EMPIRICAL STUDY ON MACHINE LEARNING ALGORITHMS IN BCI

A PROJECT WORK REPORT
Submitted to

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment of the requirements
for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING

Submitted
by

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Certificate

This is to certify that the project work entitled "EMPIRICAL STUDY ON MACHINE LEARNING ALGORITHMS IN BCI" is the bonafide work done

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Vision of the Institution

To achieve the autonomous & university status and spread universal education by inculcating discipline, character and knowledge into the young minds and mould them into enlightened citizens.

Mission of the Institution

Our mission is to impart education, in a conducive ambience, as comprehensive as possible, with the support of all the modern technologies and make the students acquire the ability and passion to work wisely, creatively and effectively for the betterment of our society.

Vision of CSE department

Serving the high quality educational needs of local and rural students within the core areas of Computer Science and Engineering and Information Technology through a rigorous curriculum of theory, research and collaboration with other disciplines that is distinguished by its impact on academia, industry and society.

Mission of CSE department

The Mission of the department of Computer Science and Engineering is

- To work closely with industry and research organizations to provide high quality computer education in both the theoretical and applications of Computer Science and Engineering.
- The department encourages original thinking, fosters research and development, evolve innovative applications of technology.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Computer Science and Engineering program provides students with an in depth education in the conceptual foundations of computer science and in complex hardware and software systems. It allows them to explore the connections between computer science and a variety of other disciplines in engineering and outside. Combined with a strong education in mathematics, science, and the liberal arts it prepares students to be leaders in computer science practice, applications to other disciplines and research.

Program Educational Objective 1: (PEO1)

The graduates of Computer Science and Engineering will have successful career in technology or managerial functions.

Program Educational Objective 2: (PEO2)

The graduates of the program will have solid technical and professional foundation to continue higher studies.

Program Educational Objective 3: (PEO3)

The graduates of the program will have skills to develop products, offer services and create new knowledge.

Program Educational Objective 4: (PEO4)

- The graduates of the program will have fundamental awareness of Industry processes, tools and technologies.

PROGRAM OUTCOMES (POs)

PO1:	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2:	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3:	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4:	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5:	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6:	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7:	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8:	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9:	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10:	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11:	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12:	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1:	**Foundation of mathematical concepts:** To use mathematical methodologies to crack problem using suitable mathematical analysis, data structure and suitable algorithm.
PSO2:	**Foundation of Computer System:** The ability to interpret the fundamental concepts and methodology of computer systems. Students can understand the functionality of hardware and software aspects of computer systems.
PSO3:	**Foundations of Software development:** The ability to grasp the software development lifecycle and methodologies of software systems. Possess competent skills and knowledge of software design process. Familiarity and practical proficiency with a broad area of programming concepts and provide new ideas and innovations towards research.

QUALITY OF THE PROJECT

I. Consideration to Factors

Factors *(Environment, Safety, Ethics, Cost)*	Type of Project *(Application, Product, Research, Review, etc.)*	Standards
This project has high impact on physical disable person by using BCI.	This project is a researched based project and going to analyze the effective result based on machine learning algorithms.	Met the standards

II. POs and PSOs addressed through the project with justification

S.NO.	POs and PSOs addressed	Justification
1	PO1	Engineering knowledge: we have applied the machine learning algorithms for comparison of the dataset.
2	PO2	Problem analysis: we have analyzed the problem and used two machine learning algorithms for finding the better results.
3	PO3	Design/Development of solutions: we designed the solution which gives the detailed and effective results.
4	PO5	Modern tool usage: We selected and applied the appropriate techniques, Modern engineering and IT tools.
5	PO6	The Engineer and Society: This Project context is to improve the many more techniques and is used for the physically disabled people.
6	PSO1	Foundation of mathematical concepts: we used methodologies like calculating the accuracy and percentages to acquire results.
7	PSO3	Foundations of Software development: This project has the proper usage of software development life cycle and methodologies of Software Systems.

DECLARATION

We hereby declare that this Project Work is titled "*EMPIRICAL STUDY ON MACHINE LEARNING ALGORITHMS IN BCI*" is a genuine project work carried out by us, in **B.Tech (Computer Science and Engineering)** degree course of **Jawaharlal Nehru Technology University Hyderabad, Hyderabad** and has not been submitted to any other course or university for the award of my degree by us.

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ABSTRACT

Now a days there are several methods to identify brain functioning and many of the methodologies are been used in BCI (Brain Computer Interface). BCI means which acts as interface between the brain and computer. A brain-computer interface (BCI) may be a hardware and software communications system that allows cerebral activity alone to regulate computers or external devices. The instant goal of BCI or Brain Machine Interface (BMI) research is to provide communications capabilities to severely disabled people that are totally paralyzed or contrary by neurological neuromuscular disorders, like amyotrophic lateral sclerosis, brain stem stroke, or medulla spinalis injury. The data flow diagram of BCI consists of these following four steps and considering it identifies as a standard BCI & those steps are: signal acquisition, preprocessing or signal enhancement, feature extraction, classification and consequently the control interface. Few equipment's named as MRI, EEoG, SMRI, EEG etc., are used for the physically disabled people and also for paralyzed people. All these methodologies are providing various effective results. Here we discussed about the machine learning which is used to identify the results of BCI methodologies. In machine learning as we are having varieties of algorithms mostly we are concentrating on SVM and KNN algorithms to identify which algorithm is giving effective result by graphical representation which is done by using visualization techniques.

ACKNOWLEDGEMENT

The satisfaction that accompanies the successful completion of the task would be put incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crown all the efforts with success.

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We express our deep sense of gratitude and thanks to all the Teaching and Non-Teaching Staff of our college who stood with us during the project and helped us to make it a successful venture.

We place highest regards to our Parents, our Friends and Well wishers who helped a lot in making the report of this project.

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LIST OF SYMBOLS AND ABBREVATIONS

ABBREVATION	DESCRIPTION
BCI	Brain-Computer Interface
AI	Artificial Intelligence
EEG	Electroencephalography
MRI	Magnetic Resonance Imaging
ALS	Amyotrophic Lateral Sclerosis
MA	Mental Activity
FNIRS	Functional Near Infrared Spectroscopy
SMR	Sensorimotor Rhythms
ERD	Event Related de-synchronization
ERS	Event Related Synchronization
SF	Spatial Filtering
CSP	Common Spatial Pattern
LP	Laplacian Pattern
SNR	Signal-to-noise Ratio
IC	Independent Component
SVM	Support Vector Machine
KNN	K-Nearest Neighbor
NN	Neural Networks
LDA	Linear Discriminant Analysis
UML	Unified Model Language
PCA	Principal Component Analysis
ICA	Independent Component Analysis
PFC	Prefrontal Cortex

CHAPTER NO 1

INTRODUCTION

1.1 INTRODUCTION

1.1.1 MACHINE LEARNING:

Machine learning is an application of Artificial Intelligence (AI) which gives the power automatically to learn and improve from experience without being explicitly programmed to the systems. Machine learning focuses on the event of computer programs which may access data and use it learn for themselves.

The process of learning begins with observations or data, like examples, direct experience, or instruction, so on seem for patterns in data and make better decisions within the longer term supported the examples that we provide .

The first aim is to permit the computers learn automatically without human intervention or assistance and adjust actions accordingly.

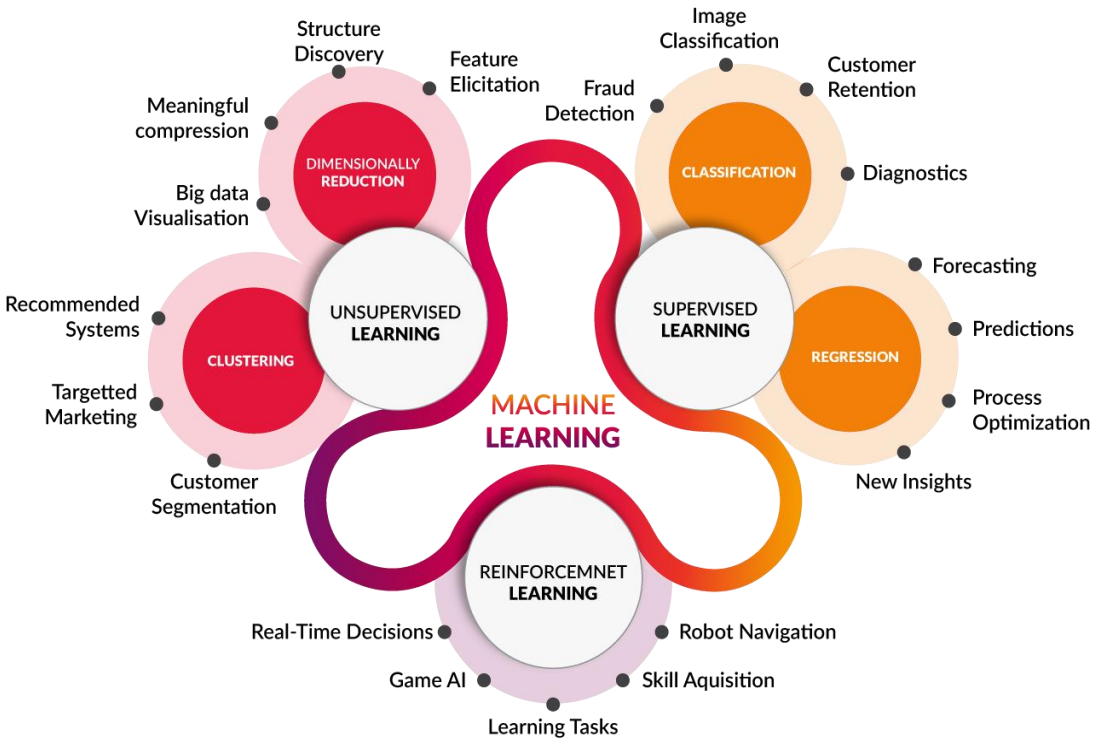


Fig.1.1.1 Overview of Machine Learning

At a high-level, machine learning is just the study of teaching a computer virus or algorithm the way to progressively improve upon a group task that it's given. On the research-side of things, machine learning are often viewed through the lens of theoretical and mathematical modeling of how this process works. However, more practically it's the study of the way to build applications that exhibit this iterative improvement.

There are some ways to border this concept, but largely there are three major recognized categories:

- Supervised learning
- Unsupervised learning
- Reinforcement learning.

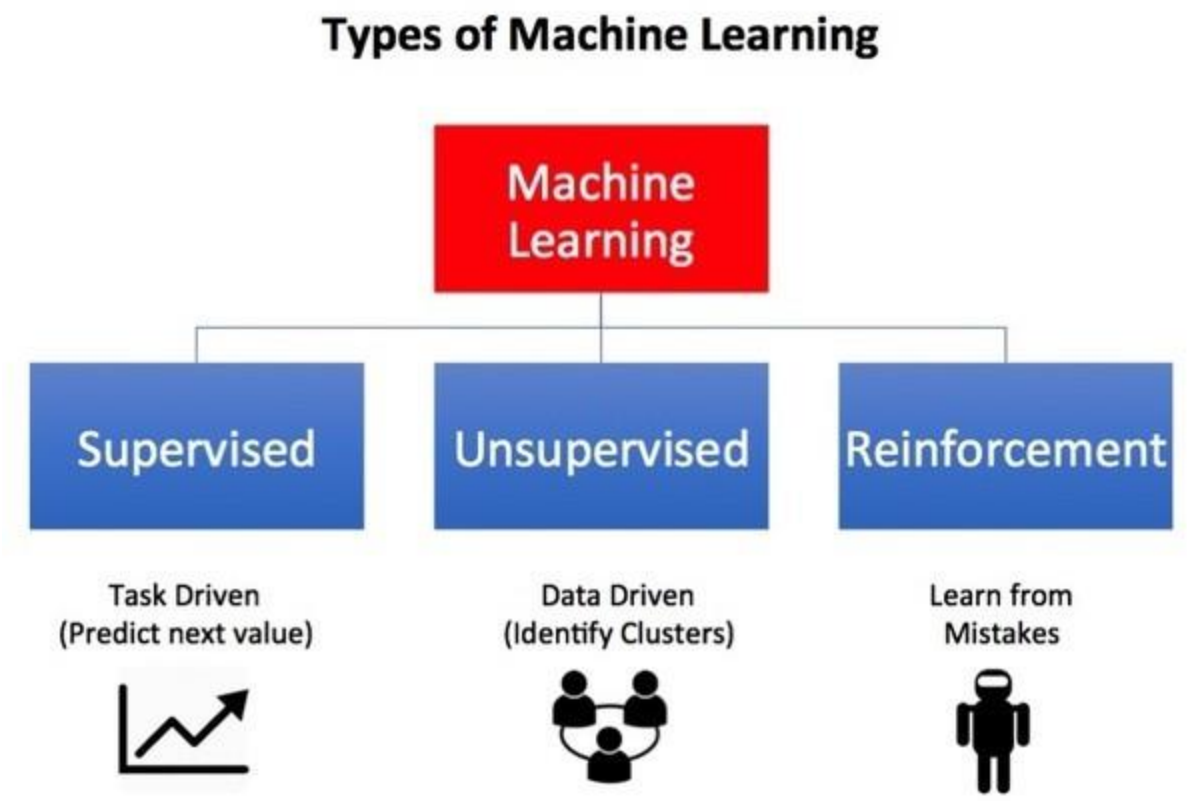


Fig.1.1.2 Machine Learning algorithms

1.1.2 Supervised Learning:

Supervised learning is that the hottest paradigm for machine learning. It's the simplest to know and therefore the simplest to implement. It's very almost like teaching a toddler with the utilization of flash cards.

Fig.1.1.3 Example of Supervised Learning Algorithm

Given data within the type of examples with labels, we'll feed a learning algorithm these example-label pairs one by one, allowing the algorithm to predict the label for each example, and giving it feedback on whether it predicted the right answer or not. Over time, the algorithm will learn to approximate the precise nature of the connection between examples and their labels. When fully-trained, the supervised learning algorithm are going to be ready to observe a replacement, never-before-seen example and predict an honest label for it.

1.1.3 Unsupervised Learning:

Unsupervised learning is extremely much the other of supervised learning. It features no labels. Instead, our algorithm would be fed tons of knowledge and given the tools to know the properties of the info. From there, it can learn to group, cluster, and/or organize the info during a way such a person's (or other intelligent algorithm) can are available and add up of the newly organized data.

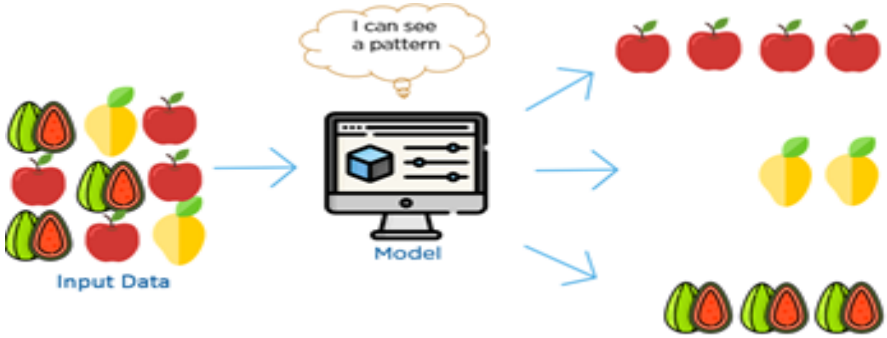


Fig.1.1.4 Example of Unsupervised Learning Algorithm

What makes unsupervised learning such a stimulating area is that an awesome majority of knowledge during this world is unlabeled. Having intelligent algorithms which will take our terabytes and terabytes of unlabeled data and add up of it's an enormous source of potential profit for several industries. That alone could help boost productivity during a number of fields.

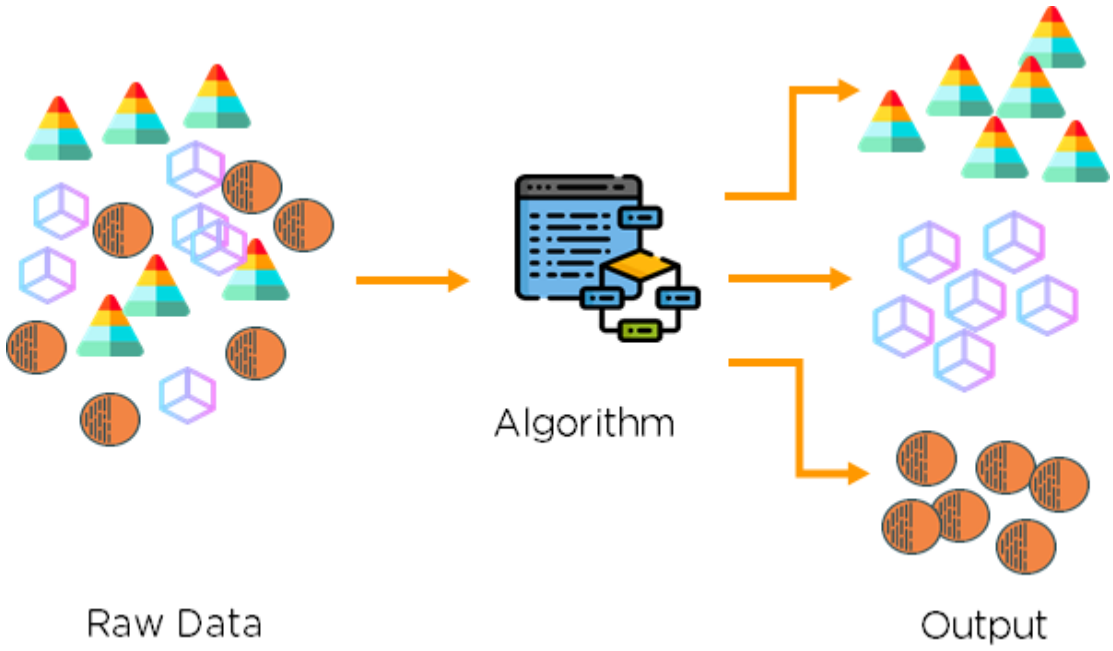


Fig.1.1.5 Separation of the raw data

1.1.4 Reinforcement Learning:

Reinforcement learning is fairly different in comparison to supervised and unsupervised learning. Where we will easily see the connection between supervised and unsupervised (the presence or absence of labels), the connection to reinforcement learning may be a bit murkier. Some people attempt to tie reinforcement learning closer to the 2 by describing it as a kind of learning that relies on a time-dependent sequence of labels, however, my opinion is that that simply makes things more confusing.

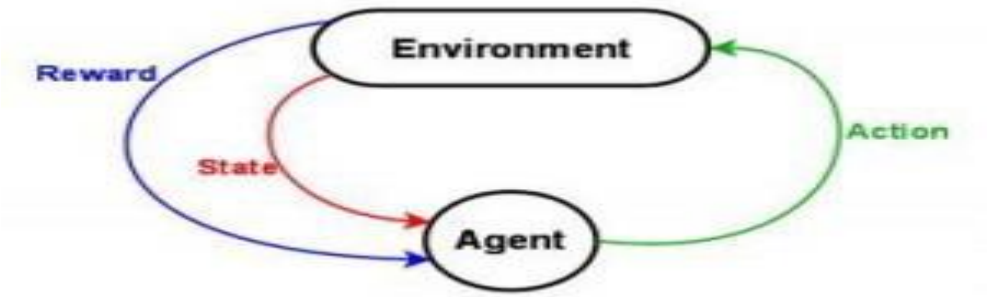


Fig.1.1.6 Working of Reinforcement Learning

1.2 BCI (Brain-Computer Interface):

A Brain-Computer Interface (BCI) may be a system that acquires and analyzes neural Signals with the goal of making a channel directly between the brain and therefore the computer. Such a channel potentially has multiple uses. [1]

BCI may be a communication system that recognized users' command only from his or her brainwaves and reacts consistent with them. PC and subject is trained. Walk in the park can contains desired motion of an arrow displayed on the screen only through subject's imaginary of something because the consequence of imaging process, certain characteristics of the brainwaves are raised and may be used for user's command recognition, e.g. motor mu waves (brain waves of alpha range frequency related to physical movements or intention to move).[1]

An Electroencephalogram based BCI provides a replacement communication channel between the human brain and a computer. Patients that suffer from severe motor impairments (late stage of Amyotrophic Lateral Sclerosis (ALS), severe spastic paralysis, head trauma and spinal injuries) may use such a BCI system as an alternate sort of communication by mental activity. [2]

The utilization of EEG signals as a vector of communication between men and machines represents one among the present challenges in signal theory research. The principal element of such a communication system, more referred to as "Brain Computer Interface", is that the

interpretation of the EEG signals associated with the characteristic parameters of brain electrical activity. [2]

The role of signal processing is crucial within the development of a real-time Brain Computer Interface. Until recently, several improvements are made during this area, but none of them are successful enough to use them during a real system. The goal of making simpler classification algorithms, have focused numerous investigations within the search of latest techniques of feature extraction. [4]

The main objective of this project is that the establishment of a Time – Frequency method, which allows EEG signal classification between two given tasks, also because the importance of the state which will be the art in time-frequency and Human Mission Interface. The extension of this method to a five-task classification problem are getting to be also considered. [4]

The electrical nature of the human system a nervous system has been recognized for quite a century. It's documented that the variation of the surface potential distribution on the scalp reflects functional activities emerging from the underlying brain. The surface potential differentiation are often recorded by fixing an array of electrodes to the scalp and will be measure the voltage between pairs of electrodes, which are then filtered, amplified, and recorded. The resulting data is known as the EEG. [4]

Each site features a letter (to identify the lobe) and variety or another letter to spot the hemisphere Location. The letters **F, T, C, P,** and **O** represents

- F- Frontal
- T- Temporal
- C- Central
- P- Parietal
- O- Occipital

Even numbers (2, 4, 6, and 8) ask the proper hemisphere and odd numbers (1, 3, 5, and 7) ask the left brain. The z indicates to an electrode which is placed on the midline.

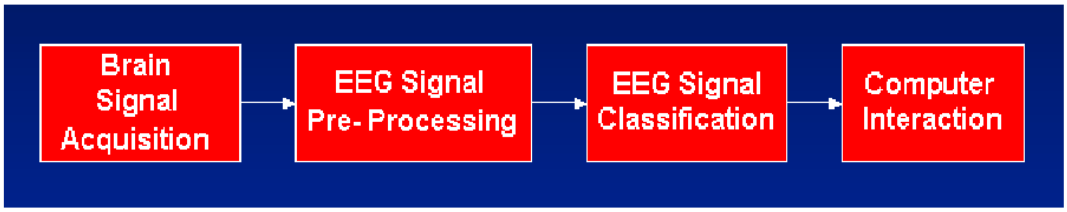


Fig.1.2.1 BCI common structure

1.3 STRUCTURE OF BRAIN-COMPUTER INTERFACE:

The common structure of a Brain-Computer Interface is that the following:

1) Signal Acquisition: The EEG signals are obtained from the brain through invasive or non-invasive methods (for example, electrodes). [5]

2) Signal Pre-Processing: Once the signals are acquired, it's necessary to wash them. [5]

3) Signal Classification: Once the signals are cleaned, they're going to be processed and classified to seek out which type of mental task the topic is performing. [5]

4) Computer Interaction: Once the signals are classified, they're going to be employed by an appropriate algorithm for the event of a particular application. [5]

1.4 BRAIN-COMPUTER INTERFACE ARCHITECTURE:

The processing unit is divided into a preprocessing unit, liable for device detection, and a feature extraction and recognition unit that identifies the command sent by the client to the generates an motion associated to the present instruction.[1]

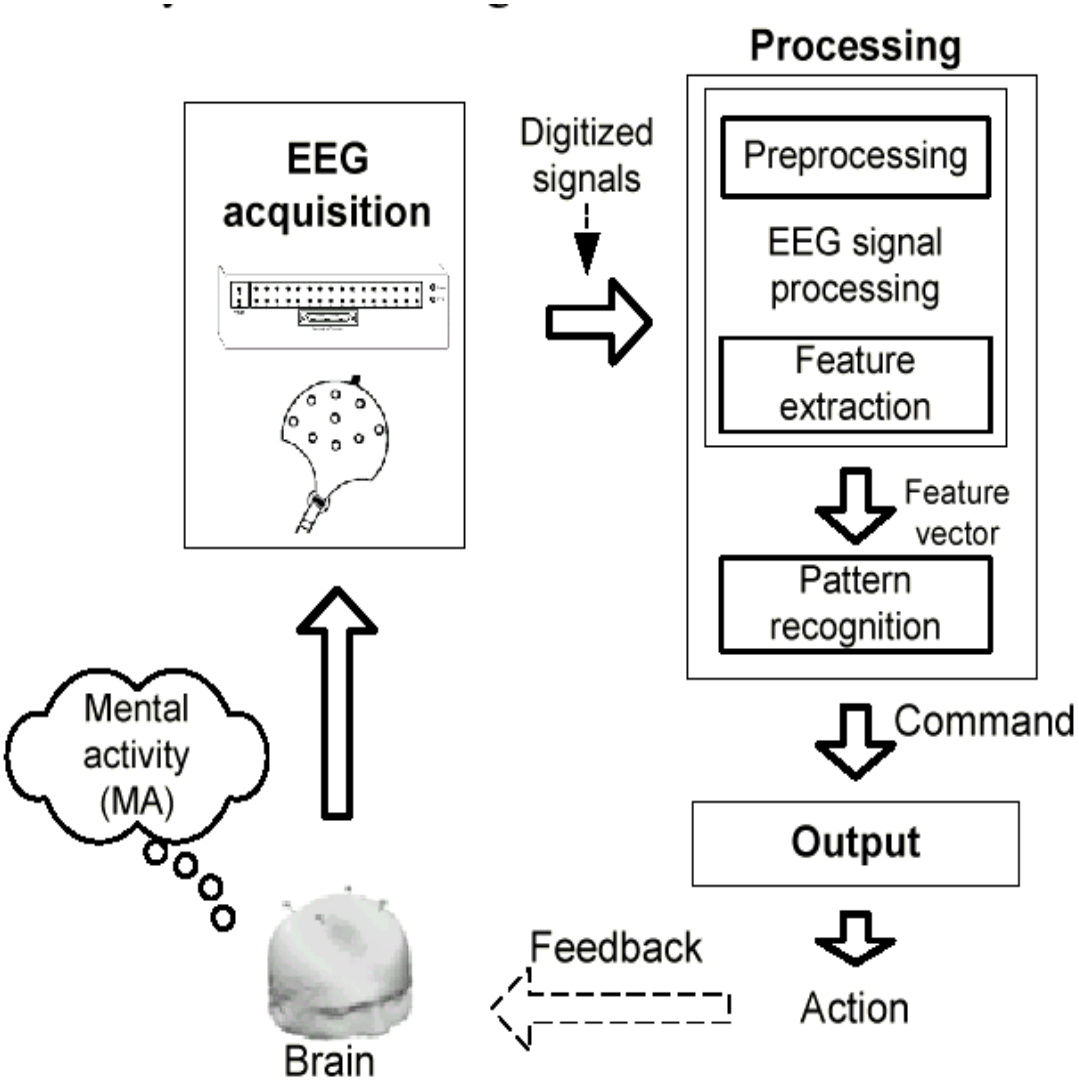


Fig.1.4.1 Architecture of BCI

1.5 APPLICATIONS OF BCI:

Direct neutral interface have done in various fields of research as there are displayed in below Figure.

Fig.1.5.1 Applications

1.5.1 Medical applications:

Healthcare field features a sort of applications that would cash in of brain signals altogether associated phases including prevention, detection, diagnosis, rehabilitation and restoration as shown in Figure. [6]

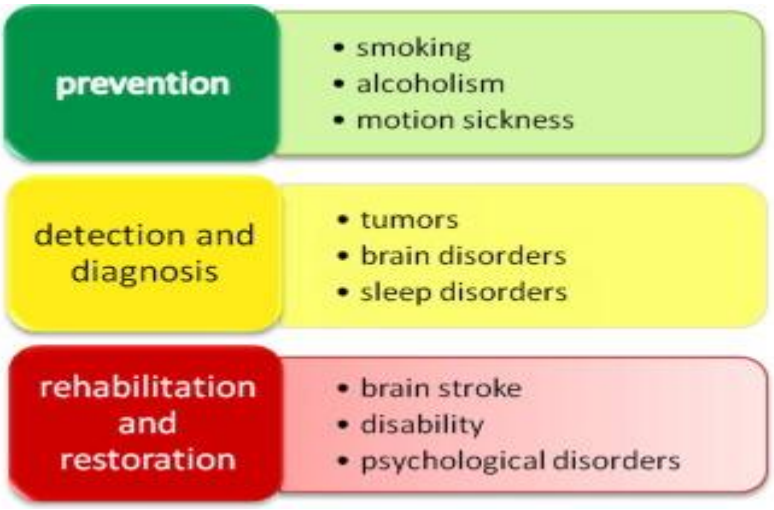


Fig.1.5.2 Medical Applications

1.5.2 Neurogonomics and smart environment:

As previously mentioned, deploying brain signals isn't exclusive to the medical field. Smart environments like smart work houses, smart workplaces or transportations could also derive direct neutral interface in offering further safety, luxury and ethical control to human

routine life. They're also expected to witness cooperation between Internet of Things (IOT) and BCI technologies. [7]

1.5.3 Neuromarketing and advertisement:

Marketing field has also been an interest for BCI researches. The research has explained the advantages of using EEG evaluation for TV advertisements associated with both commercial and political fields. On the opposite hand, the researchers have considered the impact of another cognitive function in neuromarketing field. They need been curious about estimating the memorization of TV advertisements thus providing another method for advertising evaluation. [7]

1.5.4 Educational and self-regulation:

Neurofeedback may be a promising approach for enhancing brain performance via targeting human brain activity modulation. It invades the tutorial systems, which utilizes brain electrical signals to work out the degree of clearness of studied information. Personalized interaction to every learner is established consistent with the resultant response experienced. [8]

1.5.5 Games and entertainment:

Entertainment and gaming applications have opened the marketplace for nonmedical brain computer interfaces. Various games are presented like in where helicopters are made to fly to any point in either a 2D or 3D virtual world.

1.5.6 Security and authentication:

Security systems involve skill based, system based and/or biometric based authentication. They need shown to be susceptible to several drawbacks like simple insecure password, shoulder surfing, theft crime, and cancelable biometrics. Cognitive Biometrics or electrophysiology, where only modalities using bio signals (such as brain signals) are used as sources of identity information, gives an answer for those vulnerabilities. The motivation behind exploring the feasibility of electrophysiology is that bio signals can't be casually acquired by external observers. They can also be of great value for disabled patients or users missing the associated

physical trait. This makes such signals difficult to synthesize and thus improves the resistance of biometric systems to spoofing attacks.

CHAPTER NO 2
LITERATURE REVIEW

2.1 CORTICAL EFFECTS OF USER TRAINING IN A MOTOR IMAGERY BASED BCI MEASURED BY FNIRS AND EEG [4]

- Motor imagery (MI)-based brain-computer interface (BCI) on activation patterns of the sensorimotor cortex. FNIRS and EEG are used for 2-class right and feet. [4]
- In the training enhancement of activation pattern emerges, represents Functional near-infrared spectroscopy (FNIRS) increases and electroencephalography (EEG) of upper beta waveband. These are visible with low BCI performance. These are useful in clinical applications at promoting and guiding neuroplasticity.
- Brain signals are measured and converted to regulate signals for various applications which provides the feedback to the used.
- BCI will control the changes via SMR [sensorimotor rhythms] which are primary and posterior centrals in cerebral mantle.
- SMR based BCI's was very useful within the clinical application like SCI patients which mean medulla spinalis patients will use. The SMR based BCI's injury of the medulla spinalis will thanks to the sudden stroke and impaired patients. During this SMR will helps them because it was appear as if the important movements.
- MI based BCI influences on the cortex and therefore the activation pattern. MI has the similar effect like motor training i.e.; specific activation of the cortical areas and cerebellum.
- The present study of the cortical effects in BCI has been used with multi-channel FNIRS.
- FNIRS is emerging non-invasive method and is said to FMRI [functional resonance imaging] which is predicated on the blood-oxygen-level dependent [BOLD] signal.
- In present study we use FNIRS & EEG since these are wont to find the effect of the future MI-based on activation patterns of the SMR.
- Low performance of BCI effects cortical performance and it can reduce by neuroplasticity [Future work].

- It is employed to diffuse [oxy-Hb] increase in FNIRS in activation patterns.
- ERD [Event related de synchronization] have decrease accuracy and
- ERS [Event related synchronization] have increase accuracy.

ADVANTAGES:

1. Very useful within the clinical applications.
2. By using this signals are converted to deploy the feedback of the user.
3. The above methods are wont to find the effect of the signals supported the blood-oxygen level.

DISADVANTAGES:

1. By using the above methods the efficiency has been reduced.
2. As efficiency has been decreased accuracy also will decreased as they're inter-related.

2.2 SUPPORT VECTOR NETWORKS [9]

- It is employed for 2 group classification problem.
- Input vectors are non-linearly mapped.
- SVM was wont to separate the training data without errors.
- Compares the performance of SVM to varied classical learning algorithms that stands because the benchmark in optical character recognition.
    - R.A.Fisher [1963] ⟶ pattern recognition.
    - Rosenblatt [1962] ⟶different quite learning machines: perception or neural networks.
    - Rosenblatt ⟶Algorithm that permits all the weights for neural network and to attenuate the error.
    - Rumel hart, Hinton & Williams [1986] ⟶Back propagation.
- SVM has 2 types conceptual and technical.
    - Conceptual solved 1965 for the case of optimal hyper planes where an optimal hyper plane means finding the maximal margin between vectors.

- Technical is claimed by using optimal hyper planes it says the way to treat high dimensional feature space.
- Instead of creating dot products with SVM, the non-linear transformation gets compared first then makes the result.

Comparison ⟶ two vectors in input space and gets non-linear transformation ⟶ result.

Optical hyper planes: Separation of coaching data without errors. Optimal hyper plane algorithm. Soft margin hyper plane: training data can't be separated without the error (minimal number of errors). The tactic of convolution of the Dot-product in feature space: To construct hyper plane during a feature space one has got to transform the n-dimensional to N-dimensional.

- SVM has three ideas
  - The solution technique from optimal hyper planes.
  - The idea of convolution of the dot-product.
  - Notation of sentimental margins.

ADVANTAGES:

1. Used for separating data.
2. Easy to match with other algorithms.
3. High Dimension space can easily find.

DISADVANTAGES:

1. Linear Transformation isn't compared.
2. Training data can't be separated without the error.
3. n-dimension to N-dimension due to feature space in hyper plane.

2.3 BEAM FORMING IN NON INVASIVE BRAIN COMPUTER INTERFACES [10]

- Beam forming technique that focuses a wireless signal towards specific receiving device, instead of having signals spread altogether directions from a broadcast antenna. It leads to more direct connection which is quicker & more reliable.

- Spatial filtering (SF) constitutes an integral a part of building EEG (Electroencephalography) based BCI's.
- Algorithms used for SF are common spatial pattern (CSP) & independent component analysis. They require labeled training data for identifying filters that provide information on subject's intention.
- Beam forming is used to construct spatial filters that extract EEG sources originating within pre-defines regions of interest within the brain.
- Beam forming is experimentally compared with CSP & Laplacian Spatial Filtering (LP) during a two class motor-imagery paradigm .It performs CSP & LP on noisy datasets.
- IN principle any non-invasive recording of brain activity like EEG, MEG, FMRI are often wont to construct a non-invasive BCI.OF of these EEG is that the most affordable and most generally available.
- The obstacle faced to construct a strong BCI supported EEG is that the low signal-to-noise ratio (SNR) of EEG recordings.
- One of the foremost successful algorithms for SF in non-invasive BCI's supported motor imagery is that the common spatial patterns (CSPs) algorithm.

Methods

 Notation.

 SF by Beam forming.

 Beam former properties.

ADVANTAGES:

1. Direct connection which is quicker and more reliable.
2. Used to construct a non-invasive BCI. It's most affordable and widely available.
3. Successful algorithms for Spatial filtering in non-invasive BCI supported motor imagery is that the Common Spatial Patterns (CSPs).

DISADVANTAGES:

1. Low signal-to-noise ratio (SNR) of EEG recordings.

2.4 ASSESSING THE EFFECTS OF VOLUNTARY AND INVOLUNTARY EYE BLINKS IN INDEPENDENT COMPONENTS OF ELECTROENCEPHALOGRAM [11]

- Effect of voluntary & involuntary eye blinks in independent components [ICs] contributes to EEG signals was assessed to make templates foe eye blinks artifact rejection from EEG signals with small number of electrodes.
- 14 EEG and 1 vertical electrooculography signals were recorded for 20 subjects during experiments for the attention blink.
- Voluntary & involuntary blink features from all channels present significant differences in delta band.
- Distorting effects have continued influence for 3.0 to 4.0s.
- Eye blink effects cease to exist after the zero-crossing 4times no matter the time.
- EEG signals has been generated with the movement of eyelid/eyeball which effects on
    - Delta(0.5-4.0Hz)
    - Theta(4.0-8.0Hz)
    - Alpha(8.0-13.0hz)
- EEG signal depends on the
    - Orientation of eye ball.
    - Trajectory of eye lid.
    - Location of the electrode o the scalp.
    - Propagation path of the electrical field across the top.
- EEG signals should be recorded with eyes open and with none constraints to permit investigation into intrinsic enclogenous brain activities albeit the attention blink artifactual contamination EEG signals can't be avoided due to the structure of physical body.
- Relevant cerebral information interfered with the EOG signal would even be cancelled within the EEG signal corrected employing a regressing based approach.

Properties:

- The influence of the artifact is attenuated with increase in distance from the eyes.
- The activity of the artifacts appears to propagate along the anterior, posterior axis during a symmetric way.
- The principle component analysis & independent component analysis [ICA] separates EEG signals into spatially and temporarily distinguishable components.

Voluntary [Exp 1]:

- An audio file had been used as an alert sound in windows 8.1 OS and therefore the audio are going to be sort of a beep sound.
- After the alert has been done then the attention blink should be propagated in order that for each 1second both eyes should be blinked after the sound had done.
- To avoid interference with other eye-related potentials

The occipital positive potential i.e.; is an invoked potential supported the changed visual stimulus, which usually occurs roughly 300ms after the onset of a blink. The cerebral potential caused by the reference way which represents a process for anticipation of the change within the visual stimulus from the attention movement.

- The dataset consists of three sessions
- Each session 20 trails ⟶ next session's starts after 60s ⟶ normal adults blink 3.0s ⟶ sound of 5/6s.

Involuntary [Exp 2]:

Three sounds

A—Ring finger

S—Middle finger

D—Index finger

- After 20 trails, the right answers are displayed.
- 90% of the entire trails correctly and to repair their eyes at the central back cross fixation.

ADVANTAGES:

1. Creates templates for eye blinks using EEG.
2. Voluntary and involuntary have different features in delta band.
3. Improves performance.

DISADVANTAGES:

1. Effect of artifacts increases distance of eye.
2. Zero-crossing effects when eye blinking.

2.5 COMPOSITE COMMON SPATIAL FOR SUBJECT-TO- SUBJECT TRANSFER[21]

- CSP is extraction method for EEG. Existing CSP-method exploit co-variance matrices on a subject-by-subject basis in order that inter-subject information is neglected. At present CSP for subject-to-subject transfer, where we exploit a linear combination. It has two methods
- CSP is extraction method for EEG.
- Existing CSP-method exploit co-variance matrices on a subject-by-subject basis in order that inter-subject information is neglected.
- At present CSP for subject-to-subject transfer, where we exploit a linear combination
- It has two methods
    - Composite covariance matrix.
    - Numerical experiments [data set Iva in BCI completion III confirm that composite CSP methods improve performance over standard CSP].
- EEG has been wont to record multiple sensors placed on scalp. Non-invasive BCI makes use of EEG to transfer out intention into an impact signal for device like compute, wheel chair etc.
- CSP was successfully applied to the matter of classifying EEG data involving motor-imagery task.

CSP--□Variance of 1 class is maximized. Variance of other class is minimized at an equivalent time.

CSP

Is a set of EEG signals of one trial measured from D electrodes with T representing the amount of sample time-points during a trial? Appropriate labels from either positive class or negative class.

E.g.: In motor-imager positive/negative class represents to right/left hand movement.

- ❖ CSP with composite covariance matrices.
- ❖ Most existing CSP methods are on the subject-by-subject basis.

There are 3 methods

- ➢ Method 1
- ➢ Method 2
- ➢ Traditional method

Method 1: trial matrices-□de-emphasized covariance matrices.

Method 2: emphasized covariance's matrices with similar characteristics to the topic.

Numerical experiments

Data set IVa BCI competition III: the info set IVa contains EEG has been divided into two classes.

- ➢ Imagery movement of right hand[R].
- ➢ Imagery movement of right foot [F].

In each trial EEG signals are measured by 118 electrodes from 5 different subject while 280 trials are performed foe each subject. av, aw, ay-subjects.

• Method 1 & 2 worked with small number of samples.

• Traditional is best & sufficient number of coaching samples.

ADVANTAGES:

1. Improves the performance.
2. Traditional method is best because it takes and calculates many numbers of coaching samples.

DISADVANTAGES:

1. The information has been neglected.
2. CSP uses only a linear combination.

CHAPTER NO 3

MOTIVATION

AI is getting used for various purposes today and one among these purposes is for Human Welfare. Stroke affects 16 million people worldwide per annum. Early Stroke detection can help patients survive a stroke with greater chances of recovery. Hence, detecting a stroke at an early stage is a crucial problem needing attention.

Motivation has been defined primarily in reference to goal setting and goal pursuit. Recent research in neuroscience [21] uses a compatible definition of motivation that can be made interoperable with AI technology concepts. Additionally, it identifies the involvement of specific brain regions during a way that supports the planning of appropriate BCI. From a cognitive perspective as well, motivation is conceived of as being goal directed [22, 23]. The connection to the goal has been further refined into planning and implementing stages [24], also suggesting that goal setting is primarily motivational, while goal striving is best characterized in terms of volitional factors [24].

According to [22], the neural systems implicated within the representation of cognitive goals overlap significantly with those handling the generation of motivated behaviors. Especially, Brain Sci. 2018, 8, 166 4 of 21 the lateral prefrontal cortex (PFC) might function a convergence zone during which motivational and cognitive variables are integrated [22].

The identification of specific brain regions whose activation may reflect motivational dimensions is an important step in designing appropriate BCI. In terms of activity measurement, there's a considerable body of labor associating PFC asymmetry with motivational direction [25], which originates with the study of approach/withdrawal as a motivational dimension [26]. This research has pioneered the measurement of prefrontal asymmetry using EEG signals [26], left asymmetry being related to the expression of approach.

Additionally, they have found this relationship to be stronger within the context of incentive anticipation. Moreover, there are strong relations between motivation and reward anticipation: as an example, lateral PFC activation is modulated by the extent of reward offered [27, 28]. Amodio et al. [29] have analyzed the correlates of PFC asymmetry from a regulatory

perspective. More specifically, they found approach regulation to be most relevant to “pre-goal states”, during which efforts are mobilized towards the goal. This must be reanalyzed from the prism of a hybrid cognitive system, which could involve a mixture of goal setting and goal pursuit counting on the knowledge visible to the user from the AI computation but, in any case, is compatible with a mediation from prefrontal asymmetry.

CHAPTER NO 4

OBJECTIVES

4.1 Definition of Feasibility:

As the name implies, a feasibility analysis is employed to work out the viability of a thought, like ensuring a project is legally and technically feasible also as economically justifiable. It tells us whether a project is well worth the investment—in some cases, a project might not be doable. There are often many reasons for this, including requiring too many resources, which not only prevents those resources from performing other tasks but also may cost quite a corporation would earn back by taking over a project that isn't profitable. [11]

There are three types of feasibility studies. They are:

- Technical Feasibility
- Operational Feasibility
- Economic Feasibility

4.2 TECHNICAL FEASIBILITY

The technical issue usually raised during the feasibility stage of the investigation includes the following: [5]

• Does the required technology exist to try to what's suggested?

• Do the proposed equipment's have the technical capacity to carry the info required to use the new system?

• Will adequate response is given by proposed system ?

• Can the system is developed when it is upgraded?

Are there technical guarantees of accuracy, reliability, simple access and data security?

4.3 OPERATIONALFEASIBILITY

User-friendly

User will have the sole possibility to accumulate the values by using the acquisition methods and therefore the one who get effected with the brain stroke or the one who is physically paralyzed uses the Invasive, semi-invasive and fully invasive methods by using surgery or physical movement and therefore the values and the frequencies are noted just for the disabled person which data has been associated with the effected person only and may be used because the dataset for several experiments. [5]

Reliability

The package wills pick-up current data up so far. Regarding the old data, the new data has been entered for each usage of acquisition methods. [5]

Security

The data set and database server should be shielded from hacking, virus and duplicate of the info must be removed. [5]

Portability

The application are going to be developed using standard open source software (Except Oracle) like Java, tomcat web server, Internet Explorer Browser etc. and software will work on Windows and Linux o/s. Hence portability problems won't arise. [5]

Availability

This software are going to be available always. [5]

4.4 ECONOMIC FEASIBILITY

The computerized system takes care of the data flow and procedures of the existing system and will generate all the reviews of the manual system along with the number of other management reports.

This is required because the activities are spread throughout the organization customer wants a centralized database. Further a number of the existing data are often re-written for an equivalent user and it are often stored because the data set in data base server. [7]

Benefits of feasibility study:

• Improves project teams' focus.

• Identifies new opportunities.

• Valuable information is provided for a "go/no-go" decision.

• Narrows the business alternatives.

• Identifies a legitimate reason to undertake the project.

• By evaluating multiple parameters we can increases the success rate.

• Aids decision-making on the project.

• Identifies reasons to not proceed.

CHAPTER NO 5

PROBLEM STATEMENT

5.1 Existing System:

In existing system it are often stated that the bottom paper consists of data associated with BCI (Brain Computer Interface) and there are several methods used and people are named as acquisition methods. BCI can be a computer-based system that which acquires brain signals, analyzes and translates signals into commands that are passed to an output device to hold out desire action. In theory, any sort of brain signal might be wont to control a BCI system. [1]

The acquisition methods are as follows:

Non-Invasive	Partially-Invasive	Invasive
Cost Efficient	Costly	Costly
Easily monitored	Difficult to monitor	Difficult to monitor
No medical training	Requires medical training and assistance	Requires medical training and assistance
Poor spatial resolution	High spatial resolution	Higher spatial resolution
No risk of infection	Risk of infection	Risk of infection and inflammation
Long-term recording	Short-term recording	Very short-term recording

Table.5.1 Acquisition Methods

The four algorithms in base paper are named as

- SVM(Support Vector Machine)
- KNN(K-Nearest Neighbours)
- NN(Neural Networks)
- LDA(Linear Discriminant Analysis)

SVM

1. SVM take cares of outliers.
2. SVM outranges KNN when large features and lesser training data are present.
3. SVM is optimized over a subset of the info, which is those data points that lie on the separating margin.
4. SVMs require less grid-searching to urge a fairly accurate model. [13]

KNN

1. If training data is far larger than no. of features (m>>n), KNN is best than NN.
2. KNN may be a non-parametric model.
3. KNN supports non-linear solutions.
4. KNN can only output the labels.
5. KNN classification needs no retraining phase.

K-NN requires no training time, whereas training neural networks is quite time-intensive. However k-NN will probably take for much longer at evaluation time, especially if you've got many data points and don't resort to approximate search. [16]

K-NN is extremely simple and requires tuning just one hyper parameter (the value of k), while neural net training involves many hyper parameters controlling the dimensions and structure of the network and therefore the optimization procedure. [16]

NN (NEURAL NETWORKS)

1. NN needs lot of hyper parameter tuning compared to KNN.
2. Neural networks need large training data compared to KNN to realize sufficient accuracy. [13]

LDA (LINEAR DISCRIMINANT ANALYSIS)

LDA makes use of the whole data set to estimate covariance matrices and thus is somewhat susceptible to outliers. Takes more training time and matrix ops.

5.2 Proposed System:

In proposed system therefore out of 4 algorithms mentioned above have chosen two algorithms and that they are SVM and KNN. The actual dataset has been taken from the kaggle.com and therefore the training of the info also as training of the info and along the prediction of the info has been done to the actual data sets by using those two specific algorithms. [17]

Out of 4 algorithms named only two has been used because these two algorithms had the special features so as to coach , test and predict the info set and it'll be more easier for displaying the result by using those algorithms. However the efficiency and accuracy will get differed from one algorithm to the opposite algorithm this comparison will results in the simplest algorithm supported the efficiency and accuracy.

The visualization of the info also done since it are often easier for the popularity and may be easier to settle on the simplest algorithm out of two algorithms i.e., SVM and KNN. [13][16]

CHAPTER NO 6

DESIGN METHODOLOGY & IMPLEMENTATION

6.1 HARDWARE AND SOFTWARE REQUIREMENTS:

Hardware Requirements:

Hardware interfaces specifies the logical characteristics of every interface between the software package and therefore the hardware components of the system. the subsequent are some hardware requirements.

- Hard Disk : 500GB
- RAM : 4GB

Software Requirements:

Software Requirements specifies the logical characteristics of every interface and software components of the system. the subsequent are some software requirements :

- Operating System : Windows
- Technology : Machine Learning
- Language : Python

6.2 DATA FLOW DIAGRAM:

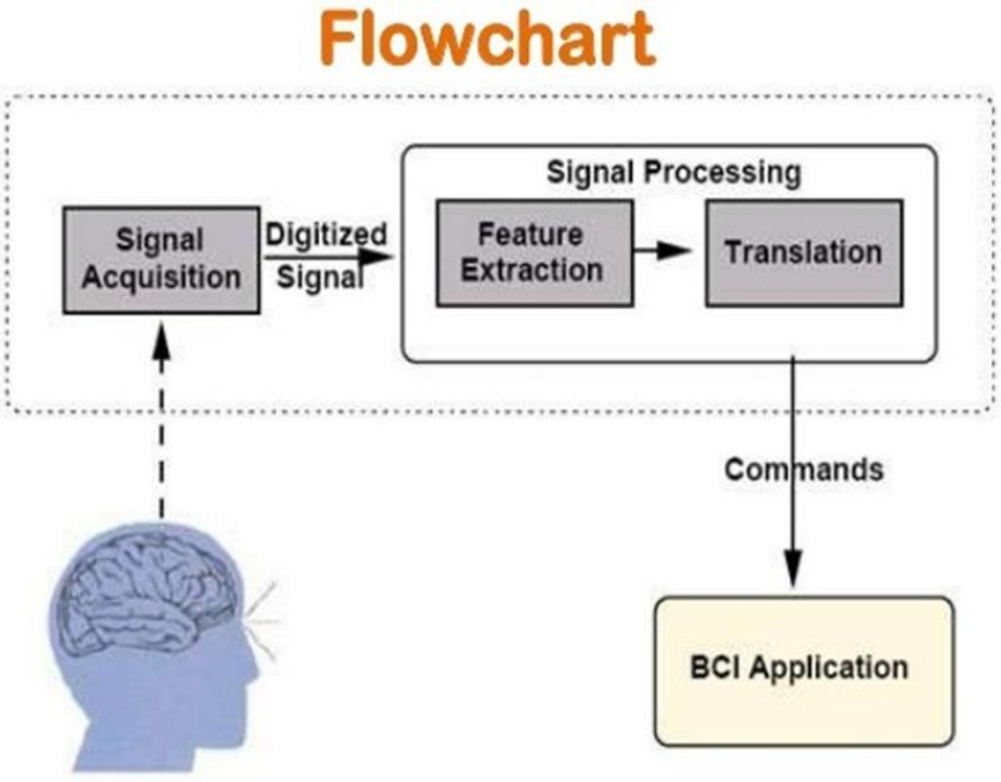


Fig.6.2.1 Data Flow Diagram

6.3 UNIFIED MODELING LANGUAGE (UML):

The Unified Modeling Language (UML) could also be a standard language for specifying

- visualizing
- constructing
- documenting

The UML represents a set of best engineering practices that have proven successful within the modeling of huge and sophisticated systems. The UML may be

a vital a part of developing objects oriented software and therefore the software development process. The UML uses mostly graphical notations to precise the planning of software projects. The teams of project communicate, explore designs, and prove software architectural design by using UML.

6.3.1 Goals of UML:

The primary goals within the design of the UML were:

- Provide users with a ready-to-use, expressive visual modeling languages other can develop and exchange meaning full models.
- Provide extensibility and specialization mechanisms to increase the core concepts.
- Be independent of particular programing language and development processes.
- Provide a proper basis for understanding the modeling language.
- Encourage the expansion of the OO tools market.
- Support highest-level development concepts like collaborations, frame works, patterns and components.
- Integrate best practices.

6.3.2 Why use UML?

Because the strategic value of software increases for several companies, the industry looks for techniques to automate the assembly of software and to enhance quality and reduce cost and time-to-market. UML includes part of technology, visual programming, patterns and frameworks. Business also seek techniques to manage the complexity of systems as they increase in scope and scale. Especially, they recognize the necessity to unravel recurring architectural problems, like Physical distribution, concurrency, replication, security, load balancing.[32]

6.3.3 Relations:

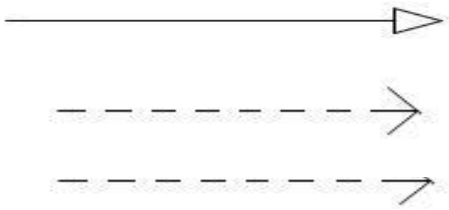
1. **Dependency:** Dependency may be a linguistic relation between two things during which change to thing may affect the semantics of other things. A dependency provided as a dashed-line, which makes as a label.

Dependency

2. **Association:** Association may be a structural relationship that describes set of links. A link being a connection among objects. Aggregation may be a special quite Association a structural relationship between an entire and its parts.

Association

3. **Generalization**: Generalization may be a specialization / generalization relationship during which objects of specialized element (child) are substitutable for object of the generalized element (parent). During this way the childish areas the structure and behavior of generalized element (parent).



4. **Realization:** A realization can be a formal relationship between classifiers where as one classifier shows contract that another classifier will also carry out relationships in two places among interfaces and classes between use case collaborations. Graphically provided a cross between generalization and Dependency relationships.

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6.4 UML DIAGRAMS:

UML diagram is meant to let developers and Customers view a software from a special perspective and in varying degrees of abstraction. UML diagrams commonly created in visual modeling tools commonly include:

1. **Use Case Diagram:** A use case diagram within the Unified Modeling Language (UML) may be a sort of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to exist as a graphical overview of the functional provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The most purpose of a use case diagram is to point out what system functions are performed that actor. Roles of the actors within the system are often depicted.[31]

Fig.6.4.1 Use Case Diagram of SVM and KNN

2. **Class Diagram:** In software engineering, UML tells the structure of a system by showing the system's classes, their attributes, methods, and also relationships among the classes. [32]

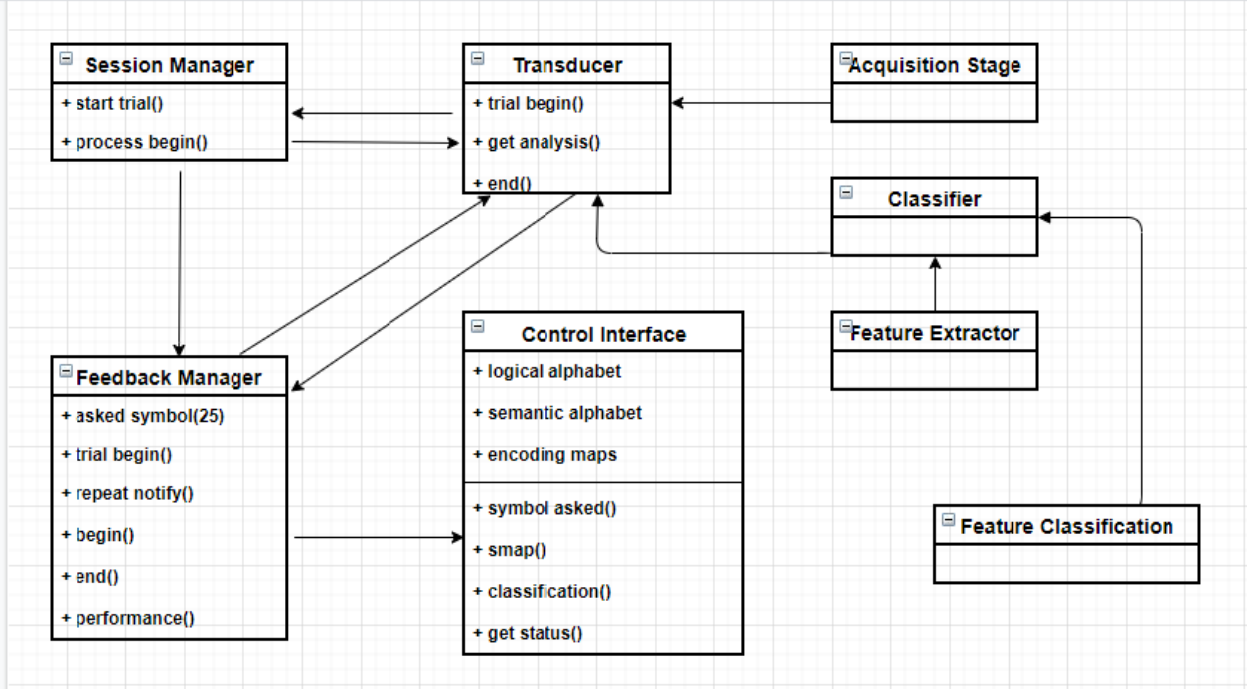

Fig.6.4.2 Class Diagram of SVN and KNN

3. **Sequence Diagram:** A sequence diagram in Unified Modeling Language (UML) could even be a quite interaction diagram that shows how processes operate with one another and in what order. It's a construct of a Message Sequence Chart.[31]

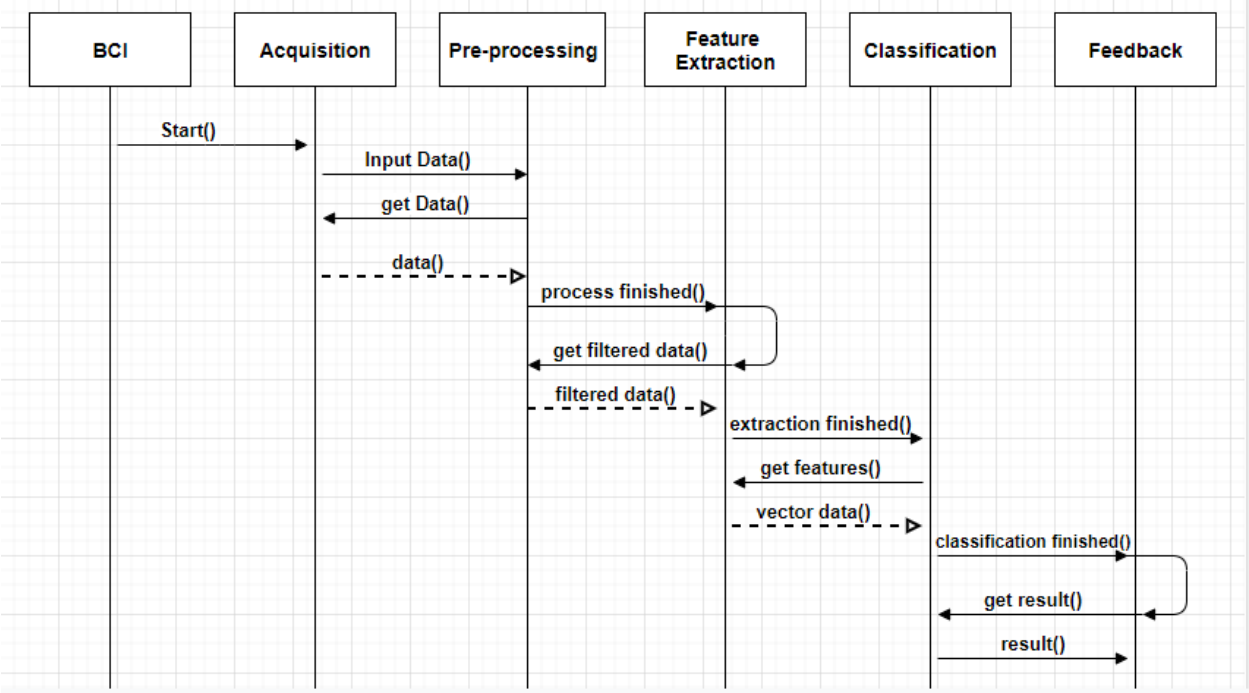

Fig.6.4.3 Sequence Diagram of SVM and KNN

4. **Activity Diagram:** Activity diagrams is of representation of graph during which line by line activities and actions are done to support for choice, iteration, concurrency within Unified Modeling Language. Activity diagrams are often won't to explain the business and operational step-by-step workflows of components during a system. An activity diagram shows the flow of process.[32]

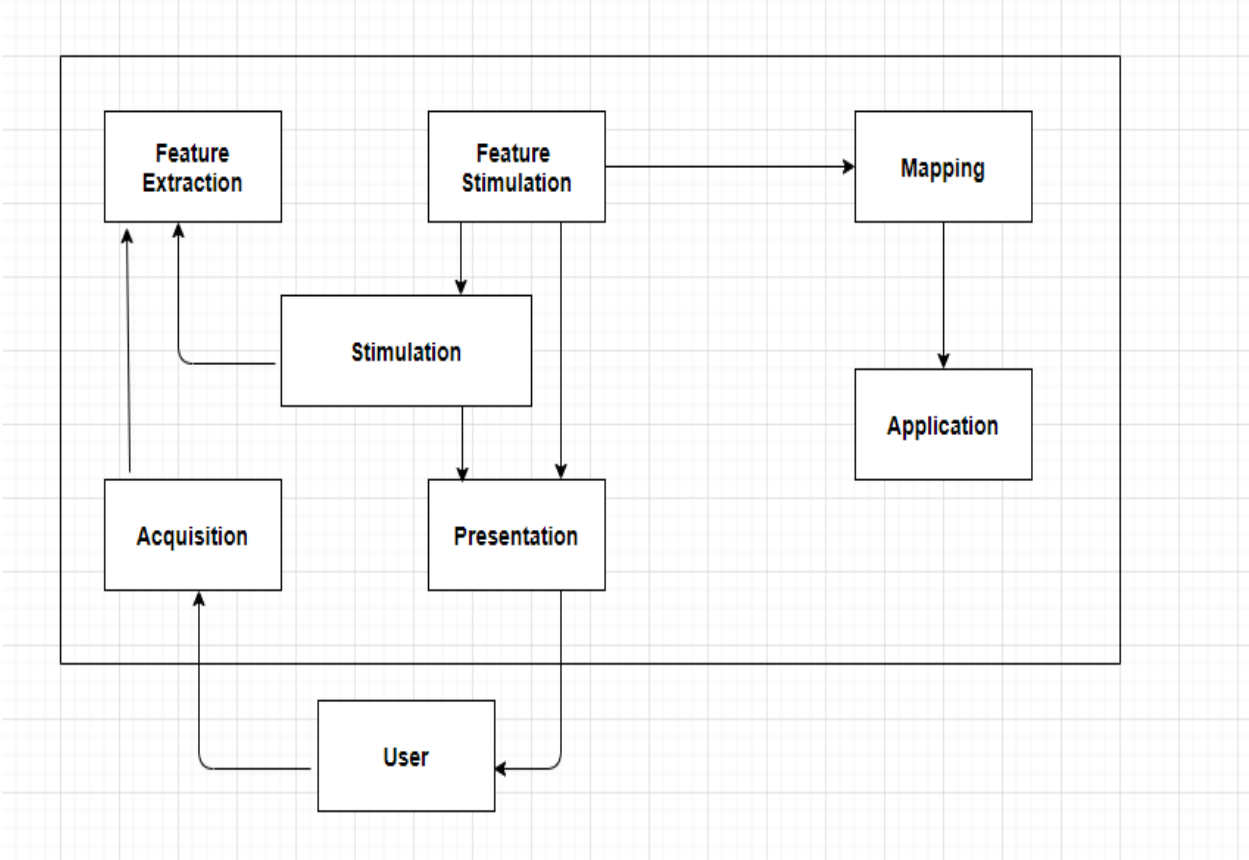

Fig.6.4.4 Activity Diagram of SVM and KNN

5. **Deployment Diagram:** Deployment Diagram could even be a kind of diagram that specifies the physical hardware on which the software will execute. It also determines how the software is deployed on the underlying hardware. It maps software pieces of a system to the device that are becoming to execute it.[32]

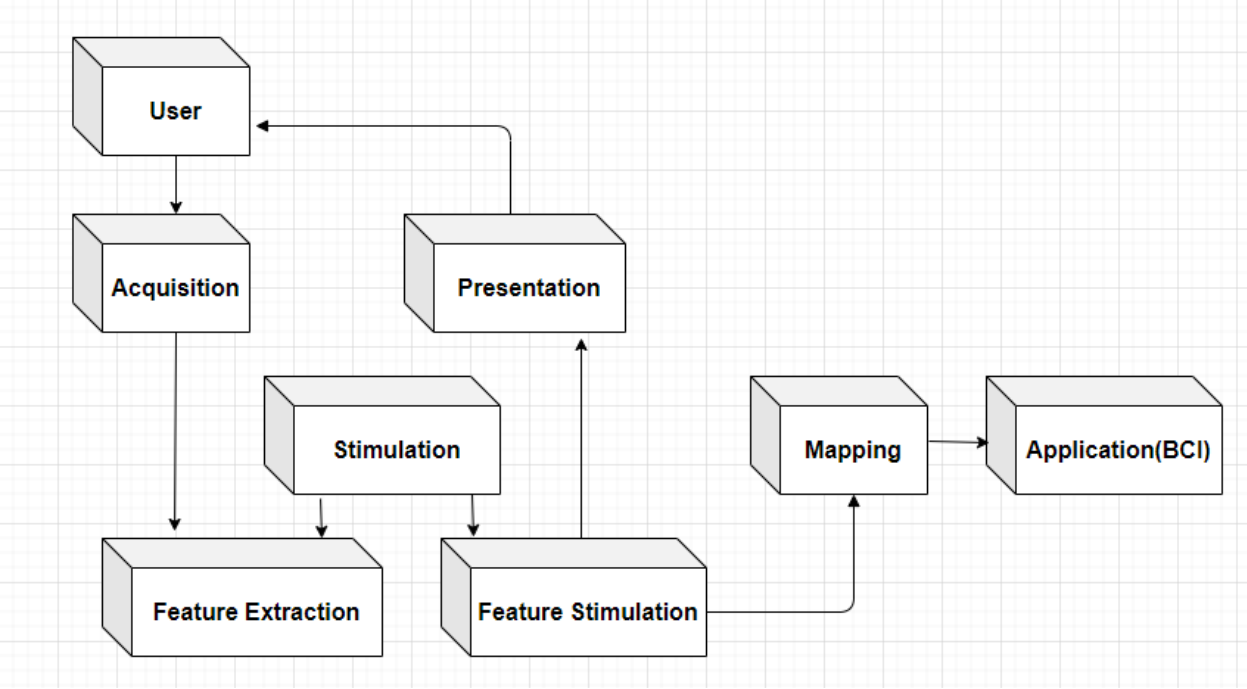

Fig.6.4.5 Deployment Diagram of SVM and KNN

6.5 ALGORITHMS IMPLEMENTED:

6.5.1 COMPARISON OF SUPPORT VECTOR MACHINE AND K-NEAREST NEIGHBOUR

In this project, we are using Support Vector Machine and K-Nearest Neighbor algorithms for comparison.

Fig.6.5.1 Comparison of SVM and KNN

6.5.2 SUPPORT VECTOR MACHINE (SVM):

Support Vector Machine may be a supervised machine learning .It is used for classification and regression process. The most purpose of the SVM algorithm is to make the choice boundary or best line which may separate n-dimensional space into classes in order that the upcoming points are often kept within the proper category. The simplest or perfect decision boundary is

named hyper-plane. So, the SVM basically a representation of various classes during a hyper-plane in multi-dimensional space. SVM chooses the acute points or vectors that creates in creating hyper-plane. These extreme classes are called support vectors and this algorithm referred to as Support Vector machine. [12]

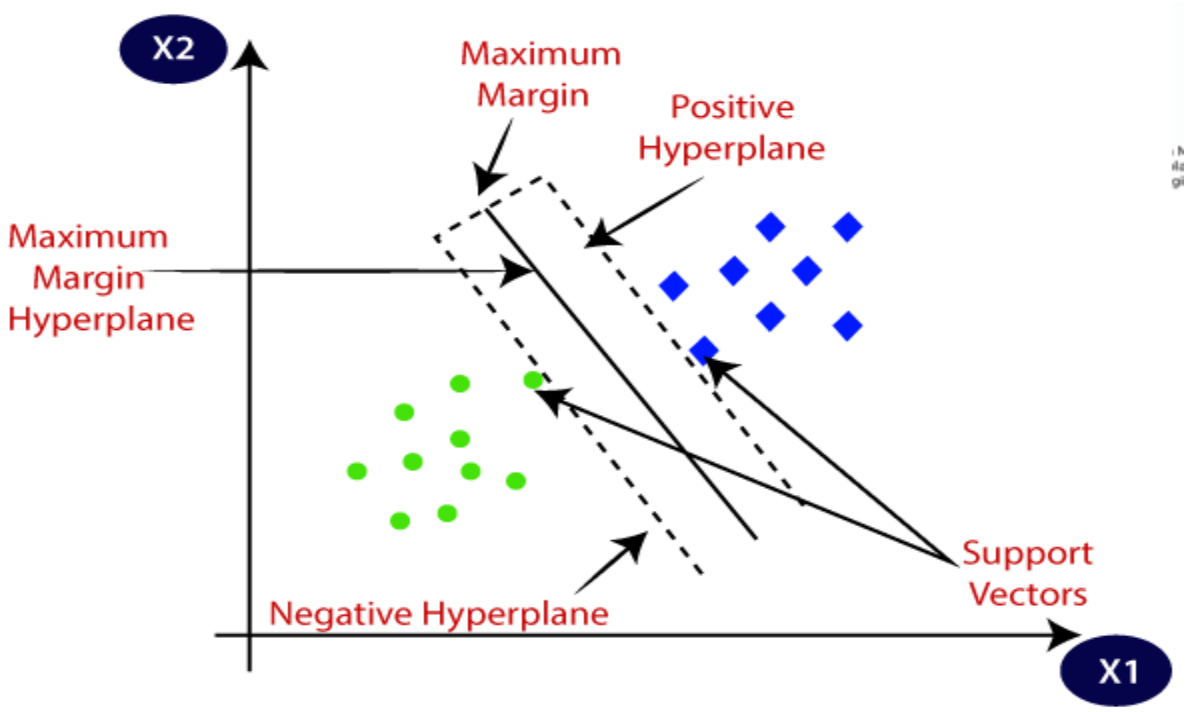

Fig.6.5.2 Overview of SVM

6.5.3 TYPES OF SVM:

SVM is of two types:

- Linear SVM
- Non Linear SVM

Linear SVM:

It's used for linearly segregate data i.e. if a dataset is assessed into two classes by using only single line in order that data is named as linearly separable data and classifier used is named Linear SVM classifier. [13]

Non-Linear SVM:

It's used for non-linearly separated data i.e. if a dataset can't be classified by using only single line in order that data is named as non-linear data and classifier used is named non-linear SVM classifier. [13]

6.5.4 Hyper-plane and Support Vectors in SVM:

Hyper-plane:

The size of hyper-plane depends on the features present in dataset.

- If the amount of features = 2 then hyper-plane = line.
- If the amount of features = 3 then hyper-plane = two- dimensional plane.

We create hyper-plane of maximum margin meaning maximum distance between the info points.

Support Vectors:

The info points that are nearest to the hyper-plane which affect the position of the hyper-plane is understood as support vector and these vectors support the hyper-plane.

6.5.5 How does SVM works?

Let’s imagine we've two tags: green and blue, and our data has two features: x and y. we would like a classifier that, given a pair of (x, y) coordinates, outputs if it’s either green or blue. We plot labeled training data on a plane: [13]

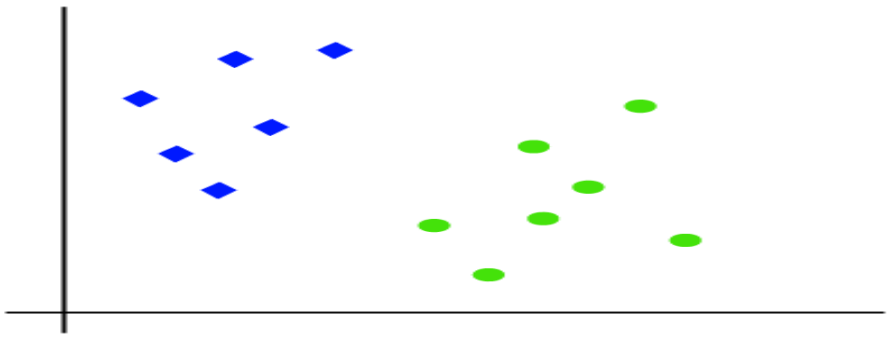

Fig.6.5.3 Plotting the classes

As it is 2D line we will separate these two classes by using line. We will also use multiple lines to separate these lines.

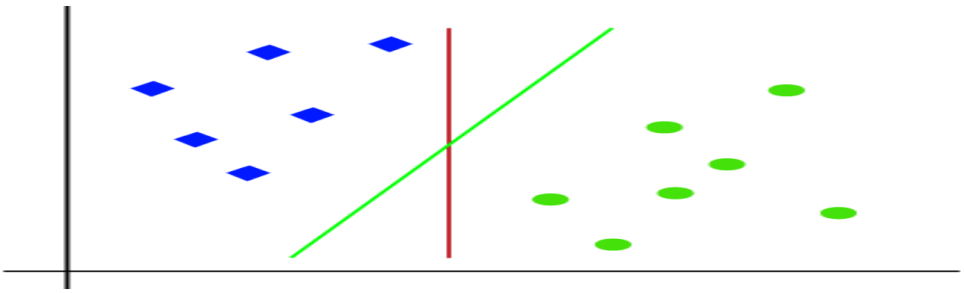

Fig.6.5.4 Separating the classes

The distance between the vectors and therefore the hyper-plane is named as margin. The hyper-plane with maximum margin called optimal hyper-plane.

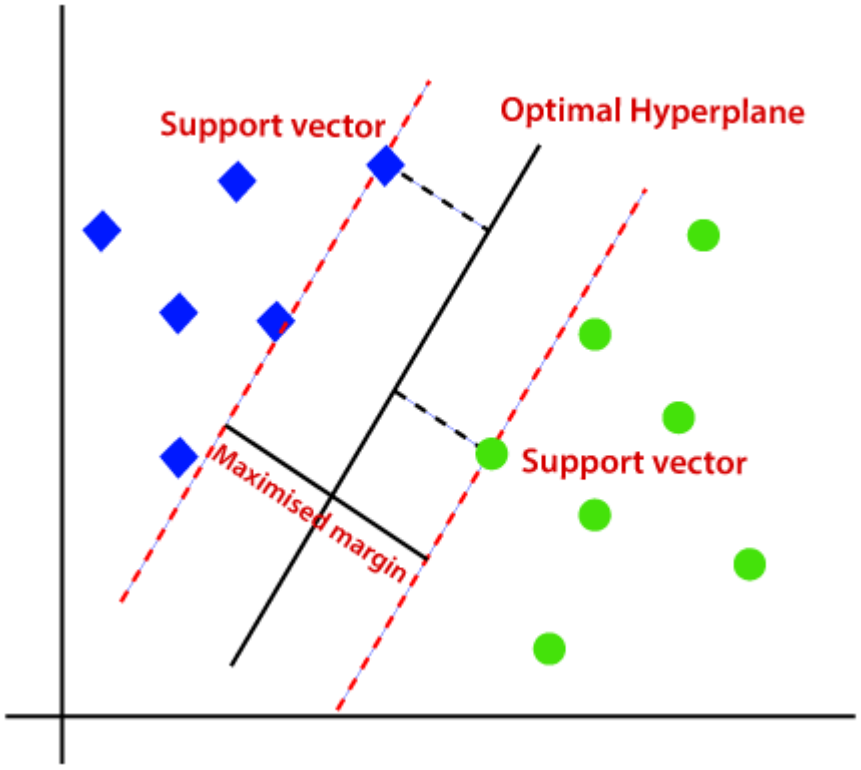

Fig.6.5.5 Plotting the Hyper plane with margins

Non-linear SVM:

For data linearly arranged, we will draw a line, in non-linear data we cannot draw just one line.

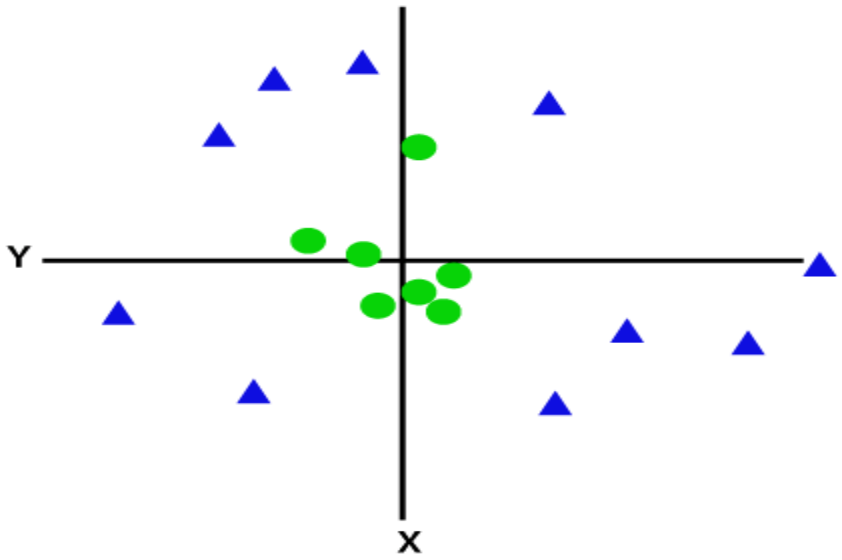

Fig.6.5.6 Non Linear SVM with two Classes

So here's what we'll do: we'll add a 3rd dimension. Up so far we had two dimensions: x and y. We create a replacement z dimension, and that we rule that it's calculated a particular way that's convenient for us: $z = x^2 + y^2$ (you'll notice that's the equation for a circle).

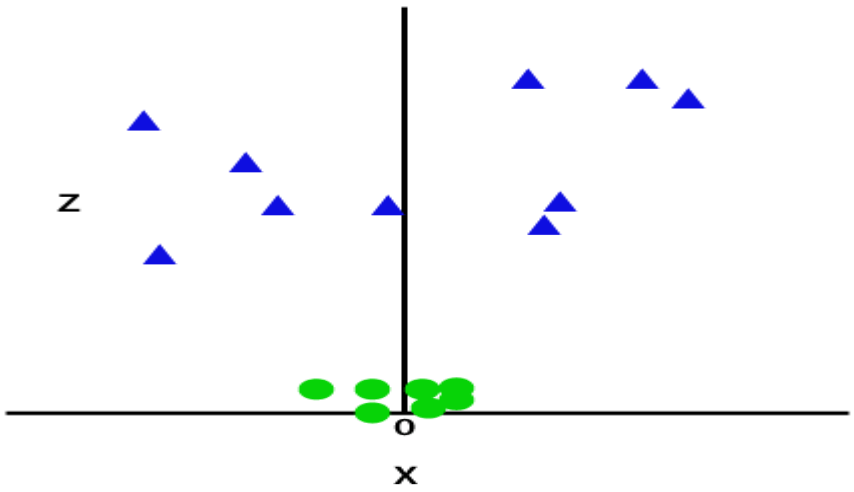

Fig.6.5.7 Three Dimension SVM

SVM will divide data sets into classes.

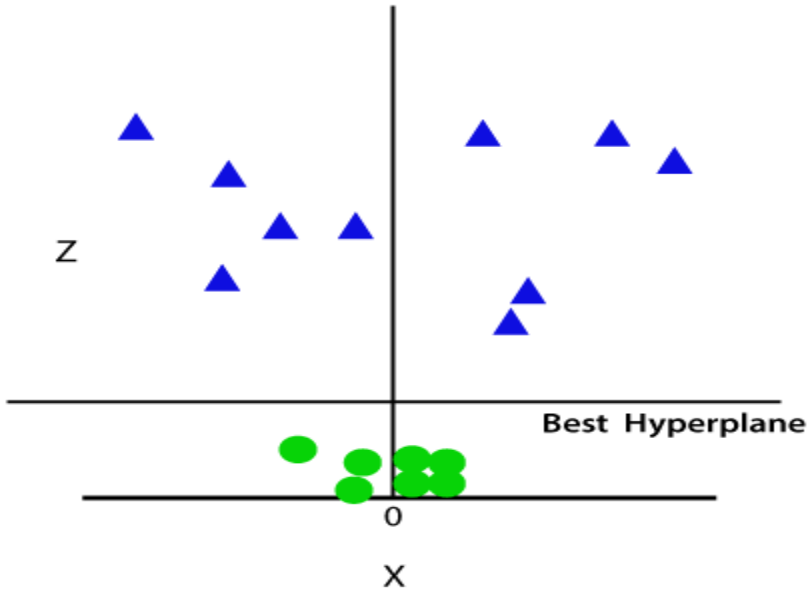

Fig.6.5.8 Plotting the Hyper Plane for 3dimension

In 3D we draw hyper-plane is plane parallel to the x-axis at a particular z (z=1) and therefore the circumference of radius is 1.

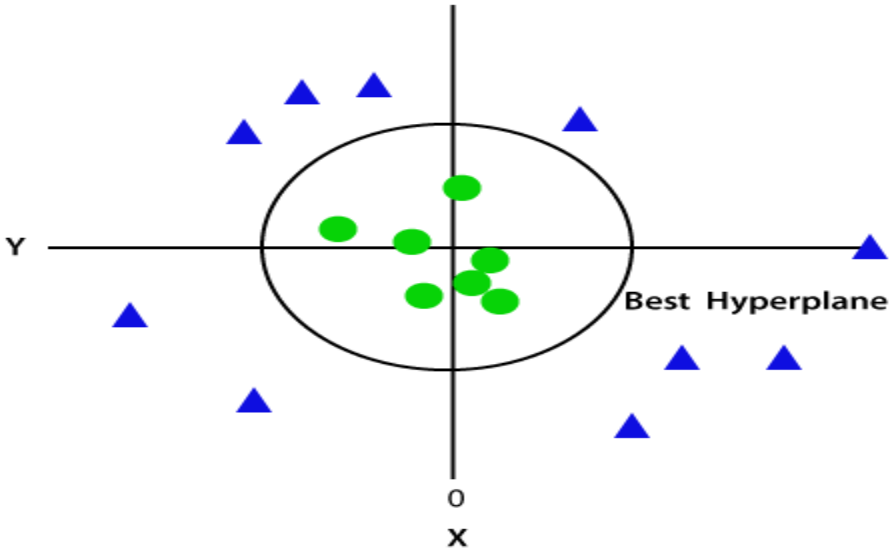

Fig.6.5.9 Drawing the Hyper Plane with Radius 1

6.5.6 Kernel trick

In our example we found how to classify nonlinear data by cleverly mapping our space to a better dimension. However, it seems that calculating this transformation can get pretty computationally expensive: there are often tons of latest dimensions, all of them possibly involving a sophisticated calculation. Doing this for each vector within the dataset are often tons of labor, so it'd be great if we could find a greater solution. [14]

And we're in luck! Here's a trick: SVM doesn't need the particular vectors to figure its magic, it actually can get only with the dot products. This suggests that we will sidestep the expensive calculations of the new dimensions! This is often what we do instead:

• Imagine new space we want:

• $z = x^2 + y^2$

• Figure out wat scalar product space looks like:

• $a \cdot b = xa \cdot xb + ya \cdot yb + (xa^2 + ya^2) \cdot (xb^2 + yb^2)$

• Tell SVM to try to its things, but using the new product — we call this is often a kernel function.

That's it! That's the kernel trick, which allows us to step-side tons of pricy calculations. Normally, the kernel is linear, and that we get a linear classifier. However, by using non-linear kernel (like above) we will get nonlinear classifier without transforming data at all: we only change the scalar product thereto of the space that we would like and SVM will happily Chung alone. [15]

Note that the kernel trick isn't actually a part of SVM. It are often used with other linear classifiers like logistic regression. A support vector machine only takes care of finding the choice boundary.

6.6 K nearest neighbor algorithm (KNN):

KNN may be a supervised machine learning algorithm. This algorithm is employed for classification and regression process. The input calculates the space of a replacement datum to all or any other training data points. [16]

KNN algorithm assumes similarity between the new case or data and available cases and that they keeps the new case into the foremost similar category to the all cases available. KNN stores all available data and classifies new datum regarding similarity then new data appears in order that it are often classified into compatible category using KNN algorithm. [16][17]

It is also called as lazy learner algorithm because it doesn't learn from the training data set instead it stores the dataset and in classification time it performs action on dataset.

6.6.1 How does K-NN works?

1. Determine the parameter k=number of nearest neighbors. [17]

2. Calculate the space between the query-instance and every one the training samples.

3. Sort the space and determine nearest neighbors supported the k - th minimum distance.

4. Gather the category of the closest neighbors.

5. Use simple majority of the category of the closest neighbors because the prediction value of the query instance.

6.6.2 Choosing the value of K:

'K' in KNN could even be a parameter that refers to the number of nearest neighbors to incorporate within the majority of the voting process. Few ideas on picking a worth for 'K'. [18]

1. There is no structured method to hunt out the only value for "K". We'd wish to hunt down with various values by trial and error and assuming that training data is unknown...

2. Choosing smaller values for K are often noisy and may have a far better influence on the result.

3. Larger values of K will have decision boundaries which are smoother which makes mean lower variance but increased partially. Also very expensive.

4. Differently to choose K is though cross-validation. A way to select the cross-validation dataset from the training dataset. Take the small portion from the training dataset and call it a validation dataset, then use the same to measure different possible values of K. this way we are becoming to predict the label for every instance within the validation set using with K equals to 1, K equals to 2, K equals to 3 ... then we glance at what value of K gives us the only performance on the validation set then we'll take that value and use that because the ultimate setting of our algorithm so we are minimizing the validation error.

5. Generally, practice, choosing the price of k is k = sqrt (N) where N stands for the quantity of samples in your training dataset.

6. Plan to keep the price of k odd so on avoid confusion between two classes of data.

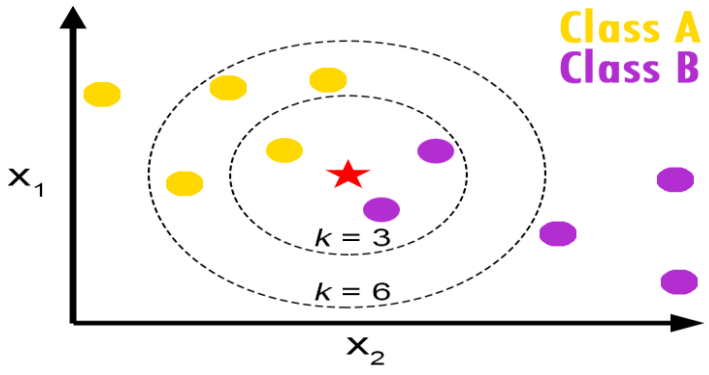

Fig.6.6.1 Representing of KNN

Euclidean distance is used as distance metric. It also assigns point to the category among its k nearest neighbors (where k is an integer). [19]

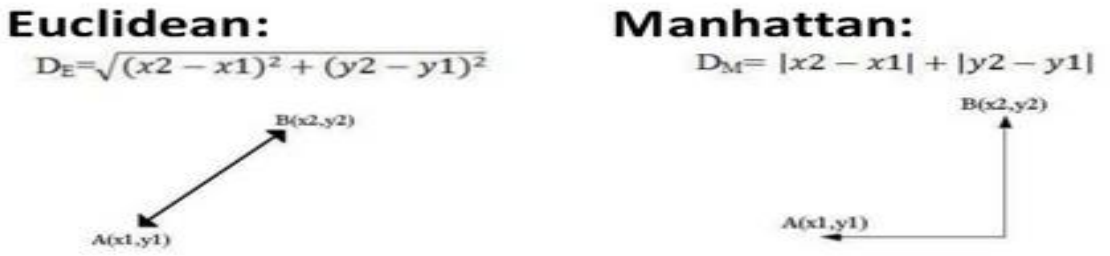

Fig.6.6.2 Formulae for finding k

6.6.3 Working of KNN:

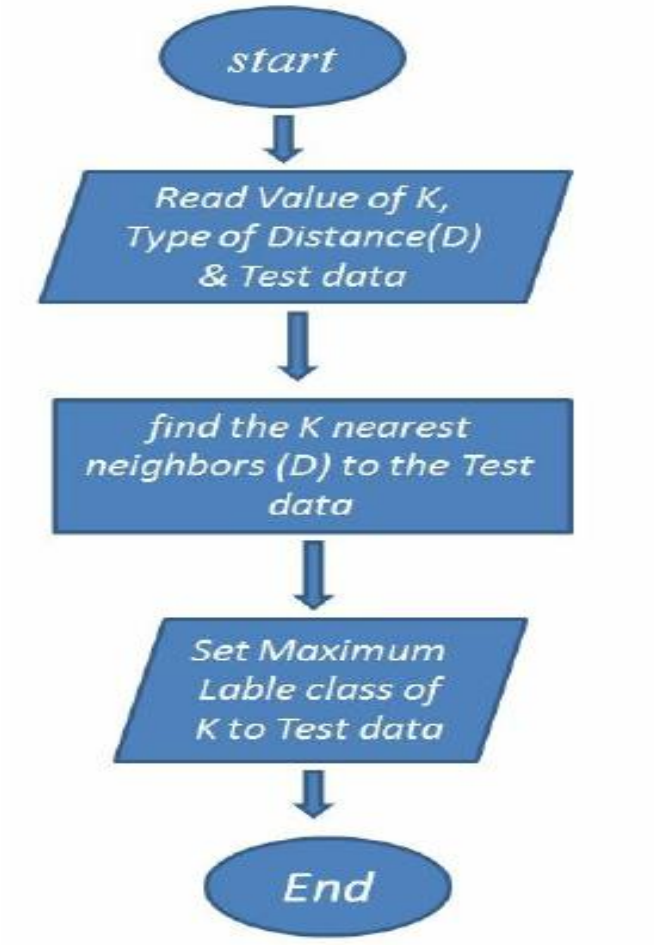

Fig.6.6.3 Working of KNN

6.6.4 Pros of KNN:

1. Simple to implement.

2. Flexible to feature/distance choices.

3. Naturally handles multi-class cases.

4. Can be best in practice with sufficient representative data.

CHAPTER NO 7
EXPERIMENTAL STUDIES

7.1 Introduction to testing:

Testing is an activity performed for evaluating

- product quality
- improving it
- identifying defects and problems [33]

" Under specified conditions a system or component is executed, the results are observed or recorded, and an evaluation is done as per the system or component by the activity." [33]

" Both static and dynamic are presnt in all life cycle activities, with planning, preparation and evaluation of software products and work related products - to satisfy specified requirements, - to demonstrate or explain that they are fit purpose and - to detect defects." [33]

7.2 Testing Process:

The purpose of testing is to get errors. Testing is that the process of trying to get every conceivable fault or weakness during a work product. It provides how to see the functionality of components, sub-assemblies, assemblies and/ organized product. These software meets its requirements and user expectations and doesn't fail in an unacceptable manner by the method of exercising software with the intent of ensuring . There are various sorts of test. Each test type addresses a selected testing requirement. [33]

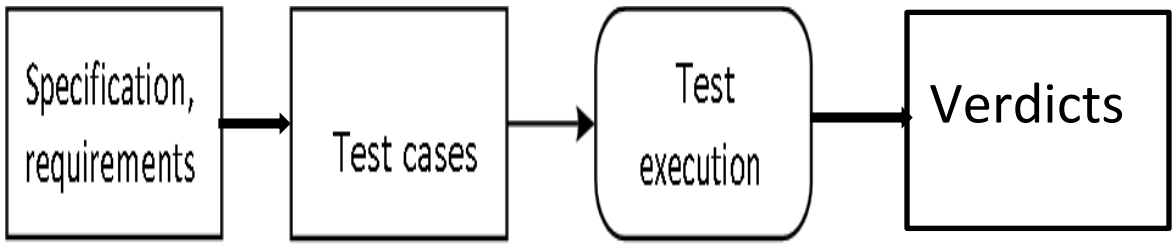

Fig.7.1.1 Basic Concepts of Testing

7.2.1 Debugging Vs. Testing:

Debugging	Testing
Finding cause of the bug	Finding the bug

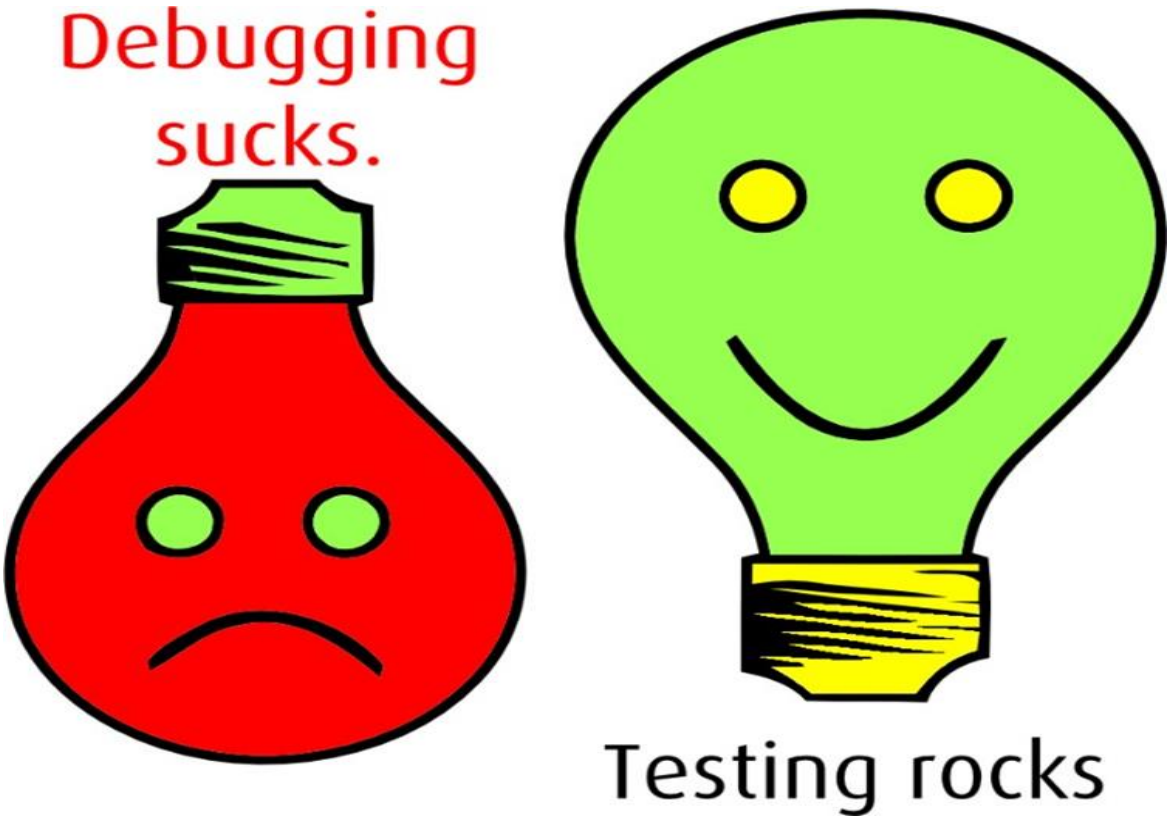

Fig.7.2.1 Debugging Vs Testing

7.3 TYPES OF TESTING:

7.3.1 Unit Testing:

Unit testing involves the planning of test cases that validate that the interior program logic functioning properly, which program inputs produce valid outputs. The internal code flow and all decision branches should be validated. It's the testing of individual software units of the appliance. It's done after the completion of a private unit before integration. This is often a structural testing, that relies on knowledge of its construction and is in evasive. Unit tests perform basic tests at component level and test a selected business process, application, and/or system configuration. [33]

7.3.2 Integration Testing:

Integration tests are designed to check integrated software components to work out if they really run together program. Testing is event driven and is more concerned with the essential outcome of screen sub fields. Integration tests explains that the components were individually satisfied, by successfully unit testing & the mixture of components is correct and consistent. Integration testing is specifically aimed toward exposing the issues that arise from the mixture of components. [33]

7.3.3 Functional Testing:

Functional tests provide a particular format demonstrations that in which functions are tested and are available as specified by the commercial and technical requirements. Its sub sequent items:

Valid Input: valid input of Identified classes must be accepted**.**

Invalid Input: invalid input of Identified classes must be rejected.

Functions: Identified functions must be exercised.

Output: Identified classes of application out puts must be exercised.

Systems/Procedures: Interfacing systems or procedures must be invoked. Organization and preparation of functional tests is concentrated on requirements, key functions, or special test cases. Additionally, systematic coverage per training to spot Business process flows; data fields, pre-defined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and therefore the effective value of current tests is decided.

7.4 Result Analysis:

Output for KNN:

Accuracy of train data-set**:** 100.0

Accuracy of test data-set: 93.17129629629629

Visualization of KNN:

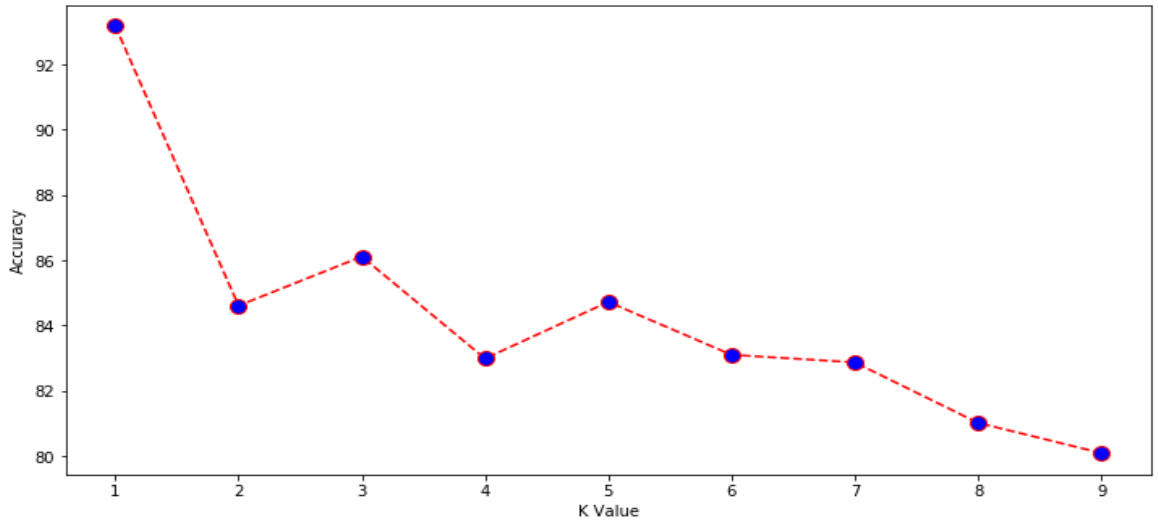

Fig.7.4.1 Graph of KNN

Output for SVM:

SVM confusion matrix:

```
[[217 29 32]
 [35 223 44]
 [18 42 224]]
```

Accuracy of train data-set: 88.59126984126983

Accuracy of test data-set**:** 76.851851851851851

Visualization of SVM:

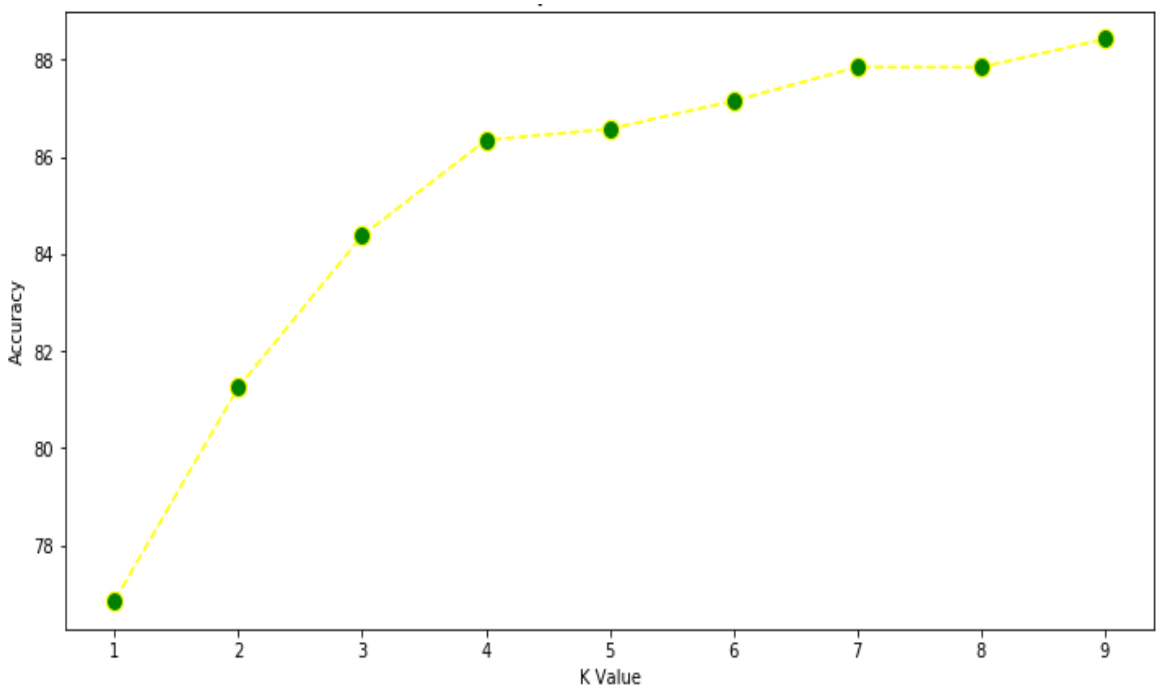

Fig.7.4.2 Graph of SVM

Comparison of SVM and KNN:

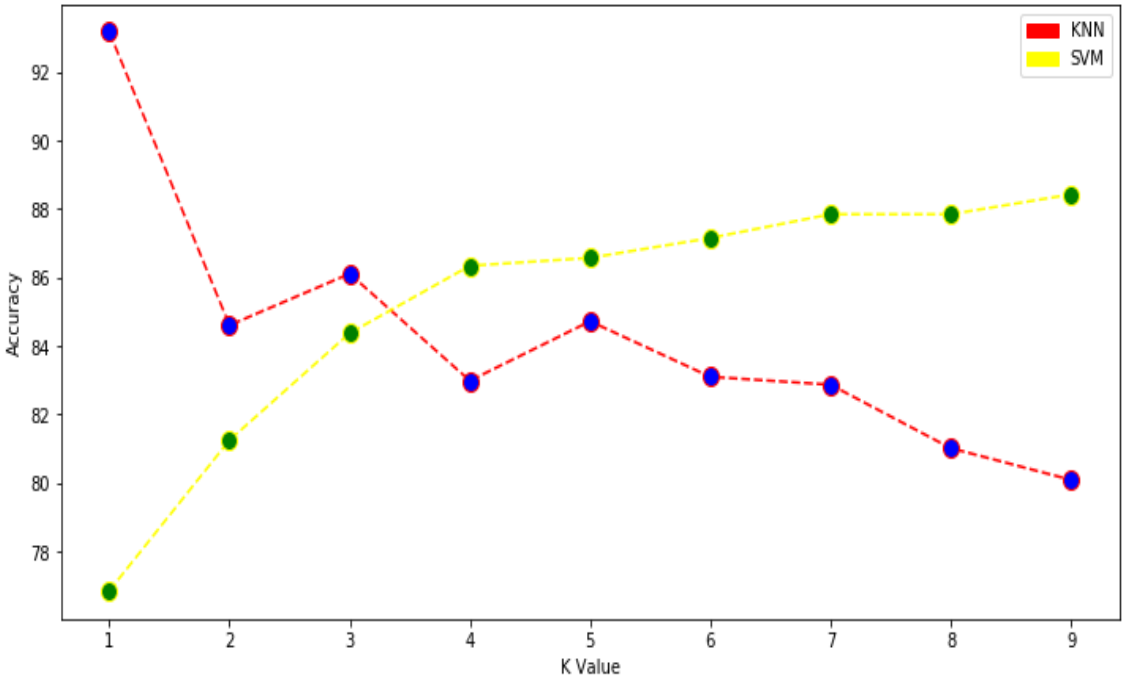

Fig.7.4.3 Comparison of KNN and SVM with graphs

- From the above comparison it has been stated that KNN has giving the better and effective results when compared to SVM.

CHAPTER NO 8

CONCLUSION & FUTURE ENHANCEMENT

8.1 CONCLUSION:

As we'll see there are many useful applications of brain computer interface. It are often very helpful for people with moving disabilities as human - machine interface. But it are often also used for control of human body muscles. There are also many possibilities in military domain. Last are the applications for creating our lives easier. So at some point maybe all people are wearing BCI-caps and using hands only for eating. Or without using caps but with inserts right in CNS.

The goal of creating simpler classification algorithms, have focused numerous investigations within the search of latest techniques of feature extraction. A BCI possesses to be useful for an honest kind of tasks, as an example, when a BCI is used because the most control device for a handicapped individual. Various feature extraction and classification algorithms are mentioned. Feature extraction is applied on raw brain data to extract useful signals and to get rid of artifacts generated by eye movements, muscle movements, and therefore the like. Various feature extraction methods are used, including CSP, PCA, ICA, and WT.

Here we will use various methodologies which are wont to interact with BCI in machine learning. At the present out of the many algorithms in machine learning we used only two algorithms i.e. SVM and KNN. These two algorithms are used for the comparison of an equivalent dataset but with the various algorithms i.e. two algorithms has been compared with the only dataset by using Python in machine learning.

We can say that KNN is best than SVM because the comparison has been done and efficiency and accuracy varies for the both algorithms albeit same dataset had been used.

8.2 FUTURE ENHANCEMENT:

However, now researchers are more curious about deep-learning approaches like deep belief networks, CNNs, and a hybrid of varied classification algorithms. An advantageous BCI system is one that features a smooth coordination between all of those parts of the BCI. The most aim of research in BCI is to supply a far better way of communication; however, the methods applied to achieve this aim can differ.

The comparison are often done further by using deep learning algorithms and neural networks as BCI will get associated with the system of nerves since the signal acquisition had been done from the neurons that are located in brain and by using deep learning and NN we will get much accurate results and may be used further as BCI methods would be very helpful in future for classification with the datasets of body parts i.e. eyes (movement of eye balls) , ears, hands, legs arms, foot etc.

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[32] http://www.holub.com/goodies/uml/

[33] http://www.testingreferences.com/testinghistory.php

APPENDIX

Code:

```
# Importing the libraries
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.metrics import accuracy_score

# Importing the dataset
dataset = pd.read_excel(r'C:\Users\lenovo\Documents\svm_knn\user_a.xlsx')
X = dataset.iloc[:, 1:].values
y = dataset.iloc[:, 0].values



# Splitting into the Training set and Test set
from sklearn.model_selection import train_test_split
X_train, y_train, X_test,  y_test = train_test_split(X, y, test_size = 0.30, random_state = 0)

# Feature Scaling
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)



# Fitting KNN to the Training set
from sklearn.neighbors import KNeighborsClassifier
knn = []
```

```
for i in range(1,10):

    classifier = KNeighborsClassifier(n_neighbors=i)
    trained_model=classifier.fit(X_train,y_train)
    trained_model.fit(X_train,y_train )

    # Predicting the Test set results

    y_pred = classifier.predict(X_test)

    # Making the Confusion Matrix

    from sklearn.metrics import confusion_matrix

    cm_KNN = confusion_matrix(y_test, y_pred)
    print(cm_KNN)
    print("Accuracy score of train KNN")
    print(accuracy_score(y_train, trained_model.predict(X_train))*100)

    print("Accuracy score of test KNN")
    print(accuracy_score(y_test, y_pred)*100)

    knn.append(accuracy_score(y_test, y_pred)*100)
plt.figure(figsize=(12, 6))
plt.plot(range(1, 10),knn, color='red', linestyle='dashed', marker='o',
         markerfacecolor='blue', markersize=10)
plt.title('Accuracy for different  K Value')
plt.xlabel('K Value')
plt.ylabel('Accuracy')

# Fitting SVM to the Training set
```

```
from sklearn.svm import SVC
from sklearn.metrics import confusion_matrix
svm_lit = []
for i in range(1,10):
    classifier = SVC(kernel = 'rbf', random_state = i,C=i)
    trained_model=classifier.fit(X_train,y_train)
    trained_model.fit(X_train,y_train )



# Predicting the Test set results
    y_pred = classifier.predict(X_test)
    svm_lit.append(accuracy_score(y_test, y_pred)*100)

# Making the Confusion Matrix
    cm_SVM = confusion_matrix(y_test, y_pred)
    print(cm_SVM)
    print("Accuracy score of train SVM")
    print(accuracy_score(y_train, trained_model.predict(X_train))*100)


    print("Accuracy score of test SVM")
    print((accuracy_score(y_test, y_pred)*100))

#### test plot ##################
svm = (accuracy_score(y_test, y_pred)*100)
plt.figure(figsize=(12, 6))
plt.plot(range(1, 10),svm_lit, color='yellow', linestyle='dashed', marker='o',
         markerfacecolor='green', markersize=10)
plt.title('Accuracy for different  K Value')
plt.xlabel('K Value')
plt.ylabel('Accuracy')
```

```
########### compare two algorithms with accuracy ###############
import matplotlib.patches as mpatches
plt.figure(figsize=(12, 6))
plt.plot(range(1, 10),knn,color='red', linestyle='dashed', marker='o',
         markerfacecolor='blue', markersize=10)
plt.plot(range(1, 10),svm_lit, color='yellow', linestyle='dashed', marker='o',
         markerfacecolor='green', markersize=10)
plt.title('Accuracy for different  K Value')
plt.xlabel('K Value')
plt.ylabel('Accuracy')
red_patch = mpatches.Patch(color='yellow', label='SVM')
#plt.legend(handles=[red_patch])
red_patch1 = mpatches.Patch(color='red', label='KNN')
plt.legend(handles=[red_patch1,red_patch])
```