$$

Comparably it is the distribution of a classification of d sets of one- dimension discrete Fourier transformation, Perform along one dimensions in any order at a time.

This compositional aspect quickly gives the easiest and most common multidimensional discrete Fourier transformation recognized as row- column algorithm. Row- column algorithm perform a classification of d set one dimensional, first we transform along the n1 dimension then we transform along the n2 dimension. This method is usually display the complexity of $O(N \log N)$ where N shows the total number of transformed data points [29].

Example for Multidimensional FFTs

If we use N-D array using a fast Fourier transformation it will return the same result as we calculate during the 1-D transformation along each dimension of X. The output will be the same size of Y as we computing with x dimensional FFTs [30].

3.1.4 Discrete Sine Transform

Discrete sine transform (DST) is a kind of transform technique as discrete Fourier transform (DFT) but it is required a complete real matrix for transformation. It behaves like imaginary parts of discrete Fourier transform with the length doubled, acting on real data and odd functions. Half sample of input and output is shifted in some variants [31].

Replaces the columns of a real matrix with their discrete sine transforms. An integer between 1 and 4, denotes the type of transform (DST-I, DST-II, DST-III, DST-IV). These transforms are described as follows (a matrix having n rows) [32].

$$\text{DST-I:} \quad X[k, :] := 2 \sum_{j=0}^{n-1} X[j, :] \sin\left(\frac{\pi(j+1)(k+1)}{n+1}\right), \quad k = 0, \dots, n-1$$

$$\text{DST-II:} \quad X[k, :] := 2 \sum_{j=0}^{n-1} X[j, :] \sin\left(\frac{\pi(j+\frac{1}{2})(k+1)}{n}\right), \quad k = 0, \dots, n-1$$

$$\text{DST-III:} \quad X[k, :] := (-1)^k X[n-1, :] + 2 \sum_{j=0}^{n-2} X[j, :] \sin\left(\frac{\pi(j+1)(k+\frac{1}{2})}{n}\right), \quad k = 0, \dots, n-1$$

$$\text{DST-IV:} \quad X[k, :] := 2 \sum_{j=0}^{n-1} X[j, :] \sin\left(\frac{\pi(j+\frac{1}{2})(k+\frac{1}{2})}{n}\right), \quad k = 0, \dots, n-1$$

Following diagram shows the working of DST

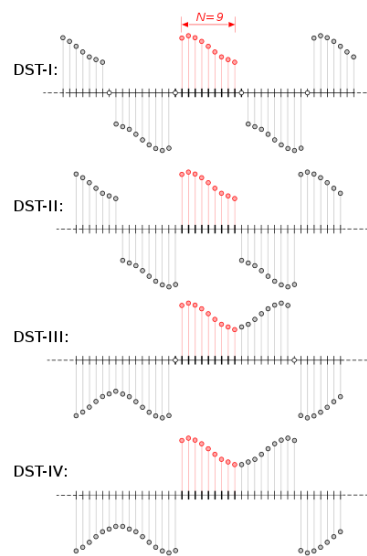


Figure 19 Example of DST

DST is used in solving differential equations through spectral methods.

Discrete sine transform (DST) solves a signal in a way that sum of sinusoids having variant frequencies and amplitudes. DST performs operations on a function at limited number of discrete data points. DST cannot be applied on continuous data it is only applicable on discrete data [33].

3.1.5 Regression Analysis

Regression is used to analysis the dependent variable. It analysis the relationships between different dependent and independent variables. Regression check the response of dependent variable when other independent variable is varied. Dependent and independent are two types of variables that are to be observed in the regression analysis. In regression analysis it is observed that what expected effect on dependent variables is when independent variables are varied with different scenarios. Regression analysis is extensively used in the field of prediction and forecasting. Regression analysis is massively used in the field of machine learning, where it explore the dependent and independent variable and examine the different mode of relationships between these variables. It examine that in which circumstances and parameters are dependent variables are varied with which independent variable. Which helps to predict the data and also used forecasting and many other fields [34].

3.1.5.1 Interpolation and extrapolation

There are two type of values in the data set, first is “X” and second is “Y”. We have to make a regression model to filter these two values. Values of X are given and known. Know the values of variable Y have to predict in the given range of values. To predict the value within the given range is called the interpolation. Extrapolation is perform only on the regression assumption. Values are imagined outside the data to predict the value of Y, this is called extrapolation. Extrapolation is based only on the assumption. The model fails when there is difference between assumption values and the data set values. For successful extrapolation assumption should be much closer to the values of

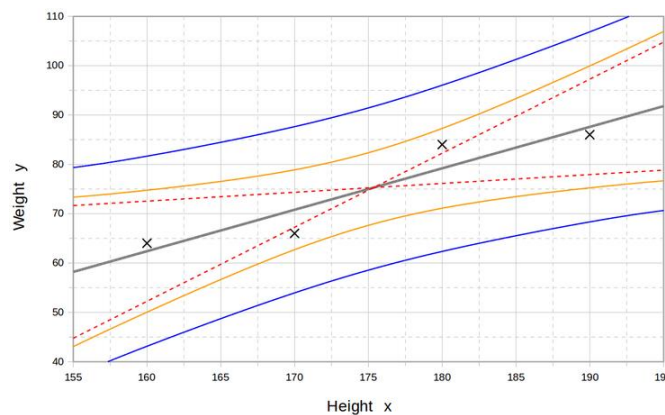


Figure 20 interpolation & extrapolation

data set or given range values, otherwise model leads to

Failure. There is an interval between given values of the data and the assumption values for extrapolation that creates the uncertainty. In short interval result improves level of accuracy. However it doesn't cover all the errors. To perform best extrapolation there is need of best practice. Finest practices can make results better and efficient and it can improve level of accuracy [35].

Above diagram showing the filtering model for regression. Interpolation and extrapolation is performing. There are two variables X and Y. The middle straight line provides the best balance between data point or variable below and upside the line. There are two dotted lines that represents the utmost lines. And there are two curves in the diagram. First curve the shows the total estimated values and the second curve represents the predictive values for the new measurement [36].

3.1.5.2 Types of Regression

Regression has hundreds of its type. Each type of regression is used for specific purpose in specific circumstances and for distinct data. Here discussing the some main types of

regression that can use in different environment for distinct context, parameters and precise data.

3.1.5.3 Linear regression

It is the earliest type of regression that was designed before 250 years. By its designs it is easily drifted by human for computing of small data. It is not applicable for the predictive analysis. There many deficiencies when it is applied on modern data. It is not suitable for contemporary analytic data. It is convenient only for small data [37].

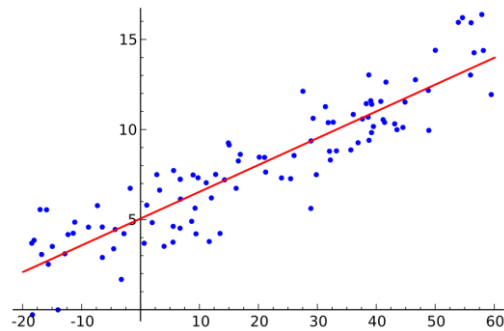


Figure 21 linear regression

3.1.5.4 Logic regression

it used when all choices are all variable are in the binary form, where result come only in false or true, 0 or 1 and pass or fail. It used to detect fraud detection. It is vigorous form of logistic regression [38].

3.1.5.5 Jackknife regression

It is new type of regression which very useful and accurate. Techniques of data reduction using jackknife regression it is also using as general clustering. There were many drawbacks in traditional regression like accuracy was not enough good, jackknife cover all these issues and perform very well with independent variables [38].

3.1.5.6 Logistic Regression

David Cox developed logistic regression while analyzing the binary data in 1958. Logistic Regression is used where we have to deal with dependent variable. In other words it is used where we have to face binary outcomes like 0 or 1, dead or alive, sick or healthy and pass or fail. There is another type of logistic regression is multinomial logistic. In this regression we can deal the dependent variables which have more than two outcomes. For example “Product A” vs. “Product B” vs. “Product C”. In multinomial regression values are not ordered, these value can be specific set of values. Logistic regression is very powerful tool for analyzing the categorical variable. Where we have to deal with categorical variables logistic regression is the best choice for

example logistic regression can be used to find the absenteeism of the species in the quadrat and is there presence of any disease to seedling or damage. The logistic model fit the model of seedlings that are out planted in 50-tree rows that are die for damaging the forest that is an observed response. This observed number than converted in the proportion to fit in the model of logistic regression to examine the how much seedless will die from damaging the forest and how much seedless will die the disease. This logistic regression makes the model and predict the ratio of seedless damaging due to forest and die with the disease. This prediction is based on the data provided. The accuracy is depend on the data and observation of seedless. To improve the accuracy take the more data more observations more test and make it as best practice to refine observation [39].

3.1.5.7 Logistic Regression Model

In logistic regression model there is a logistic function that is used to put the model to data. This logistic function fit model to the data. This logistic function put the data into model. There are three ways to fitting data into the logistic regression model. And these way of fitting data are different to each other. There are two variable X and Y to fit in the model and there is an 'S' Shape logistic function. These variable y or y/m put a response to the shape of 'S' function to the variable x which is independent. Variable y shows the growth of data versus time which is variable logistic curve with x. And next to fit the responses to proportional with the given range of 0 and 1 [40].

3.1.5.8 'S' Shaped Logistic Function

Logistic regression models are of three types.

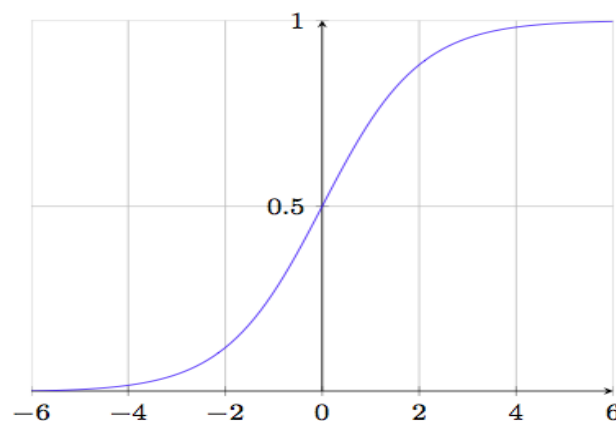


Figure 22 Logistics regression model

Table 1: Logistic function

Model	Deterministic component	Stochastic component
1	$E(y) = \gamma / [\gamma + \exp(\alpha + \beta x)]$	y is normal
2	$\pi = E(y/m) = \exp(\alpha + \beta x) / [1 + \exp(\alpha + \beta x)]$	p = y/m is approximately normal
3	$\pi = E(y/m) = \exp(\alpha + \beta x) / [1 + \exp(\alpha + \beta x)]$	y is binomially is binomial

Where:

Variable Y has continuous response

E(y) is the expected or it is normal value of y

Exp (x) = x function exponential;

Proportion of success is p

X is a fixed independent variable [41].

3.1.5.9 Applications and Field Example

Logistic regression is used for probability of binary data, it make analysis and finds the probability that which value have more chance to come as final result. For example logistic regression can measured the probability of pass and fail students. Logistic regression is also used in medical and marketing field to measure the probability of disease and the product. For example it can measure the probability of having a cancer or any other disease in people after making analysis of age, race, sex, blood test and state of residence. And in marketing filed it can be used to measure the profit and loss probability of a product based on the age, sex, nature of the customers and state of residence. Logistic regression also used in engineering filed. In engineering field it used to get the success or failure probability of a product or system or the process [42].

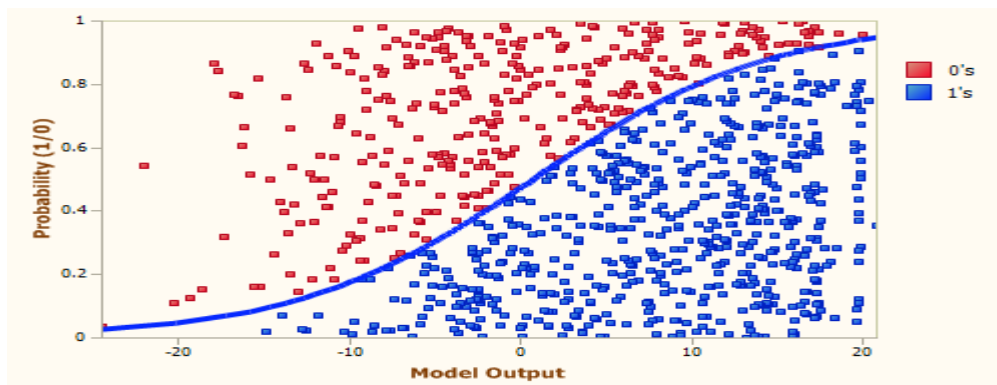


Figure 23 Logistics regression probability analysis

3.1.6 PCA

Principal component analysis is a procedure which is used to reduce the spatial property dimensionality of a dataset (e.g. It is use to convert 3D dimensional data/information into 2D dimension). It is used to convert and transform a dataset of higher values into lower scale value with minimal loss of information. The PCA is use to reduce then number of variables and help in avoiding the multicollinearity. It is a technique that used in the compression and classification of data up to the maximum extent. This linear rework has been wide utilized in knowledge analysis and compression. Principal half analysis relies on the applied math illustration of a variate [43].

Some time we found duplicate information in one or different variables of a dataset. PCA analysis and identifies the duplicate data over a million of datasets. Here, we get our desired outcome of the principle part analysis is to project a house into a smaller space that represents the information “well”.

The attainable application would be a pattern classification task, wherever we tend to would like to chop back down the machine worth and conjointly the error of parameter estimation by reducing the amount of dimensions for the feature house by extracting the mathematical space which describes our knowledge “best”. Importantly, dataset on that PCA technique is to be used should be scaled. As a common person, it's a way of summarize the information. Imagine we have some bottles on board. Every bottle is delineated by its own attributes like color, strength and etc. however redundancy can arise as a result of several of them can live connected properties. Therefore what PCA can knock off in this case we summarized every wine within the stock less characteristic [43].When PCA is employed with Neural Network, at the start the redundant knowledge within the knowledge set is eliminated and therefore the data obtained is trained victimization Neural Network[43].

Principal Component Analysis (PCA) algorithm

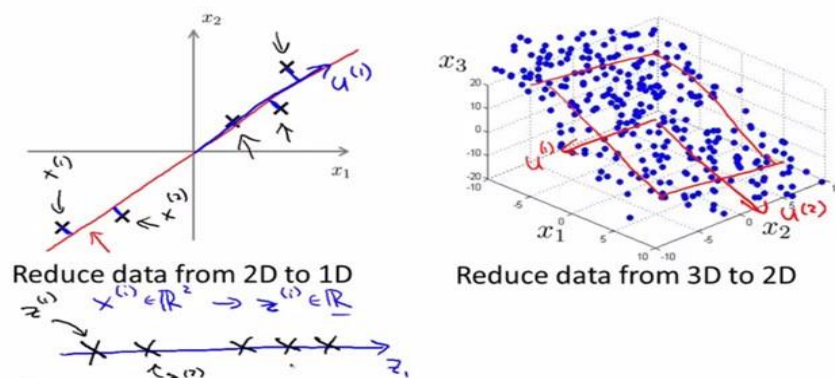


Figure 24 PCA reducing 2D data into 1D

The Principal Component Analysis figure calculates the node and the variance matrix of the input file columns and the eigenvectors, characteristic and the directions of peak variance with in the file columns and the eigenvectors, characteristic and the directions of the peak variance with the information house The high price of the eigenvalue indicates the heavy variance of an information on the corresponding eigenvector. The eigenvectors are often sorted by decreasing eigenvalues, for example variance. The PCA figure node and the output of the variance matrix, of PCA model, also the PCA decomposition of the first knowledge columns of eigenvectors. The computer model is too formed the last output port and it contains the eigenvalues also the additionally the eigenvector projection necessary to remodel each information row from the primary house into the new laptop house [44].

The computer apply the node and transforms of the knowledge row from the first area into the new area of PC, victimization of the eigenvector projections within the model of PCA. Some extra forms of the first knowledge set to reborn into a new set of the computer coordinates by multiplying the first zero-mean data row by the eigenvector matrix that generates the spectral decomposition of the table knowledge. By reducing the amount of eigenvectors, we have a tendency to effectively cut back the spatiality of the new knowledge set. Usually, solely a set of all PCs is important to stay one hundred data from the first knowledge set [44].

The additional tolerant by losing the data of the upper spatiality reduction of an information area. The configuration and settings of the PCA apply the node permits to outline the most acceptable data lose to calculate the resultant spatiality reduction supported the mandatory variety of PC's. Notice that PCA may be a numerical way/technique. This suggests the reduction method solely effects on the numerical columns and doesn't act on the nominal columns. Put together and notice that PCA ignore the missing values. On a knowledge set with several missing values, PCA area unit less effective [44].

Fig. below shows the PCA workflow. Here the coaching set is too employed and create the variance matrix, once handling the missing values of nodes and normalizing all the knowledge columns to constitute the values from [0, 1]. primary m eigenvectors of PCA model and then applied to remodel the information set then cut back its spatiality from the first n coordinates to the m designated PCs, with $m < n$.

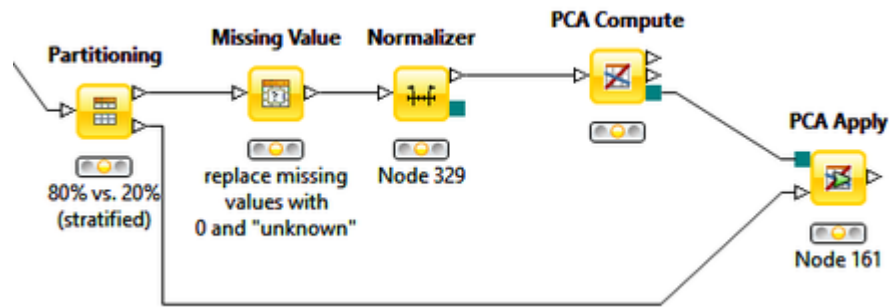


Figure 25 This is how PCA works

3.1.6.1 Eigenvalues

Eigenvalues also called characteristic roots [45]. The eigenvalue for a given issue measures the variance all told the variables that is accounted for by that issue. The magnitude relation of eigenvalues is that the magnitude relation of informative importance of the factors with relation to the variables. If an element incorporates allow eigenvalue, then its tributary very little to the reason of variances within the variables and will be unnoticed as redundant with additional vital factors. Eigenvalues live the number of variation within the total sample accounted for by every issue. An issue's eigenvalue may be computed because of its square factor loadings for all the variables [45].

3.1.6.2 Properties of PCA

The principle part will be outlined as a linear combination of the determined variables. The output of the PCA square measure these principle elements, the amount of that is smaller amount than adequate and the amount of original variables is lesser, just in case after we would like to discard and cut back the size of our dataset. The PC processes some of the helpful attributes that square measured listed below [46].

- 1: The PCs square measure basically the linear combos of the first variables, and the weights vector during this combination is truly the eigenvector found that successively satisfies The principle of statistical procedure.
- 2: The PCs square measure the orthogonal, as already mentioned.
- 3: The variation gift within the computers decrease and we tend to move it from the first PC at the last one, therefore it has some importance [46] [47].

3.1.6.3 Application of PCA

The PCA is used as a spatial property reduction technique that is used in domains like identity verification, PC vision and its compression. It's additionally used for

location patterns in knowledge of the high dimension within the field of the finance and data processing bioinformatics, etc. [48].

Usage in programming:

The application of PCA, you'll be able to hardcode the total method in any type of programming language, like C++, Python, R and many more or directly use the additional libraries created out thereby contributors. However, it's suggested to hardcode just in the case of matter isn't complicated so you truly get to check what precisely is going on within the backend once the analysis being done & conjointly perceive the corner and its cases. Only for instance, in the programming language of R, there square measure libraries referred to as prompt, etc. that may be used for direct application [48].

The steps to perform PCA for the purpose of visualization are:

1. Translate the information of data so the center is at its origin
2. Calculate the covariance matrix
3. Find the principal components
4. Reduce the data information using the needed principal components [49].

3.1.6.4 Objectives of PCA

- PCA reduces attribute area from a bigger range of variables to a smaller range of things and in and of itself may be a "non-dependent" procedure (that is, it doesn't assume a variable quantity is specified).
- PCA could be a spatiality reduction or knowledge compression technique. The goal is dimension reduction and there's no guarantee that the scale are explicable (a reality typically not appreciated by statisticians)
- To select a set of variables from a bigger set, supported that original variables have the very best correlations with the principal element [50] [51].

3.1.7 Wavelet Transform

3.1.7.1 Wavelet

Wavelet is a wave or oscillation that has some amplitude, it starts from zero and continuously increases but it also decreases to its original position and that is zero. For example you can imagine this as a heartbeat because heart also creates some oscillation, it increase and decreases continuously. Wavelet also has some specific properties that make it very useful in the field of signal processing. Wavelets can also

be combined through some specific technique that is known as **convolution**, in which we reverse, shift, multiply and add the wavelets with partition of known signals to extract features from the unknown signals [52].

Wavelet is not just limited to extract data from the specific signals it can also be used for audio signals and images, compression and decomposition process is applied to the signals that extract the desirable data in the form of original information [52].

3.1.7.2 Wavelet Theory

Wavelet is not limited to specific subjects; it has a broader range of subjects to work. All wavelets are represented as time frequency domain, time frequency domain means all the signals are presented on the layer for time and harmonic analysis related to continuous time signals frequency [53].

Harmonic analysis is the chapter of mathematics that is only enterprise with superposition of basic waves and the representation of signals. All wavelets use time frequency representation of the signals like discrete and continuous wavelet transform, they both use the same representation of their signals. Almost every useful continuous wavelet transform uses continuous-time clean reserves and discrete wavelet transforms have discrete time pure reserves [54] [53]. These clean funds are called the wavelets

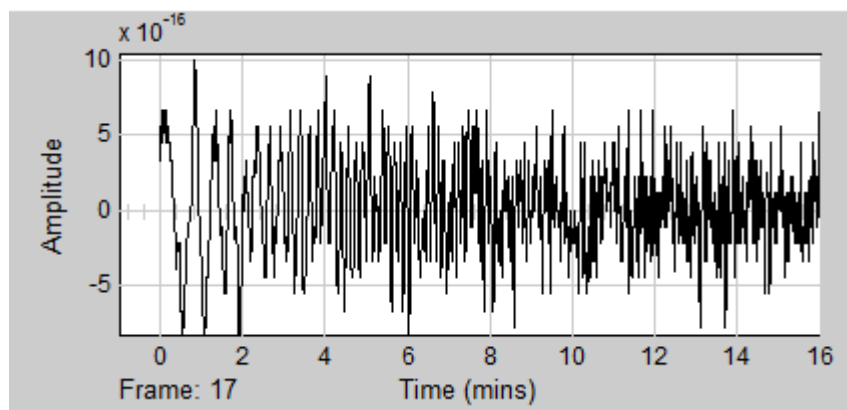


Figure 26 Wavelet representation

3.1.7.3 Wavelet Transform

Wavelet transform is the model of wavelets. For last two decades a new mathematical technology has enabled the scientists to have the deep view in the phenomenon of time variant and that is wavelet transform. This invention makes a lot of changes in the field of signal processing, image processing as well as data analysis [55].

We already are familiar with the Fourier series and Fourier transformation which plan the time scope signal in the frequency domain. But in every technology there are some limitation, in Fourier transform there are also some limitations which is, *different in time domain but it has same frequency representation*. Fourier transform only gives that data which frequency components exist in the signals and it cannot tell that at which time the frequency component occurred. However, time frequency representation needed in some cases

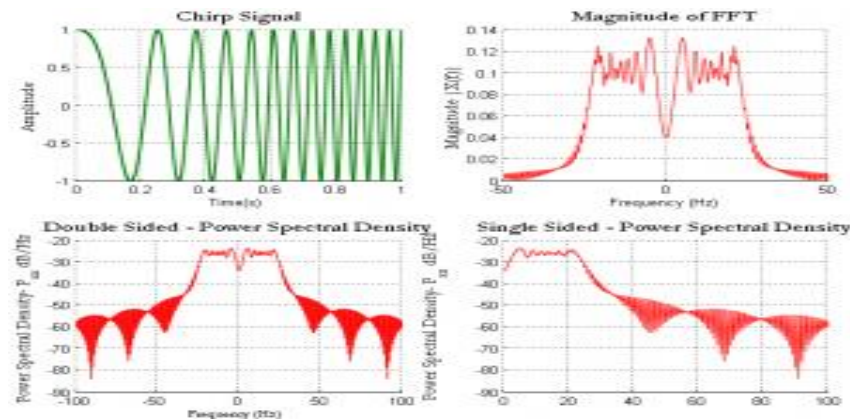


Figure 27 wavelet and fourier transform representation on time domain

Basic idea of wavelet transform is that it should allow revision in the time continuation and should not allow the changes in the shape of data [55] [56].

$$\Delta t \Delta \omega \geq 1/2$$

Here t represents the time and omega represents the angular frequency.

When delta t is large, it means

- Resolution time is bad
- Frequency resolution is good
- Low frequency means large scaling factor

When delta t is small, it means

- Good time resolution
- Bad time frequency
- High frequency means small scaling factor

Most of the information in wavelet transform is similar to precise time Fourier transform, but wavelet transform has some special additional properties which makes

it some preferred than to short time Fourier transform, in time it has some higher analysis [55].

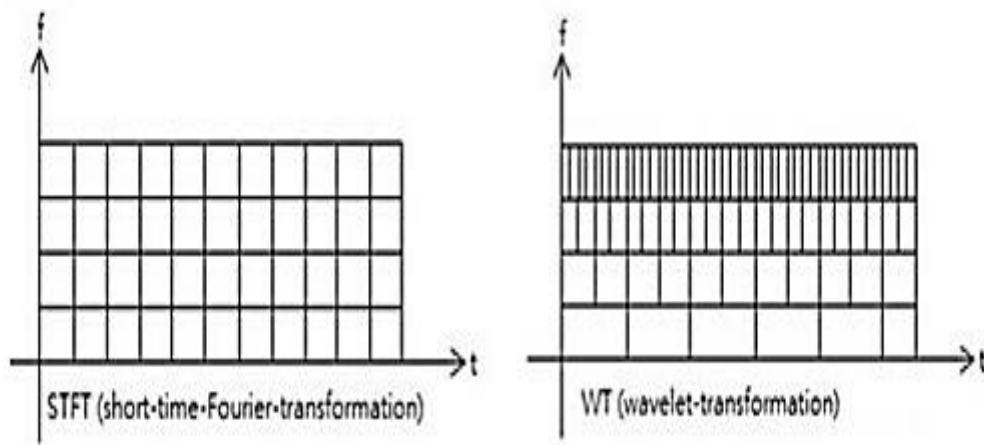


Figure 28 Wavelet vs fourier transformation

This all shows that the wavelet transform is very much better than the short time Fourier transform, and for the slowly varying function, frequency domain is also very appreciating.

Here is another example of time varying signals over the time frequency domain [55] .

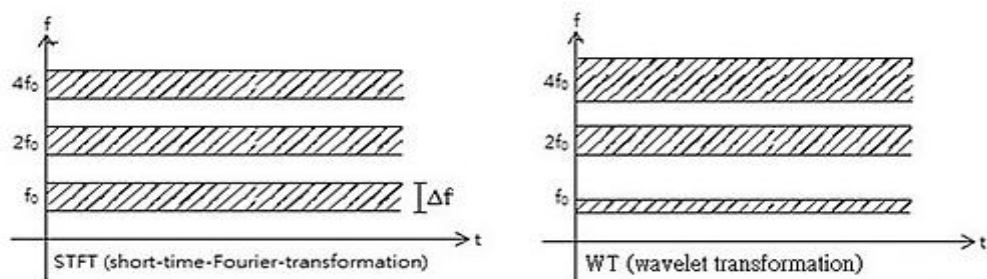


Figure 29 Time frequency domains

3.1.7.4 Advantages of using wavelet transform

1. It provides a better way of analyzing signals in both time and frequency domain
2. Provides better representation of discontinuous and sharp signals
3. Provides construction and deconstruction of periodic and non-periodic signals
4. It has more sufficient storage for signals than Fourier transform [57].

3.1.7.5 Wavelet Compression

Wavelet compression is used to compress the data which is very suitable for *signal processing, video compression, audio compression*. The goal is to compress the data in little space.

Discrete wavelet transform is successfully applied for the compression of Electrocardiograph. Wavelet compression technique is well for every type of data but some of are very applicable through this like, transient signals are highly compressed by wavelet compression and creamy, repeated signals are highly compressed by other techniques like particularly traditional harmonic compression by Fourier transform [58].

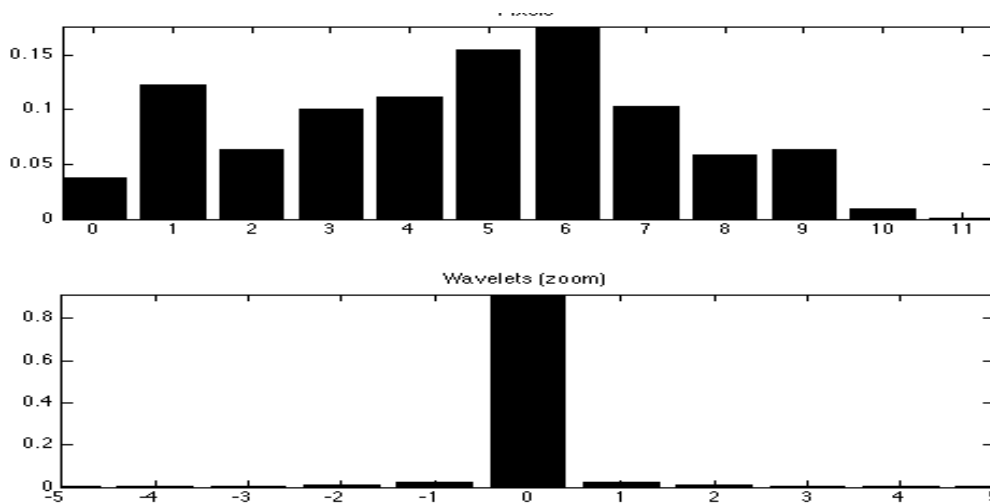


Figure 30 Wavelet Compression for transient signals

3.1.7.6 Continuous Wavelet transform

Mathematically, the continuous wavelet transform figure out essential level of continuous signals along a decisive of continuous wavelets.

$$WTu_a = \{s, \varphi u_a\} = \int_{-\infty}^{\infty} s(t) \varphi * u_a(t) dt$$

Where

$$\varphi u_a = \frac{1}{\sqrt{a}} \varphi \{t - u/a\}$$

Here w and t are the resulting wavelet coefficients, where u is changing factor and a is enlargement factor. For the continuous time signal s (t), the scale factor should be

positive. If the continuous wavelet meets the compatibility circumstances you can use wavelet to regenerate authentic or real signals [59].

Most of the signals in real time are available as discrete time samples and the form of signal $s(t)$ is not accessible.

For this reasons, you select the discrete signals and shifts it to the continuous signals and then numerically solves the continuous wavelet transform.

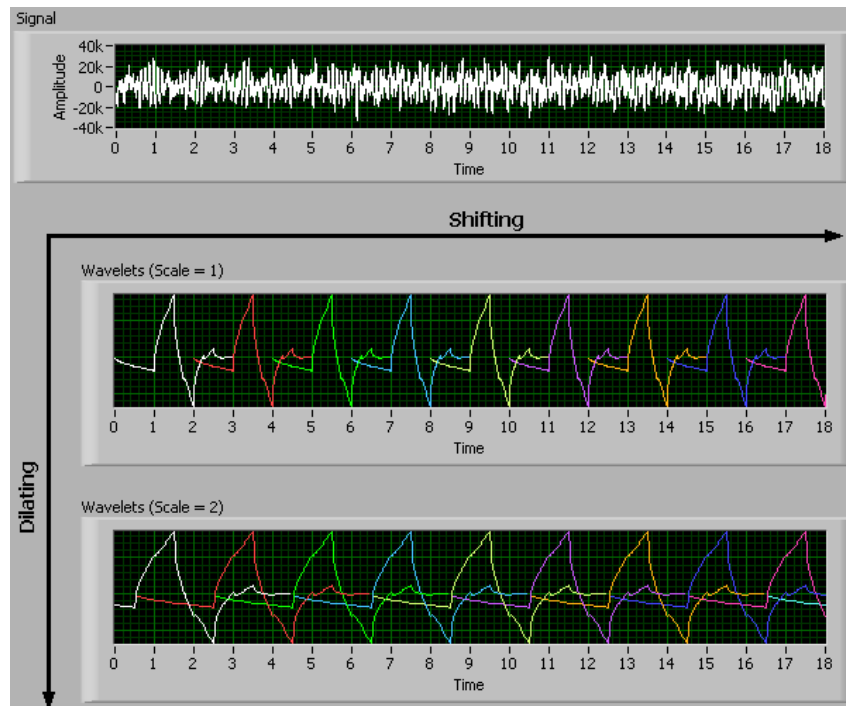


Figure 31 Continuous wavelet transform with positive scale factor

It involves the following steps

1. Shifts the wavelet continuously along the time axes
2. Figure out the each shifted wavelet and analyzed signals
3. Lengthen the wavelet on the scale you specify
4. Repeats the step 1 to step 3 until you reach the maximum scale [59].

3.1.7.7 DE noising signals using wavelet transformation

Electroencephalogram (EEG) is the recording of brain signals that are in the form of electrical signals over a minimum amount of time. Brain signals are generated through the assault of neurons which are uniformed by the EEG. The voltage level of brain signals are low which can be corrupted by various types of noises. These signals can be used to analyses various types of brain diseases like sleep disorder, insomnia and

parasomnia. Many of the noise removal techniques are available by various scientists but some has some special features that makes them have the upper level like *Independent component analysis, principle component analysis, wavelet transform and wavelet packet transform* are available and can be implemented in the matlab. These all techniques are used to reduce the noise from the signals and purifies the signal in its original form, performance factor can be improved through wavelet transform [60].

This proposed system is used to convert complex signals into its original refined form.

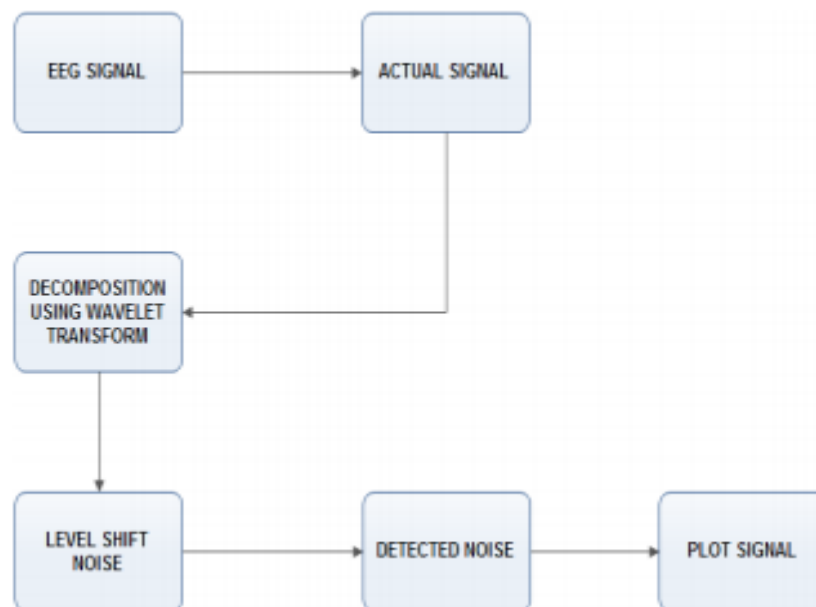


Figure 32 De Noising process

Steps

1. Bring the EEG signal from the database
2. Select the actual signal and mutilates the signal to remove the noise from it
3. Decompose the signal to perform the shifting method
4. Divide the level of EEG signal
5. Recognize the level of signals, minimum and maximum value
6. Set the EEG value as threshold
7. Identify the signal noise
8. Apply the wavelet transform to remove the noise
9. Draw the signal [60].

3.1.7.8 Discrete wavelet transform

Discrete wavelet transform uses an exercise of simple wavelet transformation that use discrete values from wavelets and translations accepting some defined rules. However, it break down the signal into orthogonal sets of wavelets, which creates a very big difference in continuous wavelet transform and discrete wavelet transform [61].

The discrete function can be generated from the wavelet scale which can explain its scaling properties.

$$\phi(x) = \sum_{k=-\infty}^{\infty} a^k \phi(Sx - k)$$

Here's s the scaling factor and furthermore the space middle from two points the function muster managed and the scaling function should be orthogonal in its integer translates [61].

$$\int_{-\infty}^{\infty} \phi(x)\phi(x + 1)dx = \delta_{0,1}$$

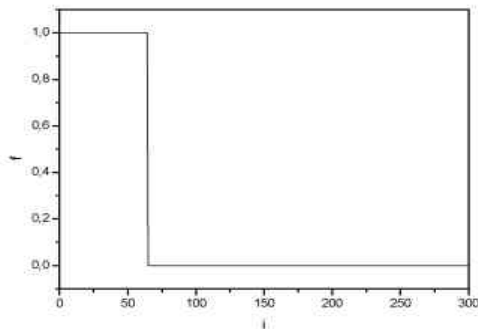
After addition of the more conditions, we can have the desired results from all the equations. The wavelet can be obtain from the scaling function

$$\varphi(x) = \sum_{k=-\infty}^{\infty} (-1)^{k-N} a^{N-1-k} \varphi(2x - k)$$

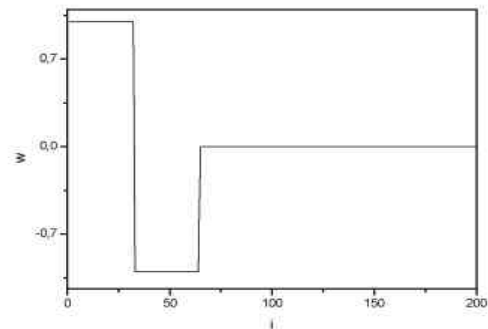
Here N is a positive integer, where the wavelets generate the orthogonal basis to break out the signals.

Examples

Some of the wavelets scaling function are shown below in which wavelets are plotted. Very famous category of orthogonal wavelets is a group of *Daubechies*. Wavelets are commonly designated by integer of nonzero coefficients a and k , and in Daubechies the most famous categories are Daubechies 4, Daubechies 6 and further more. When the

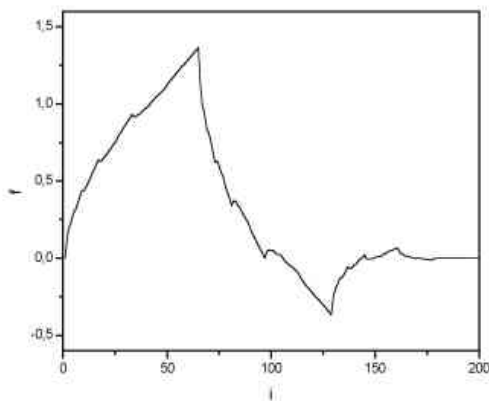


Haar function

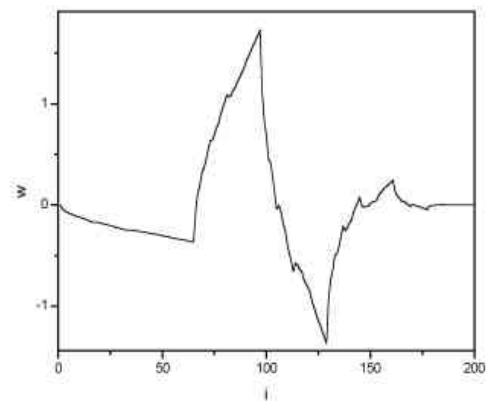


Haar wavelets

number of coefficients are increasing, the functions become smoother. Here you can see the comparison between



Daubechies 4 scaling function



Daubechies wavelet

Daubechies 4 and 20 bellow. And another famous example of discrete wavelets is Haar wavelet, which use box function for scaling [61] [62].

3.1.7.9 Discrete wavelet transform algorithm

Now a day many of the algorithms are available for the implementation of discrete wavelet transform but some are the best and some has some minor benefits. Most

famous and the old is *Malaat* (pyramidal) algorithm. In malaat algorithm two cleaners are generated from the wavelets coefficients which can be named as smoothing and non-smoothing filters and these are used to obtain data from all the scales. If the total amount of data is $D=2^N$ is used and the power of signal is L , $D/2$ data on the scale of $L/2^{(N-1)}$ are generated than $(D/2)/2$ data at scale $L/2^{(N-2)}$. When we have the result of this algorithm called malaat is array of the like length as the input one.

Where the data of result is filter out from the large scale to the small scale.

By having all these steps, the inverse of the discrete wavelet transform can re generate the original signal from the wavelets. But here is important note that the wavelet which we have used for the base decomposition will not be changed, if we try to do so. But by using haar wavelet, the original one can be re generated [63].

Example

In the given pictures you can see the 1024 data and in other pictures the discrete wavelet transform is applied through haar wavelet, Daubechies 4 and Daubechies 20.

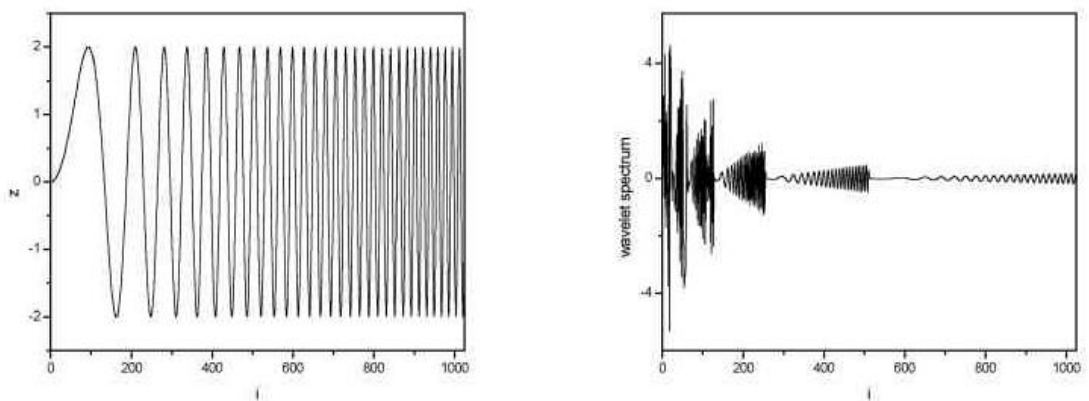


Figure 34 Malaat example

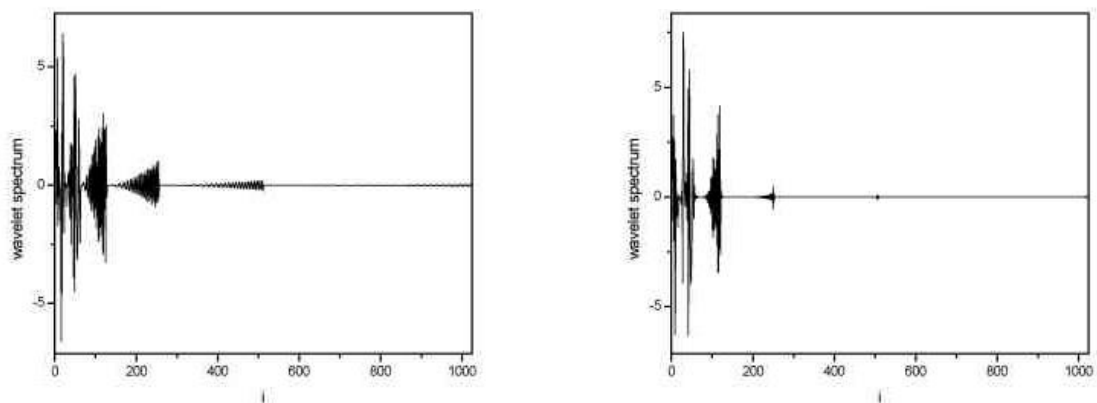


Figure 33 Malaat

Here by seeing the figures you can build in your mind that the discrete wavelet transform achieved from the Daubechies 20 wavelets has the smallest numbers of nonzero values or you can say above zero. Daubechies 20 is the most famous one which is continuously used in the wavelet transformation and you can see from the figures that it is closer to the sin function. So, here from the results we can say that the wavelet which has a lowest number can build the sine signal [63].

3.1.7.10 Discrete wavelet transform applications

1. Signal de noising
2. Data compression

3.1.7.11 Signal de noising

Discrete wavelet transform can also be made for signal de noising or feature extraction. From the DWT if we take some number of highest coefficients and we perform an inverse discrete transformation we can achieve more or less de noised signal [64]. Now, the question can be raised that **how to choose the highest coefficients?** Well here we use the most simple method that we have tried so far is thresholding. From the below images you can see the original image is given and then we added the noise in it and then de noised the signal [64].

Original Image

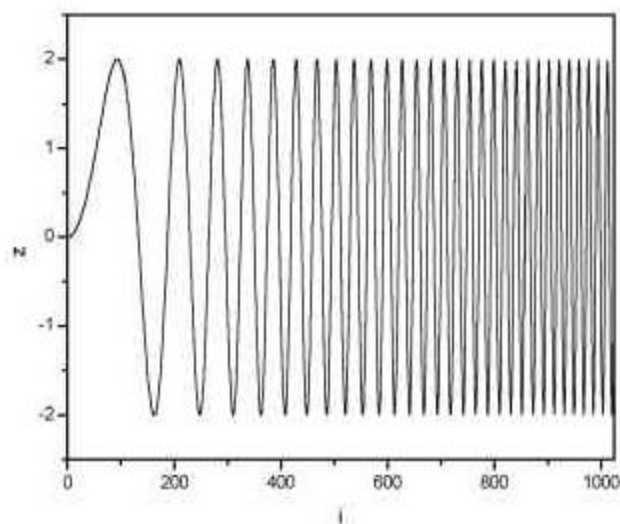


Figure 35 Original image with no noise

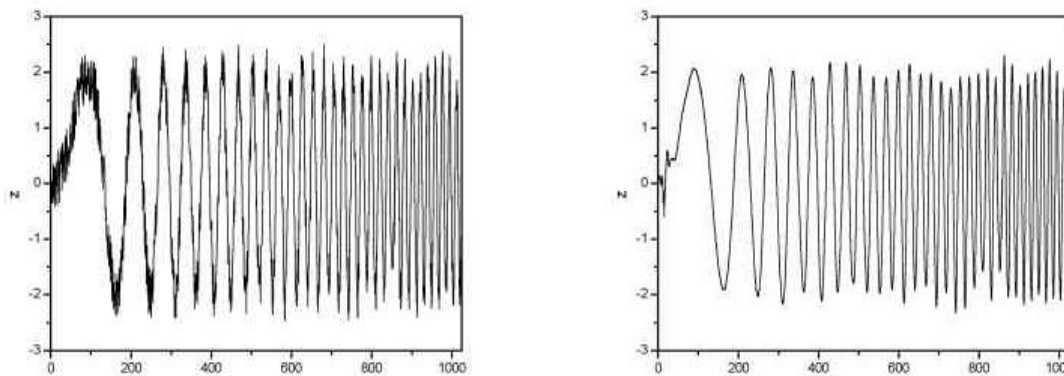


Figure 36 one with noised and on is De noised image

3.2 Languages

3.2.1 Matlab Programming

Matlab stands for matrix laboratory. Matlab is numeric computing and multi-paradigm environment. Matlab supports different languages like C, C++, and C#, Java, FORTRAN and Python. Matlab also a programming language itself. Matlab programming language developed by the MathWorks. Matlab is very efficient language to perform mathematical functions like matrix. There are many built in functions for matrix and other mathematical operations. Matlab programming can also plot graph. It can perform Polar Plot, Semilogx or semilogy, Loglog, Mesh, Nichols Plot and Bode Plot. Matlab programming is easy to use. It's syntax similar to C programming Language.

3.2.2 C Language

C is a computer programming language which is used for general purpose. It is developed between 1969 and 1973 by Dennis Ritchie at Bell Labs. C language allow structured programming and it support recursion and lexical variable scope. C language has a very unique design in which it provides construct. As C language provides construct so the instructions of the C language typically maps with the machine instructions. It is used utensil the UNIX operating system. It has a C compiler which converts the high level language into machine language. American National Standard Institute standardized the C language since 1989. C is most powerful and efficient language that's why it is most popular language after passing 40 years. C language is portable, source code of C can run on another operating system without changing the code. C language allow object oriented programming and it allow to work on open source projects. Open source projects impact on millions of people. As C is a general

purpose language so a lot of programming languages are based on the C and C++ language.

3.2.3 Python

Python is a very power full and efficient high level programming language. It is developed by Guido van Rossum. Syntax of python is very easy and it is also general purpose language. Python is used in different domains, it is used in web development, scientific and mathematical computing and desktop graphical user interface. Django, Bottle, SymPy, NumPy, Pygame and Panda3D are the libraries of the python that are used for web development, scientific and mathematical computing and desktop graphical user interface respectively. Python has a very simple and easy syntax so that you can think about the solution only, rather than focusing on the syntax. Python is free and open source language, and it has a very large community. Python is Extensible and Embeddable language. Many other language code can be embed in this language. You can embed the peace of code of C/C++ language, it increases the performance and efficiency of the program. This is a very unique feature that other language many not allow. Python is a portable language, you can run the python code on different platform without changing it. You can run the same python program on Mac and windows. There are large number of built in libraries in the python that increase the features of language. [64]

3.3 Applications

3.3.1 Matlab R2016

Matlab stands for matrix laboratory. Matlab is numeric computing and multi-paradigm environment. Matlab supports different languages like C, C++, and C#, Java, FORTRAN and Python. Matlab also a programming language itself. Old version of matlab had some dependencies and portability issues. Matlab 2016 overcome with these problem. Matlab 2016 came with new features. It is online and has cloud based also. It has mocking framework for unit testing. And there Lot of new built in features in matlab 2016. [64]

3.3.2 IDLE 2.7

Python 2.7 is the version of Python IDE. It has many new features, it has bug fix release. It uses the tkinter GUI toolkit for coding. IDLE 2.7 has very interactive interpreter with the colorizing of code output, input and error messages.

Debugging is very easy as compare to other versions. Idle 2.7 has many other new option and shortcut in the menu bar that are very useful to code fast. [65]

3.4 Libraries

3.4.1 Thinkgear

Thinkgear.dll is a library that is used to communicate the neurosky or mind headset with the application. It establishes the connection between application and the neurosky or Mindset to interpret the data stream. Like if we want to use the neurosky signal in matlab we have to use thinkgear.dll.

3.4.2 Svmlibs

Svmlib is an integrated software which used to implement support vector machine, distribution estimation and regression.

3.4.3 Scikit

Scikit is library of python that is used to implement classification, regression, clustering, Dimensionality reduction, Model Selection and preprocessing.

3.4.4 Numpy

Numpy is library of python programming language. It is used to adding support of matrixes and arrays of multidimensional. It is also used when we have to established connection between Neurosky and the python.

3.4.5 Nled

Nled library is used in ubuntu to establish connection of Neurosky with python and to turn led on and off using raspberry pi.



CHAPTER 4

4.1 Summary

A brain computer interface (BCI) is a transmission system that convert brain action into a direction for an object or computer. The technology of brain computer interface show an extremely spreading field of research. It produced a collective understanding among users and enclosing systems. The primary objective of BCI research is to compose systems that grant the paralyzed people to contact with other persons, to handle unreal wheels, or to control their environment. A substitute application field for brain-computer interfaces (BCIs) occur in the field of multimedia communication. To produce systems for management in the area of dependable technology or multimedia transmission, many condition of BCI systems are presently being tested. Research areas consist of assessment of invasive and noninvasive technologies to extent brain activity, assessment of handle signals (i.e. arrangement of brain action that can be used for communication), developing of algorithms for explanation of brain signals into computer commands, and the developing of new BCI applications.

4.2 Conclusion

Brain computer interfaces are the tools which allow the humans to communicate with external devices with their brain. Human brain produces electrical signals which can be recorded by using some BCI technology, but the recorded signals are not as purified as we expect, signals also came with some noise which needs to be purified. Then, some algorithms and techniques are used to capture the workable signals from the brain and remove the noise. Useful signals than forwarded to the device which we want to control by our thoughts and noise would be filtered. Some algorithms which needs to be mentioned here are SVM classifier, logistics regression classifier, Fourier transform, Discrete sin transform, Discrete cosine transform, Resolvent mean. Brain computer interface is now one of the most researched topic in the world and many of the fields are using these research to produce some useful results for them, like in medical field it is very trending because for disable people it is producing very useful results like a paralyzed person who is not able to run, not able to do his own tasks can now perform his work independently by just using his brain. In past few years we saw that humans were able to control things with eyes, with voice etc. but no one thought that the technology can be reached to this level and now the present research is happening on human brain, millions of neurons makes it very difficult to understand the complexities of human brain, latest science is now working on human brain and in some years might

be it would make it possible to read human thoughts also. Overall, the BCI have helped to boost quality in BCI research, identify key directions, and promote BCI research around the world.



CHAPTER 5

5.1 User Manual

5.1.1 Introduction

Our project is based on data mining in which we take a data set of paralyzed patients and we study or analyzed all the dataset and extract the values of dataset which will helpful for our project and then we classify these dataset values with support vector machine algorithm and logistic regression model and for more purified the signal we apply feature extraction on data set values like Fast Fourier Transformation, Resolvent Mean, Discrete Cosine Transformation, and Discrete Sine Formation this will help to use more purified signal and easily to access the signal without any interruption of noise.

5.1.2 System overview

Brain Computer Interface is a communication way between the mind and that object which has to be controlled. First a person wear a headset on their head and turn on the headset. The headset start blink with blue light that indicate that the headset is staring pairing with object and main thing that will be matter is the concentration and attention of person. If concentration of any person will be divert the signal can be week and do not move any object with the brain signals. When a headset is ready and paring will be done through the Bluetooth then the signal start travels from the brain and the signal is capture by the raspberry pi and all the features extraction are performed in it then person will concentrate on that object that will be control through mind and think about to move the object left or right direction. This will be done by training the user by focus or concentrate on object without training of users the object will be not control through brain signals.

5.1.3 Trouble shooting

If there is some case of trouble shooting while connecting the neurosky mind wave mobile with the hardware or computer then user will turn off the headset for 10 minutes and after the break user will turn on the headset connect the headset with hardware or computer. If headset light show the red light then it will indicate that the headset signal will be low and it will not communicate the brain signal with other object. User will recharge and replace the battery of the headset and after recharge the headset red light will change in to blue light its means headset is properly working.

5.1.4 Usage of Mindwave

1- For set the sensor user will rotate it about 90 degree with the left hand and adjust the sensor attached to the forehead of user.

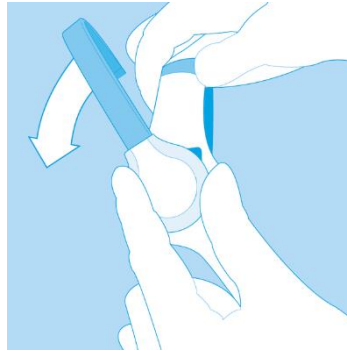


Figure 37 Mindwave wearing method

2- The upper band of head set is flexible and it will extend and have various size to fit with it. If the headset is not fit and does not touch with the forehead then remove the headset and again readjust the headset and wear the headset.

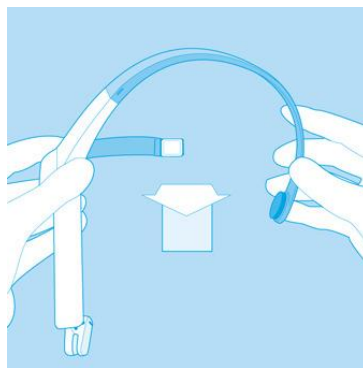


Figure 38 Telling wearing method

3- Now adjust the ear clip with your earlobe and also sure that the two metal contacts will touch with your earlobe.

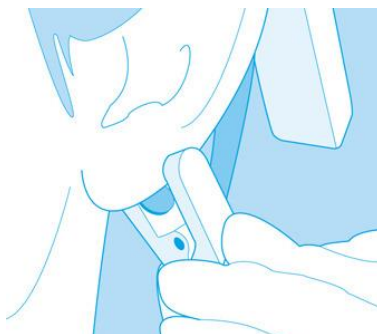


Figure 39 Adjust Ear clip

4- Note that sensor Tips always attached with your forehead and it will make your signal clear and also easy to measure the brain signals. If it will not attached with your forehead the signal is not produced and having problem to get the signal from the headset.

5- Now you will properly wear the headset and you will ready to receive the brain signal and control the object through brain signals.

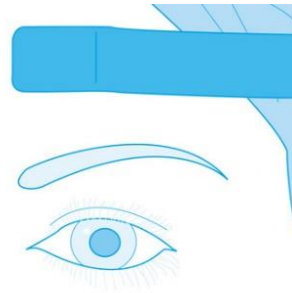


Figure 40 Should be closes to left eye



CHAPTER 6

6.1 Lessons Learnt and Future Work / Enhancements

6.1.1 Lesson Learnt

Brain computer interface is a highly growing field of research, which is very next step of understanding that how the human brain works. We also than studied a lot about this technology and concluded ourselves that we should also be a part of this innovative technology which is now a days very trending because for a non-educated person it is not easy to accept that is it possible to read human brain? By studying brain computer interface we decided to contribute in this filed and had an aim that we also would facilitate the humanity through technology. We learned that how you can serve those people who think themselves a dead person rather they have a brain. Many people are in the world who have disabilities like some do not have hands, some do not have legs, some do not have eyes but they all have a brain, a working brain which can make them realize to be a perfect person who can enjoy all the facilities of life like a normal person do. We learned that you are not dead until your brain is working. From the past studies we came to conclusion that human brain generates the electrical signals which can be recorded by keeping some device on the head which have some power full electrodes in it and then recorded signals can be used to make commands for some system and controls the system. Human brain at a time generates bundle of electrical signals which needs a power full recording device that can handle bunch of electrical signals and do which system expects from the device, we than learned two or three electrodes device is not enough for handling such brain signals, it requires a power full system and much more electrodes like minimum the device should have a 19 channels for accurate expected output.

Research work needs a time investment and should already requires some knowledge of that field which leads to the road map time, money and patience could be greatest constraints for a researcher. The research work itself demands attention to detail and accuracy. we also realized by choosing the research based project that research should be unique and should give the unique solution to that problem which did not exists already, it's not easy to develop an innovative solution when a human thinks he have all the solution to a problem, research also requires a resource which we came to know at the middle of a project in which project investment is more important to complete the research. The research should also be validated, it makes you confident and make it

trustable for other researchers who need any kind of help and make them feel that this research will not lead to wrong path.

Some of the application or tools among with we were not familiar like, python, matlab, raspberry pi, Arduino, classification algorithms, signal processing etc. we learned. During our software engineering we studied a lot, did theoretical assignments but could not explore our field that how it would be useful for us and for other humans, during our final year project we got this opportunity to explore our field and came to know that through IT we can solve most of the problems, such as medical fields, architecture, civil etc. every filed need IT to integrate with them, then we decided to contribute our skills. Market demands highly skilled person for their companies, no one is ready to accept a fresh graduate but with a big reference, we learned during our final year project that the technologies on which we are working not running in the market but thanks to our supervisor **Mr. Talha Irfan** who guided us a lot about the market work and our final work that it would not be wasted, it would help to understand other technologies and build a road path for us.

One of the biggest example of serving the humans through brain computer interface is *Stephen Hawking*. In 1963, Stephen Hawking fell into neuron disease and was given two years to live. Yet hawking went to Cambridge to become a brilliant researcher and professorial fellow at Gonville and Caius College. Stephen hawking in none as the most brilliant physicists after Einstein. Here we realized that why not we can make our paralyzed people feel that they can do wonders like normal people do.

6.1.2 Future Work / Enhancements

Firstly, we decided to work on brain signals which we would read by placing the mindwave nuerosky device on the human scalp, these signals will be passed to the computer, the computer will than process these signals and pass these signals to the target device on which we want to perform some task. But after involving in this project we came to know that human brain signals are not purified by default, they came with some noise which disturbs the target system to perform specific task, we than started searching about noise removal from the signals so that our command would be as same as we generate from the brain. We decided to apply some machine learning algorithms on the brain signals to purify signals, we applied and purified our signal like we applied svm classifier, resolvent mean, logistics regression, sin and cosine transform, wavelet transform. Our mission is to refine brain signals and with those refine EEG signals we

will perform some action. Brain computer interface is very useful for removing disabilities so decided to implement our research in robotics, and plan to control a robotic arm.

We were now working on a three channels mindwave device which did not give us a result what we expect from the device, we came to know that the channels are not enough for our expected results, for future use for decided to use open BCI brain signal recording system which is very efficient but it requires a heavy budget and at a student stage we could not afford this investment so we moved it to future experiments.



CHAPTER 7

7.1 Bibliography

7.1.1 References

- [1] K. Lewis, "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research.
- [2] [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed October 2017].
- [3] "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed August 2017].
- [4] "computer_interface," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed November 2017].
- [5] "science/article/pii," [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed 2017].
- [6] [Online]. Available: <https://cacm.acm.org/magazines/2011/5/107704-brain-computer-interfaces-for-communication-and-control/fulltext>. [Accessed October 2017].
- [7] [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research.
- [8] [Online]. Available: <https://www.nature.com/articles/srep38565>. [Accessed November 2017].
- [9] [Online]. Available: <https://www.nature.com/articles/srep38565>. [Accessed October 2017].
- [10] [Online]. Available: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087347>. [Accessed November 2017].
- [11] [Online]. Available: <https://hal.inria.fr/hal-00688344/document>. [Accessed October 2017].
- [12] [Online]. Available: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087347>. [Accessed 14 November 2017].
- [13] [Online]. Available: [https://en.wikipedia.org/wiki/P300_\(neuroscience\)](https://en.wikipedia.org/wiki/P300_(neuroscience)). [Accessed 2017].
- [14] "computer_interface#Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed 2017].
- [15] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>.
- [16] "eeg," [Online]. Available: <https://www.epilepsy.com/learn/diagnosis/eeg>. [Accessed 2017].
- [17] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>.
- [18] "EEGHistory," [Online]. Available: <http://www.edumed.org.br/cursos/neurociencia/cdrom/Biblioteca/EEGHistory.htm>. [Accessed October 2017].
- [19] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>. [Accessed 2017].
- [20] [Online]. Available: <https://sputniknews.com/science/201506081023074754/>. [Accessed 2017].
- [21] "an-introduction-to-the-discrete-fourier-transform," [Online]. Available: <https://www.allaboutcircuits.com/technical-articles/an-introduction-to-the-discrete-fourier-transform/>. [Accessed October 2017].
- [22] "Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fourier_transform. [Accessed 2017].

- [23] "Fourier-series-and-Discrete-," [Online]. Available: <https://www.quora.com/What-is-the-exact-difference-between-continuous-fourier-transform-discrete-Time-Fourier-Transform-DTFT-Discrete-Fourier-Transform-DFT-Fourier-series-and-Discrete->. [Accessed 2017].
- [24] "discrete-fourier-transform," [Online]. Available: <http://www.allaboutcircuits.com/technical-articles/an-introduction-to-the-discrete-fourier-transform/>. [Accessed August 2017].
- [25] "Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fourier_transform. [Accessed October 2017].
- [26] "FourierSeries," [Online]. Available: <http://mathworld.wolfram.com/FourierSeries.html>. [Accessed October 2017].
- [27] "Fast_Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fast_Fourier_transform. [Accessed October 2017].
- [28] "faster-fourier-transforms," [Online]. Available: <http://news.mit.edu/2012/faster-fourier-transforms-0118>. [Accessed 2017].
- [29] "briefs-on-data-processing," [Online]. Available: <https://www.tes.com/lessons/ubHCeL112MIQGA/briefs-on-data-processing>. [Accessed 2017].
- [30] "chap8," [Online]. Available: <https://see.stanford.edu/materials/lsoftae261/chap8.pdf>. [Accessed October 2017].
- [31] "fftw," [Online]. Available: <http://cvxopt.org/userguide/fftw.html>. [Accessed 2017].
- [32] "Discrete-Sine-Transform," [Online]. Available: <https://www.scribd.com/document/142252410/Discrete-Sine-Transform>.
- [33] "Discrete_sine_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_sine_transform. [Accessed 2017].
- [34] "Regression_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Regression_analysis. [Accessed 2017].
- [35] "Regression_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Regression_analysis.
- [36] "types-of-regressions-which-one-to-use," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed October 2017].
- [37] "regressions," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed October 2017].
- [38] "Logistics," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed November 2017].
- [39] "Regression 20Models," [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed November 2017].
- [40] "Regression%20Models," [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed 2017].
- [41] [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed 2017].
- [42] "regressions," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed 2017].
- [43] "analysis," [Online]. Available: <http://www.statisticssolutions.com/principal-component-analysis-pca/>. [Accessed 2017].
- [44] "pca," [Online]. Available: <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/learn43/lib/photoz/.g/web/glossary/pca.html>. [Accessed October 2017].

- [45] "pca_step_by_step," [Online]. Available: http://sebastianraschka.com/Articles/2014_pca_step_by_step.html. [Accessed October 2017].
- [46] "principal-component-analysis," [Online]. Available: <http://gisgeography.com/principal-component-analysis-gis-redundant-data/>. [Accessed October 2017].
- [47] "principal-component-analysis," [Online]. Available: <https://www.dezyre.com/data-science-in-python-tutorial/principal-component-analysis-tutorial>. [Accessed 2017].
- [48] [Online]. Available: <https://www.dezyre.com/data-science-in-python-tutorial/principal-component-analysis-tutorial>. [Accessed October 2017].
- [49] "principal," [Online]. Available: <https://www.analyticsvidhya.com/blog/2016/03/practical-guide-principal-component-analysis-python/>. [Accessed October 2017].
- [50] [Online]. Available: <http://www.dataminingreporting.com/blog/4-dimensionality-reduction-principal-component-analysis-pca>. [Accessed October 2017].
- [51] K. Lewis, "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed October 2017].
- [52] "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed October 2017].
- [53] "Harmonic_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Harmonic_analysis. [Accessed 2017].
- [54] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed October 2017].
- [55] "wdwt," [Online]. Available: <http://klapetek.cz/wdwt.html>. [Accessed 2017].
- [56] [Online]. Available: 9. <https://www.slideshare.net/hichamberkouk/introduction-to-wavelet-transform-with-applications-to-dsp>. [Accessed November 2017].
- [57] "wa_cwt," [Online]. Available: http://zone.ni.com/reference/en-XX/help/371419D-01/lvasptconcepts/wa_cwt/. [Accessed 2017].
- [58] "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed 2017].
- [59] "EEG," [Online]. Available: https://www.researchgate.net/publication/4340077_Wavelet_transform_use_for_feature_extraction_and_EEG_signal_segments_classification. [Accessed 2017].
- [60] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed 2017].
- [61] [Online]. Available: <http://ijarcet.org/wp-content/uploads/IJARCET-VOL-4-ISSUE-3-1070-1074.pdf>. [Accessed 2017].
- [62] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed 2017].
- [63] "wdw," [Online]. Available: <http://klapetek.cz/wdwt.html>. [Accessed 2017].
- [64] "Learnpython," [Online]. Available: <http://www.bestprogramminglanguagefor.me/why-learn-python>. [Accessed 06 November 2017].
- [65] "Language fundamentals," [Online]. Available: <https://www.mathworks.com/help/matlab/language-fundamentals.html>. [Accessed 06 November 2017].
- [66] "C programming Language," [Online]. Available: [https://en.wikipedia.org/wiki/C_\(programming_language\)](https://en.wikipedia.org/wiki/C_(programming_language)). [Accessed 06 November 2017].
- [67] M. O, Shervin and Krucoff, "Human_BCI_research," wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed October 2017].
- [68] "article/pii," Sciencedirect, [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed September 2017].

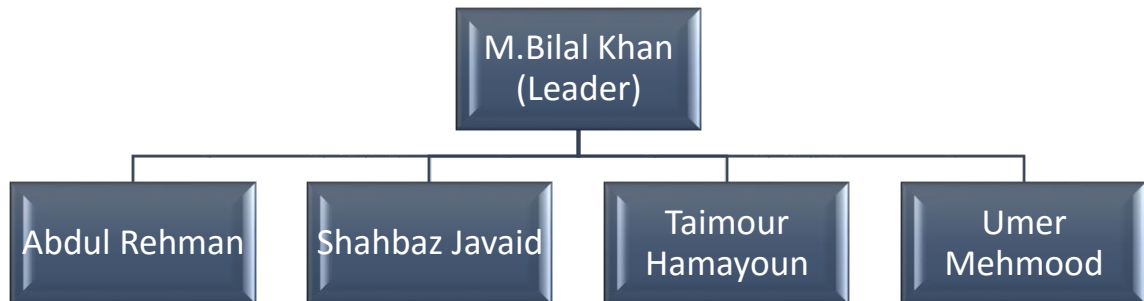
CHAPTER 7 BIBLIOGRAPHY AND REFERENCES

- [69] L. Huggins and M. W, "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed October 2017].
- [70] "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed August 2017].
- [71] [Online]. Available: <https://hal.inria.fr/hal-00688344/document>. [Accessed November 2017].
- [72] "what-is-pca," [Online]. Available: <http://support.minitab.com/en-us/minitab/17/topic-library/modeling-statistics/multivariate/principal-components-and-factor-analysis/what-is-pca/>. [Accessed October 2017].

Appendices

8.1 Appendix A

8.1.1 Team Structure



8.1.2 Roles & Responsibilities

Table 2: Roles & Responsibilities

Name	Designation	Roles
Mr. Talha Irfan	Project Supervisor	Monitored the activities throughout the project development lifecycle and guided the steps involved in completion of the project.
Mr. Abdul Rahman	Matlab Expert	Learned the use of MATLAB and Raspberry pi. Applied different feature extraction algorithms on data set like SVM classifier, Discrete sin transform, discrete cosine transform and also learned logistics regression Documentation
Mr. Bilal Khan	Python Expert	Learned the use of Python and Raspberry pi. Applied fourier transform and resolvent transformation on data set and connectivity of Neurosky Mindwave

CHAPTER 7 BIBLIOGRAPHY AND REFERENCES

		mobile with python and worked on Arduino with mindflex also done Documentation
Mr. Shahbaz Javed	Python Expert	<p>Learned the use of Python and Raspberry pi.</p> <p>Applied Discrete sin transform and discrete cosine transform on data set and worked on Neurosky Mindwave Mobile with Matlab (Worked on attention and meditation signals), also worked on Arduino with Mindflex and did Documentation.</p>
Mr. Taimour Humayoun	Matlab Expert	<p>Learned the use of MATLAB and Raspberry pi.</p> <p>Applied SVM classifier and resolvable transformation, PCA on data set and also learned logistics regression and Documentation.</p>
Mr. Umer Mehmood	Matlab Expert	<p>Learned the use of MATLAB and Raspberry pi.</p> <p>Applied Fourier transformation on data set, learned BCI, P300, PCA and did Documentation.</p>

8.1.3 Time Table

We intent to complete our project in four phases.

Table 3: Time Table

Serial No	Description of work		Start and End Dates
1	Phase One	Phase one of six weeks had consist of research, requirement and resources gathering.	24/3/2017 - 5/5/2017
2	Phase Two	Phase two consisting of seven weeks had software and hardware team to be working on their individual assignments.	11/5/2017 - 30/6/2017
3	Phase Three	Phase four consisting of four weeks had teams to integrate software and hardware.	4/7/2017- 4/8/2017
4	Phase Four	Phase four consisting of four weeks will have testing phase where the integrated products will rigorously be tested.	15/9/2017-17/10/2017

8.1.4 Budgeting

Table 4: Budgeting

Budgeting			
Sr.no	Product	Units	Price
1	Neuro Sky	1	1*28000=28000.
2	Raspberry Pi	1	1*5000=5000.
3	Raspberry Pi Kit	1	1*4500=4500.
4	Arduino Mega	1	1*1500=1500.
5	Miscellaneous (wires, Soldering, Bread boards. Led Lights, resistance)	1	1*5000=5000.
	Grand Total		44,000 PKR.

8.1.5 Experimental Results

Table 5: Experimental Results 1

Algorithms	SVM Classifier with Matlab						
	False positive (FP)	False negative (FN)	True positive rate (TPR)	True negative rate (TNR)	Positive predictive value (PPV)	Negative predictive value (NPV)	Total Accuracy
SVM	1364	430	0.8851	0.612	0.7084	0.8337	75.3%
Resolvent mean	1084	1312	0.6496	0.6920	0.6917	0.6499	51.02%
Discrete Sine Transform	1302	1913	0.4890	0.6301	0.5844	0.5369	56.87%
Discrete Cosine Transform	1248	1309	0.6504	0.6455	0.6611	0.6345	49.38%
Fourier Transform	1364	430	0.8851	0.6125	0.7084	0.8337	76.1%

Table 6: Experimental Results 2

Algorithms	SVM Classifier with Python						
	False positive (FP)	False negative (FN)	True positive rate (TPR)	True negative rate (TNR)	Positive predictive value (PPV)	Negative predictive value (NPV)	Total Accuracy
SVM	1505	450	0.8241	0.620	0.7098	0.8437	72.1%
Resolvent mean	1101	1412	0.6510	0.7001	0.6800	0.6989	66.35%
Discrete Sine Transform	1129	2010	0.5890	0.6802	0.4874	0.5560	51.7%
Discrete Cosine Transform	1208	1209	0.6711	0.5455	0.7611	0.7172	48.8%
Fourier Transform	1264	630	0.7851	0.8125	0.7084	0.8637	66.87%

8.2 Appendix B

8.2.1 References

- [1] K. Lewis, "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research.
- [2] [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed October 2017].
- [3] "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed August 2017].
- [4] "computer_interface," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed November 2017].
- [5] "science/article/pii," [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed 2017].
- [6] [Online]. Available: <https://cacm.acm.org/magazines/2011/5/107704-brain-computer-interfaces-for-communication-and-control/fulltext>. [Accessed October 2017].
- [7] [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research.
- [8] [Online]. Available: <https://www.nature.com/articles/srep38565>. [Accessed November 2017].
- [9] [Online]. Available: <https://www.nature.com/articles/srep38565>. [Accessed October 2017].
- [10] [Online]. Available: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087347>. [Accessed November 2017].
- [11] [Online]. Available: <https://hal.inria.fr/hal-00688344/document>. [Accessed October 2017].
- [12] [Online]. Available: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087347>. [Accessed 14 November 2017].
- [13] [Online]. Available: [https://en.wikipedia.org/wiki/P300_\(neuroscience\)](https://en.wikipedia.org/wiki/P300_(neuroscience)). [Accessed 2017].
- [14] "computer_interface#Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed 2017].
- [15] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>.
- [16] "eeg," [Online]. Available: <https://www.epilepsy.com/learn/diagnosis/eeg>. [Accessed 2017].
- [17] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>.
- [18] "EEGHistory," [Online]. Available: <http://www.edumed.org.br/cursos/neurociencia/cdrom/Biblioteca/EEGHistory.htm>. [Accessed October 2017].
- [19] "Electroencephalography," [Online]. Available: <https://en.wikipedia.org/wiki/Electroencephalography>. [Accessed 2017].
- [20] [Online]. Available: <https://sputniknews.com/science/201506081023074754/>. [Accessed 2017].
- [21] "an-introduction-to-the-discrete-fourier-transform," [Online]. Available: <https://www.allaboutcircuits.com/technical-articles/an-introduction-to-the-discrete-fourier-transform/>. [Accessed October 2017].
- [22] "Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fourier_transform. [Accessed 2017].

- [23] "Fourier-series-and-Discrete-," [Online]. Available: <https://www.quora.com/What-is-the-exact-difference-between-continuous-fourier-transform-discrete-Time-Fourier-Transform-DTFT-Discrete-Fourier-Transform-DFT-Fourier-series-and-Discrete->. [Accessed 2017].
- [24] "discrete-fourier-transform," [Online]. Available: <http://www.allaboutcircuits.com/technical-articles/an-introduction-to-the-discrete-fourier-transform/>. [Accessed August 2017].
- [25] "Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fourier_transform. [Accessed October 2017].
- [26] "FourierSeries," [Online]. Available: <http://mathworld.wolfram.com/FourierSeries.html>. [Accessed October 2017].
- [27] "Fast_Fourier_transform," [Online]. Available: https://en.wikipedia.org/wiki/Fast_Fourier_transform. [Accessed October 2017].
- [28] "faster-fourier-transforms," [Online]. Available: <http://news.mit.edu/2012/faster-fourier-transforms-0118>. [Accessed 2017].
- [29] "briefs-on-data-processing," [Online]. Available: <https://www.tes.com/lessons/ubHCeL112MIQGA/briefs-on-data-processing>. [Accessed 2017].
- [30] "chap8," [Online]. Available: <https://see.stanford.edu/materials/lsoftae261/chap8.pdf>. [Accessed October 2017].
- [31] "fftw," [Online]. Available: <http://cvxopt.org/userguide/fftw.html>. [Accessed 2017].
- [32] "Discrete-Sine-Transform," [Online]. Available: <https://www.scribd.com/document/142252410/Discrete-Sine-Transform>.
- [33] "Discrete_sine_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_sine_transform. [Accessed 2017].
- [34] "Regression_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Regression_analysis. [Accessed 2017].
- [35] "Regression_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Regression_analysis.
- [36] "types-of-regressions-which-one-to-use," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed October 2017].
- [37] "regressions," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed October 2017].
- [38] "Logistics," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed November 2017].
- [39] "Regression 20Models," [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed November 2017].
- [40] "Regression%20Models," [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed 2017].
- [41] [Online]. Available: http://user.mendelu.cz/drapela/Statisticke_metody/Tutorialy/Introduction%20to%20Logistic%20Regression%20Models.pdf. [Accessed 2017].
- [42] "regressions," [Online]. Available: <http://www.datasciencecentral.com/profiles/blogs/10-types-of-regressions-which-one-to-use>. [Accessed 2017].
- [43] "analysis," [Online]. Available: <http://www.statisticssolutions.com/principal-component-analysis-pca/>. [Accessed 2017].
- [44] "pca," [Online]. Available: <http://www.cs.cmu.edu/afs/cs.cmu.edu/project/learn43/lib/photoz/.g/web/glossary/pca.html>. [Accessed October 2017].

- [45] "pca_step_by_step," [Online]. Available: http://sebastianraschka.com/Articles/2014_pca_step_by_step.html. [Accessed October 2017].
- [46] "principal-component-analysis," [Online]. Available: <http://gisgeography.com/principal-component-analysis-gis-redundant-data/>. [Accessed October 2017].
- [47] "principal-component-analysis," [Online]. Available: <https://www.dezyre.com/data-science-in-python-tutorial/principal-component-analysis-tutorial>. [Accessed 2017].
- [48] [Online]. Available: <https://www.dezyre.com/data-science-in-python-tutorial/principal-component-analysis-tutorial>. [Accessed October 2017].
- [49] "principal," [Online]. Available: <https://www.analyticsvidhya.com/blog/2016/03/practical-guide-principal-component-analysis-python/>. [Accessed October 2017].
- [50] [Online]. Available: <http://www.dataminingreporting.com/blog/4-dimensionality-reduction-principal-component-analysis-pca>. [Accessed October 2017].
- [51] K. Lewis, "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed October 2017].
- [52] "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed October 2017].
- [53] "Harmonic_analysis," [Online]. Available: https://en.wikipedia.org/wiki/Harmonic_analysis. [Accessed 2017].
- [54] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed October 2017].
- [55] "wdwt," [Online]. Available: <http://klapetek.cz/wdwt.html>. [Accessed 2017].
- [56] [Online]. Available: 9. <https://www.slideshare.net/hichamberkouk/introduction-to-wavelet-transform-with-applications-to-dsp>. [Accessed November 2017].
- [57] "wa_cwt," [Online]. Available: http://zone.ni.com/reference/en-XX/help/371419D-01/lvasptconcepts/wa_cwt/. [Accessed 2017].
- [58] "Wavelet," [Online]. Available: <https://en.wikipedia.org/wiki/Wavelet>. [Accessed 2017].
- [59] "EEG," [Online]. Available: https://www.researchgate.net/publication/4340077_Wavelet_transform_use_for_feature_extraction_and_EEG_signal_segments_classification. [Accessed 2017].
- [60] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed 2017].
- [61] [Online]. Available: <http://ijarcet.org/wp-content/uploads/IJARCET-VOL-4-ISSUE-3-1070-1074.pdf>. [Accessed 2017].
- [62] "Discrete_wavelet_transform," [Online]. Available: https://en.wikipedia.org/wiki/Discrete_wavelet_transform. [Accessed 2017].
- [63] "wdw," [Online]. Available: <http://klapetek.cz/wdwt.html>. [Accessed 2017].
- [64] "Learnpython," [Online]. Available: <http://www.bestprogramminglanguagefor.me/why-learn-python>. [Accessed 06 November 2017].
- [65] "Language fundamentals," [Online]. Available: <https://www.mathworks.com/help/matlab/language-fundamentals.html>. [Accessed 06 November 2017].
- [66] "C programming Language," [Online]. Available: [https://en.wikipedia.org/wiki/C_\(programming_language\)](https://en.wikipedia.org/wiki/C_(programming_language)). [Accessed 06 November 2017].
- [67] M. O, Shervin and Krucoff, "Human_BCI_research," wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed October 2017].
- [68] "article/pii," Sciencedirect, [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1110866515000237>. [Accessed September 2017].

CHAPTER 7 BIBLIOGRAPHY AND REFERENCES

- [69] L. Huggins and M. W, "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed October 2017].
- [70] "Human_BCI_research," [Online]. Available: https://en.wikipedia.org/wiki/Brain%E2%80%93computer_interface#Human_BCI_research. [Accessed August 2017].
- [71] [Online]. Available: <https://hal.inria.fr/hal-00688344/document>. [Accessed November 2017].
- [72] "what-is-pca," [Online]. Available: <http://support.minitab.com/en-us/minitab/17/topic-library/modeling-statistics/multivariate/principal-components-and-factor-analysis/what-is-pca/>. [Accessed October 2017].

8.3 Appendix C

8.3.1 Indexes

- Arduino, 63
- bones tissue, 18
- Brain Automation System, 14
- brain computer interaction, 13
- channels, 64
- classification, 25
- dataset, 38
- diagnoses, 19
- Discrete Cosine Transformation, 58
- discrete Fourier transform, 29
- discrete multidimensional Fourier Transformation, 32
- Discrete sine transform, 32
- Discrete wavelet transform, 48
- EEG, 16
- Eigenvalues, 40
- Electroencephalogram**, 47
- Euler theorem, 30
- Event Related Potential, 19
- Fast Fourier Transformation, 31
- feature extraction algorithms, 22
- filtration, 22
- Fourier transformation, 28
- frequency domain, 28
- games and Entertainment, 19
- Harmonic analysis, 42
- headset, 60
- human brain, 62
- hyper planes, 25
- implementation, 50
- innovative technology, 62
- Invasive BCI, 17
- kernel trick**, 28
- logistic regression, 35
- Matlab, 52
- moto, 23
- Neuroprosthetics, 16
- neurosky mind wave, 58
- Neurotransmitters, 20
- Nled library, 54
- Non Invasive BCI, 18
- Numpy, 54
- orthogonal, 41
- Pakistan, 14
- paradigm, 19
- Partially Invasive BCI, 17
- physically disabilities, 13
- Principal component analysis, 38
- programming language, 53
- Prolonged EEG, 22
- Python, 41
- Python IDE, 54
- raspberry pi, 63
- Regression Analysis**, 33
- Resolvent Mean, 58
- routine EEG, 21
- scalp, 20
- Scikit, 54
- serve humanity, 23
- Signal de noising**, 51
- signal processing*, 45
- Support Vector Machine, 25
- Svmlib, 54
- technology, 14
- Thinkgear.dll, 54
- thoughts, 13
- variance, 39
- Wavelet Transform, 42