Detection and Prediction of Bipolar Disorder using Machine Learning Techniques

A Thesis Submitted

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By

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APPROVAL SHEET

This thesis entitled "**Detection and Prediction of Bipolar Disorder using Machine Learning Techniques"** by **Ms. Nisha Agnihotri** is approved for the degree of **Doctor of Philosophy** in Computer Applications from SCSE School of Computer Science and Engineering.

I recommend the thesis for evaluation for the award of the Degree.

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CANDIDATE'S DECLARATION

I hereby certify that the research work which is being presented in this thesis, entitled "**Detection and Prediction of Bipolar Disorder using Machine Learning Techniques**" in fulfillment of the requirements for the award of degree of **Doctor of Philosophy** in Computer Applications and submitted in the School of Computer Science & Engineering, Galgotias University, Greater Noida is an authentic record of my own work carried out during a period from 2020 to 2024 under the supervision of Dr. Sanjeev Kumar Prasad, Professor in School of Computer Science and Engineering, Galgotias University, Greater Noida, India.

The matter embodied in this thesis has not been ever submitted by me for the award of any other degree in this University or any other university or Institute.

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This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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Sign. of External Examiner

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The Ph. D. Thesis submitted by Ms. Nisha Agnihotri in the subject area of "**Computer Applications**" under the supervision of **Dr**. **Sanjeev Kumar Prasad** is hereby forwarded for the evaluation and assessment for the award of the degree of **Doctor of Philosophy** of Galgotias University, Greater Noida.

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Nisha Agnihotri

LIST OF ACRONYMS

ACRONYM	MEANING
ML	Machine Learning
BD	Bipolar Disorder
UN	Uni-Polar
SVM	SVM Support Vector Machine
KNN	KNN K-Nearest Neighbor
LR	Logistic Regression
NB	Naïve Bayes
DT	Decision Tree
ANN	Artificial Neural Networks
CNN	Convolutional Neural Network
AUROC	Area Under the Receiver Operating Characteristics
MCC	Matthews Correlation Coefficient
AI	Artificial Intelligence
IPA	InterPeopleal Accuracy
EEG	Electroencephalogram

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PROBLEM STATEMENT

The main objective of the research is to build a novel proposed model to decrease the **semantic gap** for prediction and detection of Bipolar Disorder, thus, to reach the human-level performance.

- The research focus on identifying and selecting features from MiniPons to examine People's behavior and potential to cope with complex stages through perception of nonverbal channels.
- This research focus on detection and prediction of bipolar disorder and its categories by machine learning models and Deep Learning techniques.
- The prediction framework helps to increase the BDD accuracy rate.

CHAPTER-1

BIPOLAR DISORDER AND MACHINE LEARNING

This research can help and guide people having bipolar disorder, their families and all who wants to understand the basics of this brain disorder, its types, it also focuses on its treatment and the way to manage with this illness. This is not a substitute for treatment from a physician or health care practitioner, but it can be used as a basis for resolving all the queries and discussion related to bipolar disorder. As new drug treatment and medications are continually being developed, this work will guide people to be aware of its symptoms and early detection so that the disorder does not turn hazardous.

1.1 Introduction to Bipolar Disorder

Bipolar disorder is a psychiatric and mental brain disorder which is having characters of alternate mode oscillations which swings between mania and depression is very common these days. Our brain is the ultimate cause of Anxiety, stress and Depression according to Neuroscience. The mood disorder and chronic disorder in brain are the reasons of physiological feelings like Bipolar Disorder. This is a mental disorder having different stages from mania to severe depression. A serious mental and psychiatric disorder, Bipolar disorder is characterised by alternate mode swings between different states is very common these days [Liu, D., et.al,2021]. The disorder is alternate oscillations caused by People's mood swings between mania and depression states. These mood swings are due to different physical and psychological features. These set of behavioral changes, varying mood swings and psycholinguistic features are used for feedback analysis of People. Mental illness like depression, Anxiety, stress, restlessness, aggression and other mood related changes can affect and disturb any one in some situations, events or circumstances. Stress can be quantized into levels, like clinically stress has been evaluated using questionnaires and interviews which are subjective methods, whereas physical and physiological changes are utilized as

objective indicators of stress [A. R. Subhani, et. At, 2017]. This all collectively results in mental disorder which Physical and emotional changes.

1.1.1 Bipolar disorder as a Mental Illness

Now a days' Mental disorder are prime reasons of functional and social impact in our day to day life. As stated by World Health Organization (WHO), a healthy being possess a healthy mind along with physical fitness. Changes in mental health and thought processes are prime factors of age related changes throughout the world. Most of People with bipolar disorder experiences significant day to-day or week-to-week mood swings [Sau, A., et.al,2017]. This mood instability impairs daily functioning over time and increases the risk for relapse or its recurrence, thus indicating that the illness is still active. Growth in big data analysis in medical and health care sectors, the data analysis of medical data helps early detection of disease, their diagnosis, care and different community services. Machine Learning techniques have been applied during different mood swing states like emotional state, sad moments, facial expression and audio-based analysis. [Chen, M., et.al,2017]. Numerous healthcare technologies help physicians to monitor behavior and provide an efficient guide for selecting the models of Machine Learning. These algorithms provide us to visualize and helps to extract useful information from complex database to predict and optimize routine analysis of People's health and wellbeing [Islam, M., et.al, 2018].

1.1.2 Occurrence of Bipolar Disorder

In todays' sedentary and paced lifestyle have resulted in Anxiety, Stress and mental stress. Some percent of adults across the world suffer from bipolar disorder. The symptoms of bipolar disorder are characterised in early ages of childhood and adolescence [Doryab, A., et.al,2015]. Different events occurring in a People's life and the extremity of an event on their mind can make them a People of bipolar disorder. When People are not able to recognize the early symptoms of bipolar disorder and get themselves treated with certified clinician and doctors, it makes the condition worse and treating them on later stages does not provide a fruitful result.

1.1.3 Episodes of Bipolar Disorder

Bipolar disorder, a brain disorder is a recurring or repeating mood disorder and follows a pattern [Vuppalapati, C., et.al,2018]. It consists of different types of states which explains its severity namely as

(i) Mania state, in which the severity of the disease is extreme
(ii) Depression state, in which the severity of the disease is comparatively low
(iii) Normal state, in which a People functions normally and does not suffer any kind of mood disorder.

The mania and depression states can be either of one only type of extremity, i.e. a People may suffer from only mania state or depression state or can be a combination of both the states occurring at the same time.

1.1.4 Clinical Features of bipolar disorder

Those suffering from this disorder suffers from different types of symptoms which helps to recognize the severity and complexity of the disease in them such as losing interest in everyday life activities and finding it difficult to pay attention and concentrate on things [Saylan, C., et.al,2016]. They don't find themselves worthy enough of anything and a feeling of emptiness surrounds them. They start doubting their intuition and suffers from self-doubt and lack of self-worth.

1.1.5 Symptoms of Bipolar Disorder

During this course of illness, people can suffer from different states ranging from mania, depressed to well phases depending on their illness. On the basis of their complexity, they are classified into different categories of Bipolar Disorder-I and II. To understand People's condition, they must possess any three of the following symptoms such as excessive talking, less amount of sleep, giving themselves extra self-importance, psychotic behaviour such as living in delusions, etc. [Rahman, R.A., et.al,2020].

People suffering from Hypomania are considered having comparatively lower levels of severity as compared to the maniac state. In this state, they usually feel happy

and contented with sufficiently higher energy levels. But, if People suffering from hypomania are not treated at right time can lead to unavoidable situations.

People suffering from mixed state where they cannot figure out either they fall in maniac or depressive category and sometimes they can have mood swings ranging from maniac to depressive conditions. This can mark the early onset of bipolar disorder in People.

People suffering from depression takes almost two weeks of time period for proper diagnosis of the illness and it should follow a recurring pattern in frequent days because depression can have different forms and it usually occurs out of nowhere [Vinodh, 2020]. Few symptoms of depression are excessive fluctuation in body weight, inadequate sleep, feeling low all the time, feeling of guilt less worthy of themselves, they can have a feeling of sad suicidal thoughts, face psychotic recognition such as visual and audio hallucinations, severe levels of anxiety, etc.

1.1.6 Types of Bipolar Disorder

Bipolar Disorder is a mental illness that can exist for entire life and the People's mental condition can keep switching between mania to depression states. Sometimes, even after getting completely cured from the illness, People can suffer lower levels of maniac to depression levels in their lives. So, for proper diagnosis and treatment of the illness, the disorder can be classified into Bipolar Disorder – I and II and People can be treated according to the following categories as given in Figure 1.1.

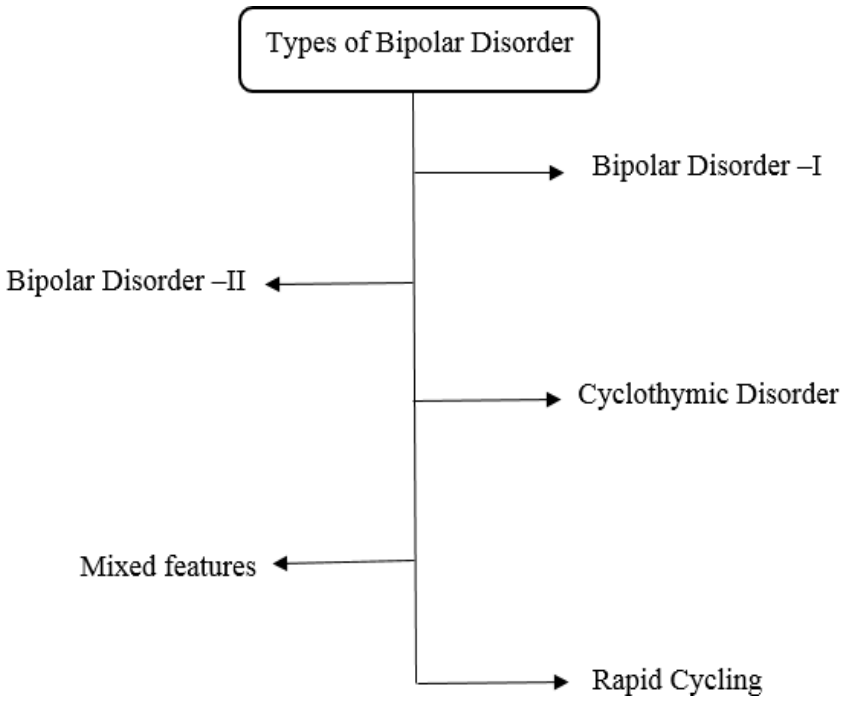

Figure 1.1 Categories of Bipolar Disorder

- Bipolar Disorder – I: This subset Bipolar Disorder has symptoms depending on fluctuation of mood episodes from maniac to depressive states. This is further being diagnosed on the basis of manic episodes which should exist for at least seven days and leads to psychotic behaviours.
- Bipolar Disorder – II: This particular category of bipolar disorder leads elevation of mood from the milder ranges of hypomania episodes which keeps on occurring alternatively win line with severe depression.
- Cyclothymic disorder: This category has symptoms in the form of brief episodes of People suffering from hypomania along with depression. They don't last for long and are not extensive. It is a brief from of mood disorder that has few cycling mood swing with it.
- Mixed Features: It is the combination of different episodes such as mania, depression and hypomania. Some of the symptoms of mixed feature are lack of sleep, high levels of energy and unnecessary cluster of random thoughts. In this feature, the People start feeling helpless, irritated and depressed and are not happy with their life.

- Rapid cycling: It's a condition of a year long suffering from different phases of mood episodes. It can range from people experiencing mood fluctuations at a very high level to very low level in one-week period during their illness. This can have different patterns of severe depression and though of suicide.

1.1.7 Order and Frequency of Different States of Bipolar Disorder

The different states such as maniac, mixed and depressive states does not follow a precise order and their frequency can't be determined. It is different for every People, for e.g., a People can suffer from a single episode for a year or more whereas some People can suffer from different episodes in a single year [Librenza-Garcia, D., et.al,2017]. A People suffering from bipolar disorder on an average can suffer from 10 episodes of maniac, depression and mixed states in their lifetime. When a People starting ageing they can suffer from higher level of episodes of maniac, depression and maniac states. Relevant data shows that students having high study related attainment are at great risk of mental disorder, while those having weak academic performance [Vieta, E, et. At, 2019].

1.1.8 Treatment of Bipolar Disorder

Proper treatment of a People suffering from bipolar disorder if treated properly can save many lives and if diagnosed and treated at early stages, then a People can be saved from suffering extreme complexity of the illness [Grünerbl, A., et.al,2015]. The audio, video and text combination modalities are suggested to fully exploit the information [Ceccarelli, F, et. At, 2021]. There are different methods through which we can cure People suffering from bipolar disorder and these treatments can be majorly classified into three broad categories such as Biological Treatments, Psychosocial Treatments and Hospitalization.

- **Biological Treatment**

  In this from of treatment, methods which are provided to cure the illness are based on biological methods. The treatment mainly consists of involving medications into the regime and certain different methods such as light therapy

sessions which can help to heal the People from within. Medications help in restoring and promoting wellness in the People and help in fighting against the disease in more permanent manner with complete removal of the illness [Stahl, S.M., et. Al, 2018]. Choosing the right course of medication and dosage is very necessary for providing proper treatment to the People. Pattern recognition are approaches that can identify multivariate patterns that are predictive of diagnosis or future outcomes [de Oliveira, et. al, 2019]. People suffering from bipolar disorder usually require different types of medication to deal with the illness.

- Mood Stabilizers: These are the medications which helps to reduce the levels of mood swings between maniac and depressive episodes. Usually lithium is one such mood stabilizer which helps in treating People more frequently. Different combinations of mood stabilizers can be prescribed to People. Mood stabilizers have been understood to develop stability and calm different parts of brain which become overactive and overstimulated over the period of time.
- Antidepressants: Antidepressants are usually found to cure depression and for people suffering from anxiety disorders. They work by altering the concentration of neurotransmitters such as serotonin, dopamine and norepinephrine.
- Antipsychotic medicines: Antipsychotic are commonly used medication for treating bipolar disorder. They help in controlling mania and treats symptoms such as delusions and hallucinations.

➢ **Psychosocial Treatment:**

Psychosocial treatments have different forms of treatment such as psychoeducation, psychotherapy, and rehabilitation centres [Stahl, S.M., et. Al, 2018].

- Psychoeducation: This helps in teaching people about the illness and provides an opportunity through which people can share their feeling about the illness and how do they cope with them. When provided an opportunity, they openly address their feelings, what kind of symptoms are they suffering from and helps them to understand that they are severely affected with the disease. This can have provided in different sessions where people suffering from the illness can talk with counsellors and clinicians which can help them to deal with the illness.
- Psychotherapy: This type of treatment where People suffering from bipolar disorder takes help from therapist. People can discuss about their feelings and the problems they suffer from without any hesitation and the entire conversation is kept confidential. Therapist suggest them different types of solutions such as changing their behaviour, attitude and habits which can help them to cope with the illness.
- Rehabilitation Centres: There are so many rehabilitation centres working for the betterment of the People suffering from mental illness. They follow a pattern and mechanism such as conducting classes, providing therapies and suggesting different alternates to cope with disease with a team of experts.

➢ **Hospitalization**

When situation goes out of control and form of medication cannot help the People, then they are hospitalized to be monitored by a team of doctors at regular period of time. This step is taken when a People condition becomes so extreme that they become a threat to themselves and other people's life [Stahl, S.M., 2018]. In this condition, if a People is not kept under observation, they can cause serious harm to themselves and people surrounding them as they cannot take control of their actions

1.2 Introduction To Machine Learning and Deep Learning

Machine Learning is a branch of artificial intelligence through which the machine learns from the data and past experiences by identifying patterns between them and making predictions through them. Machine Learning algorithms works by building a model from the sample data provided which is training data and it covers the maximum percentage of data sampling [Theobald, O., 2018]. Then once the model is developed through the training data, the test data helps in making predictions or decisions that are based on the model. Machine Learning helps to solve the problems at a faster speed and better accuracy as compared to the human mind [Jo, T., et.al, 2021]. It can work accurately with big amount of data as it has the computational ability to solve single or multiple specific tasks by training the machine through which it can identify patterns and derive relationship between them to provide the desired output.

Machine Learning is the growing and fastest application in the field of data science. There is huge demand of data scientist generating and it will further increase in the upcoming future as there is ample of big data getting generated every day which needs to be identified and solve the relevant business question from the data provided. Machine Learning is nowadays used in almost every field such as business, medicine, security, e-commerce, etc. and is expected to enter in every niche sector of the society in the future [de Oliveira, et. At. 2019]. Machine Learning knowingly or unknowingly has become an important part of everyday life in humans and it will further find it roots into all the major field very soon.

1.2.1 Machine Learning in the Field of Medicine

Machine Learning is proving as a substantial interest for all the doctors and clinicians across the world for its implementation in the field of health sciences. Two major areas where Machine Learning benefits the medical field are diagnosis of the disease and predicting outcomes of the illness [A. R. Subhani, et.at, 2017]. It helps identifying the higher risk in case of any medical emergencies or diagnosing the different sates of the illness. It has helped in various different diseases such as skin

cancer by image recognition, predicting People suffering from pre diabetes to further moving into next stages of diabetes by electronic processed data.

To process unstructured data into meaningful insights machine learning is combined with natural language processing which helps the researchers and data scientist to derive outcomes from medical reports, feedback from doctors reports and their activity [Vinodh, 2020]. Combining machine learning with natural processing language not only helps in solving unstructured data but also helps in early stage diagnosis of any illness which proves as a vital step in saving human lives by decreasing unavoidable risk at later stages. Machine Learning also plays a fundamental role in developing better healthcare system in the world by bringing together science, information, new developments and improvements in medical field and innovation in medical science. It will help to draw meaningful insights from different data sources and when combined with complex machine learning algorithm will provide desired output. It will bridge the gap between data and medical science and help to optimise biomedical research and improve health care quality.

There are different ways through which machine learning can assist the medical researchers, clinicians and doctors in the healthcare sector [Rios, A. C, et. at, 2015]. It can help them in reconstructing the underlying mechanism of any disease and this can also help the pharma companies to develop drugs according to the individual People requirement. It can help to predict outcome and develop structures when there is incomplete or partial information available about an illness by developing complex models to test data accurately. Major problem that machine learning can resolve is by deriving results from People past medical history and reports and so there is no need for physical presence of People to test a treatment.

In earlier times, a big data for clinician would mean only hundred People at a time and they tried to derive potential results though this data which wasn't accurate enough but machine learning allows to manipulate almost millions of data and so further provide results and predictions more accurately [Rawat, S. S, et.at.2022]. Machine Learning does not work like tradition statistical model instead it has a capability to imitate human cognitive process much like a human brain and make decision accordingly. Not only diagnosis, but machine learning can prove as a great

tool in the prognosis of any People also. The result from machine learning can provide crucial information through which further treatment action plan can be prepared. Predictive analysis nature of machine learning helps the clinicians to treat People beforehand even before their symptoms occur. Machine learning is proving as one of the best tools in medical science for its development and growth and would further increase in the future.

1.2.2 Machine Learning for Diagnosis of Bipolar Disorder

Bipolar disorder is an illness where People suffer mood swings which can be extremely high and low and can prove fatal for human life. Diagnosing bipolar disorder which such complex symptoms is a big task for clinicians around the world. It is difficult to understand that which state a People lies in whether manic state, depressive state or mixed state and sometimes can lead to misdiagnosis or an imperfect medical response.

Presently, a lot of people suffer from the depression mental Disorder and Bipolar Disorder and correct diagnosis, characterization, classification and to analyse is a task in itself [Chien, I., et.al, 2020]. Machine learning helps in solving this issue as it can manipulate large amount of bipolar dataset having number of variables and provide results with better precision and accuracy. Some commonly used machine learning models like support vector Machine, Logistic Regression, Artificial Neural Neural network etc. allows the researchers to gather meaningful information from the data provided and develop artificial intelligent systems [Dia, I., et.at, 2022] They have been helpful in forecasting and categorizing the possible future outcomes of the disorder.

The selection of Machine Learning models depends on the accuracy and precision provided by the model. This accuracy can be calculated through performance metrics calculation like Precision, Accuracy, R2 score, F1- Score and Recall value and the model with higher value can be used for further detection of the illness. Various different models have been used to categorize People into categories such as Bipolar Disorder-I & II, Unipolar Disorder, and healthy People [Lee, C. Y., et.at, 2021]. Machine Learning provides better results with better precision and accuracy and

clinicians all over the world are depending on models of Machine Learning to treat their People.

1.2.3 Different Machine Learning Models

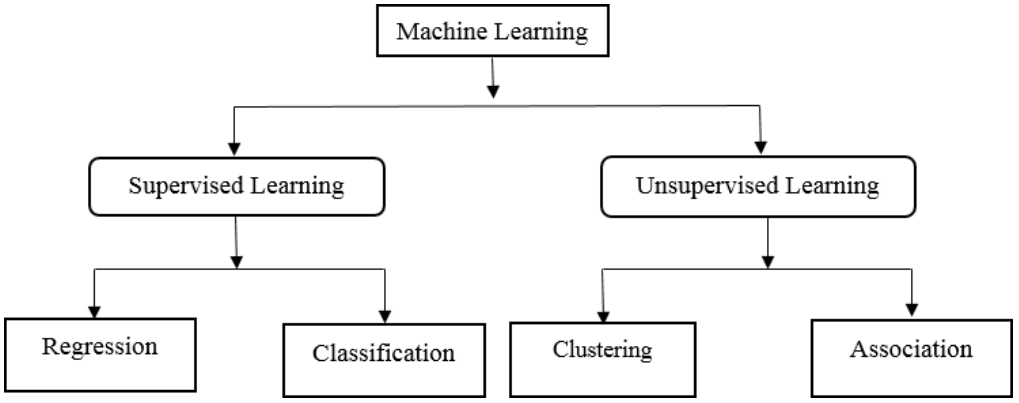

Figure 1.2. Models of machine Learning

1.2.4 Supervised Machine Learning

The part of Machine Learning, Supervised Machine Learning using labelled datasets through which it trains algorithms to get the desired output as shown in Figure 1.2. Once the data has been fitted properly, the weights are adjusted and then the input data is fitted [Jo, T., 2021]. It uses training set to teach and train model for getting the desired output. The accuracy of the algorithm is calculated by loss function and adjusting it further until the error in the model is sufficiently minimized from the model. Supervised learning is categorized into different two categories while data mining- Regression and Classification.

- Regression- Regression function helps to understand a relation between the dependent and independent variable. In supervised learning the output will have continuous values. Linear Regression, Logistic regression and polymer regression are some types of regression models [Bonaccorso, G., et.at, 2018].

- Classification- Classification function helps categories test data accurately into specific groups. It recognizing the entities from the dataset and tries to draw some conclusion through them by labelling or defining them. Decision Tree, Support Vector Machine, K-Nearest Neighbor, Random Forest are some types of classification models [Bonaccorso, G., et.at, 2018].

1.2.5 Types of Supervised Machine Learning Models

- **Logistic Regression:** Logistic Regression is a model of machine learning which helps to classify on the basis of estimation of the results through categorical variable which are further based on some independent variable [Deisenroth, M. P, et.at, 2020]. Through fitting the data in a logistic function, LR will help to predict an events occurrence probability. Optimizing the coefficients of the independent variables by further maximizing its likelihood is performed by linear regression model. It leads to optimization of the decision boundary which will minimize the cost function.
- **Support Vector Machine:** This subset of machine learning model is a non-probabilistic and linear binary classifier which helps to resolve and detect any anomalies present. This particular model is helps in reducing some amount of noisy data which further provide the best results and resolve decision making concerns. It is basically used as both a classifier and regression model. [Deisenroth, M. P, et.at, 2020]. This model is known for its different parameters and each of its parameters are plotted in a n-dimensional space with a specific coordinate assigned to them. It helps in building a hyper plane that can isolate the entire dataset into two different classes via a high dimensional feature space and this hyper plane can further disintegrate close training datasets by calculating the desired margin.
- **Decision Trees:** The Decision Tree classifier can be used for both the regression and classification problems. By dividing the dataset into various different homogenous sets on the basis of the defined attributes which help in disintegration of the data effectively. The criteria for selecting the attributes is by calculation of information gain and entropy which will split

the dataset. [Deisenroth, M. P, et.at, 2020]. Entropy helps in calculating the impurity of any variable and information gain is difference of the entropy of parent node the child nodes. The attribute which results in highest information gain is chosen as the attribute used for splitting dataset.

- **Random Forest:** Random Forest is a compilation of different decision trees which groups different models used in the prediction of outcome of a whole entity rather than any individual model. In this model, each single decision tree is involved in predicting the outcome of the all the individual models and the one with maximum votes is considered as random forest model. [Deisenroth, M. P, et.at, 2020]. To maintain the accuracy, the important factor is to maintain minimum dependency of each Decision Tree on each other. This can be achieved by the help of feature selection and bagging process.
- **Naive Bayes:** Naïve Bayes, a type of classification theorem which is calculated using Bayes Theorem. In this method, an assumption is made which says that there should be no correlation existing between the independent variables, that is the presence of any feature shouldn't have effect on any other feature present in the model. [Deisenroth, M. P, et.at, 2020]. A frequency table should be created listing out all the predictors in the classes present and calculate its likelihood. With the help of Naïve Bayes equation, we can calculate the posterior probability. The result of this model will be that one class which has the highest probability in comparison with the other classes.

1.2.6 Unsupervised Machine Learning: Unsupervised Machine Learning is used when Machine Learning algorithms helps to analyse and cluster the unlabelled datasets. It helps in discovering hidden patterns or by grouping the data without any human aid. It is best suited for image recognition, cross- selling strategies, data analysis and customer segmentation [Jo, T., 2021]. Unsupervised learning works much closer to real AI. They can be categorised into two different categories – clustering and association.

- Clustering: It helps in grouping the objects into clusters in a way that similar objects are group together and objects with no similarity are grouped together [Jo, T., 2021]. Clustering results are derived on the basis of similarities between the data objects and categorizes them accordingly.
- Association: Through association rule a relationship can be developed between the variables in a very large dataset. It works by finding the set of variables that occur together in a database.

1.2.7 Types of Unsupervised Models of Machine Learning

- **Artificial Neural Network:** These structures work similar to our human brains and process in the same manner as our brain. This is the work of nervous system in human to perform different task like facial recognition, carry blood to other parts of the body [Jo, T., 2021]. In an artificial neural network, neuron is the smallest element which performs all the work. The input from input layer is given to all nodes of hidden layer and then it is fed to each node of the output layer. There are number of nodes in each layer and several hidden layers in between. So we should be careful while passing them to the output layer. To select right number of nodes and layers using a neural network to run a given problem.

- **K- Nearest Neighbor:** This model can be used for both the methods, i.e. regression and classification. It helps in finding the nearest neighbours for all existing data points by calculating their distance from the existing data points [Jo, T., 2021]. All the classes are assigned with data points in relation with the highest number of points present among all the k-neighbours. If value of K is an odd number, it will help to reduce chances of a situation of a tie. As compared to other models, this algorithm is comparatively expensive as each point distance is calculated with each and every single data point.

- **K- means clustering:** This method works by clustering the data points by assigning them into K- groups, where K represents the number of clusters which depends on the distance from each groups centroid. The data points that are close to a similar centroid are clustered together [Jo, T., 2021]. Smaller grouping will always have a larger value of K and it shows more granularity whereas larger grouping will always have smaller value of K and it shows less granularity. Most commonly used in image segmentation, image compression, document clustering and market segmentation.

- **Hierarchical Clustering:** Hierarchical clustering is an algorithm which is categorise in two ways: agglomerative and divisive. Agglomerative follows a bottom's up approach and in this initially the data points are isolated as separate groups and then are merged together according to the similarities drawn between them until one cluster is achieved [Jo, T., 2021]. Divisive clustering follows a top-down approach and in this on the basis of the differences found between different data point a single cluster is divided.

1.3 Datasets In Consideration for The Research

The data used in research is taken from the source – Theory of mind in remitted bipolar disorder" of Participants which is an online dataset [117]. This is used in the paper titled "Theory of theory of mind in remitted bipolar disorder: InterPeopleal accuracy in recognition of dynamic nonverbal signals which is published in a Journal PLOS ONE which is a Scopus indexed Journal [10]. This is also published in PubMed and is included in National Library of Medicine which is an official site of U.S. Located in Bethesda, Maryland, NLM is a component of the National Institutes of Health (NIH), a division of the U.S. Department of Health and Human Services. In the U.S. Army Surgeon General's office, NLM began as a modest collection of medical books and journals in 1836 [119]. The largest biomedical library in the world, the National Library of Medicine is a pioneer in computational health informatics research. In order to put biomedical research into reality, NLM is essential. The research and information services provided by NLM contribute to public health, healthcare, and scientific

advancement. NLM creates solutions for improved data management and Peopleal health, innovates innovative approaches to make biomedical data and information more accessible, and supports the development of a more diverse and data-skilled workforce.

The large amount of biomedical data can be used by researchers, physicians, and the general public to enhance health thanks to NLM. PubMed is a free search engine accessing primarily the MEDLINE database of references and abstracts on life sciences and biomedical topics. The United States National Library of Medicine at the Institutes of health to maintain the database as part of the Entrez system of information retrieval. This is included in Scopus as well as web of science. The other dataset used is also an online dataset from Global trends in Mental Health Disorder [118]. This shows the percentage of people effected by various types of disorder like Bipolar disorder, Anxiety, Depression etc. This also shows the countries mostly effected and a year wise survey of the mental disorder in different countries. This is also included in National Library of Medicine.

The questionnaires and surveys administered to participants via a device form the basis of the dataset used to examine bipolar disorder. Minipons, which provide interPeopleal accuracy in signal identification that is dynamic. This minigun is used to test how well nonverbal cues are working. This is accomplished by combining affective valence and dominance by organising the stimuli data into a 2x2 arrangement. The categories show the respondents' three or two distinct audio channel types as well as their video channels. The use of computer-generated stimuli facilitates the administration of data and the recording of responses. The individual replies were asked to select between two alternative possibilities during the recording process. This dataset is separated into the subsequent categories:

- Group: Control, Depressive, Bipolar.
- Type: Control, Depressive, BD-I, BD-II.
- Correct_Answer: The MiniPons assessment's correct answer count
- Assessment scales: Dominant, Submissive, Age, Positive, Negative, and Combined Channels; Face, Body, and Audio Prosody

1.4 Research Motivation

Machine Learning and deep learning techniques are used to test and solve the mental health problems, but there are still various solutions that need to be refined. There are number of situations and symptoms that are to be discovered using machine learning for early detection of mental health domain. This is used to recognize or examine the mood episodes, state and responses with clinicians. The performance of algorithms and models may vary according to the data sample for future treatments. To classify the data regarding bipolar disorder and its features used in Machine Learning techniques can affect the classification performance. The related studies show that Machine Learning and deep learning are helpful tools in bipolar disorder and other psychiatric disorders. Most of the research and studies are still struggling for result validation due to improper evidence and sources. The aim is to investigate diagnostic practice, by applying machine learning to analyze activity patterns in mental disorder and healthy controls which are used for initial diagnosis of mental health diagnosis.

1.5 Research Objective

The main objective of the research is to build a novel approach that can decrease the semantic gap for prediction and detection of Bipolar Disorder, thus, to reach the human-level performance. In specific the following objectives are: -

- Review of the previous study of ML models and DL methods to classify the data in categories of Bipolar Disorder Like BD-I, BD-II, etc.
- A statistical Data Analysis of Bipolar Disorder dataset.
- Classification of model on the basis of parameters like R2-Score, F1-score, Precision, Recall, Accuracy and other parameters to choose the best Machine Learning model for BD early Predictions.
- Hybrid techniques like preprocessing, and feature selection are used to develop a Hybrid LSVR Model.
- Accuracy enhancement of prediction using optimized Artificial Neural Networks for prediction of prediction of bipolar disorder.

1.6 Organization of the Thesis

Rest of the Thesis is organized as follows:

Chapter 2 briefly describe the comprehensive review and study on Depression, bipolar disorder and detection and prediction of risk analysis in Bipolar disorder by machine learning. The review aiming to decrease the cause the reasons of bipolar disorder through routine updates and early detection, which is used to improve the health conditions of such People in reducing health care delay and medical cost. Few studies show that many research is being done to find the exact reasons of Bipolar Disorder.

Chapter 3 describes predicting the symptoms of bipolar disorder using machine learning This focused on statistical analysis of data used in the research and for this two online datasets of bipolar disorder was studied on the basis of categories of bipolar disorder such as Unipolar(UN) disorder, Bipolar Disorder-I, Bipolar Disorder-II, etc. Data is gathered using MiniPons, a system that relied on interPeopleal accuracy discovered by the identification of dynamic nonverbal cues. We can also conclude that data is the key factor in the entire study as bulk amount of data will help to make accurate predictions. Similarly, a deep level of understanding is important while performing each algorithm used in this study for understanding about their effect and implications.

Chapter 4 presents the early predictions and risk analysis of bipolar disorder respondents. The three types of risk factors which affect these people are prodromal symptoms, biological risk factors, and environmental risk factors. To identifies the risk at each stages are important key factors for treatment and requires less interventions. The transformation from depression to mania, from depression to bipolar disorder and from bipolar disorder to hypomania for pre identifications. The performance is evaluated by measuring the matrices like Precision, Accuracy, F1 score Recall value on dataset.

Chapter 5 The model performance is model is drawn by R2 score on the dataset, has provided the performances of the regression-based model. The R2 score value is also known as r-squared or coefficient of determination. It is calculated by checking the amount of

various present in the prediction present in the data. The final conclusion of the R2 score on the dataset is used to evaluate the performance of a regression-based Machine Learning Model. It is also called R- squared and also known as the coefficient of determination. It works by measuring the amount of variance in the predictions depicted by the dataset**.**

Chapter 6 propose optimal detection and prediction of People's condition with increased precision and framework productivity using artificial neural network algorithms. To choose the model and its type as well as parameterization of regression Function, Finding Loss or Objective Function, Overfitting and model selection, Relationship between loss functions and parameter priors, Optimal combination of hyperperameters. These are parameters of a model which can be set manually while creating a model but cannot be trained. Random and Grid Search methods are used for optimization of neurons, input layer, hidden layer, Activation Function and Learning rate.

To evaluate and keep track of the training and validated test data, the Accuracy and Loss parameters were used in each Epoch. Training Accuracy and Validated Test accuracy follows a similar increasing pattern until reaching a minimum percentage and then they stabilize. On the other hand, Training Loss reaches a certain percentage where it remains stable and validation test loss follows the same behaviour as Training loss.

Chapter 7 The hybrid model LSVR Logistic Support Vector Regressor provides improved accuracy in prediction of bipolar disorder. This chapter has contributed mainly on Dataset pre-processing using statistical Analysis, Best Features are selected using LR and SVM models, Dataset is divided into Training and Test dataset, Optimization has been done by combining the models for performance optimization. A hybrid classification approach has been designed to discover specific features and calculate high dimensional inputs in an accurate manner.

Chapter 8 describes the result and discussions of the thesis.

Chapter 9 presents the conclusion and future scope of the thesis.

A list of research papers published/ accepted/ communicated in journals and references are given at the end of the thesis.

CHAPTER-2

Review of Literature

2.1 Introduction

This related study gives a comprehensive review and study on Depression, bipolar disorder and prediction and analysis of Risk factors in Bipolar disorder using machine learning. The review aiming to decrease the cause of occurring of bipolar disorder through routine updates and early detection, which help in reducing the healthcare and the cost of medical expenses.

The related review summarises the reasons of People suffering from Bipolar disorder. The research proposes the Machine Learning models for feature selection and feature extraction of EEG, its model Classification and 10-fold Cross validation by decreasing around 94% of accuracy to identify 2-Level stress and 83.4 % identification of multilevel accuracy [Subhani, A. R, et.al, 2017]. The early stages characterisation of Bipolar disorder, its initial and early treatment and recognition are impacting critically to prevent unfavourable outcomes [Rios, A.C. et.al, 2015]. In this paper, a hypomania related symptoms are predicted from whole-brain patterns resulted for Activation in different samples in dependant in nature. This work predicts the identification at early stage of risk in adult life of bipolar disorder at initial stage [de Oliveira, L., et.al,2019]. This paper presents the outcome from CNN MDRP having Random Forest gives high accuracy results as compared to other models in prediction of bipolar disorder. This predicts the transformation in Grey and white matter of various groups of data individuals [Sujatha, R., et.al, 2021]. The implementations and intervention of early strategies will help to transform the illness also irreversible harm to People with bipolar disorder [Vieta, E., et.al, 2018]. Another study reveals that the People with depression at early stages of the onset of the illness or of the mood disorder [O'Donovan, C., et.al, 2020]. The research implements a XGB Extreme Gradient Boosting ML tool involve an EEG processing signal. A standard of 10-fold cross validation process with 94% high prediction accuracy, Precision>0.94 and Recall value>0.94 and Extreme Gradient

Boosting system tested with the dataset a new method to guide as well as diagnose People having Bipolar disorder [Mateo-Sotos, J., et.al, 2020]. A framework having Flask Web technique to handle Hypertext transfer protocol (HTTP) request of the disease prediction. For this HTML web pages are designed for display of disease prediction [Geetha, G., et.al,2020]. The study of another researcher studies a Machine Learning Decision Tree disease prediction model and to produce repot having possibly of disease prediction [Chen, M., et.al, 2017]. Applying different machine learning models on People's requirements which helps to create prediction model having symptoms [Leal, J., 2018]. In this paper, the prediction model was designed to detect anxiety and depression in older people by studying their demographic and clinical features using Machine Learning [Sau, A. et.al., 2017]. The team of researchers classify the manic and depressive episodes of mentally ill People with the use of smart phone integrated technologies [Grünerbl, A., et.al, 2015]. Another research investigates the highest feature in health to be monitored as important factor using techniques for ranking symptoms of Bipolar Disorder [Kumarasinghe, K., et.al,2020]. To monitor the day to day health and routine analysis a mood charting model was proposed [Bauer, M., et.al, 2006]. The study of correlated mental illness symptoms is recorded from smartphones which helps to make a conclusion that early predictions helps to record the daily day to day activities for a time interval [Faurholt-Jepsen, M., et.al, 2018]. An AD model having real time tweets was designed to predict the depressive states of the People [Kumar, A., et.al, 2019]. A methodology to evaluate techniques to minimize human interference of data collection as well as labelling using Machine Learning [Liu, D., et.al, 2021]. The literature review for the prediction of Anxiety Disorder using Machine Learning algorithm to support care of People along with the early predictions [Muhammad, A., et.al, 2020]. Machine Learning techniques to predict a high quality solution of brain illness using online tools like Twitter, Facebook etc for study and predict results for the same [Islam, M. R., et.al,2018]. Another team of Research analyst focuses on mental health conditions, illness and Machine Learning applications for psychology and mentally ill disorder [Shatte, A. B. R., et.al, 2019]. The results of Neuro Imaging techniques for clinical assessment of young children with the use of qualitative estimation on electronic dataset to reduce health risk by valuable prediction to give an insight for better understanding of imaging technologies [Lee, H.J., 2019]. Machine Learning model on electronic dataset record to reduce health risk by providing valuable

prediction information gave insights on electronic imaging technologies which can be further studied using Machine Learning [Martinez, A., et.al,2018]. This paper gives a Machine Learning model by demonstrating wide range of prediction treatments and research support as well as clinical support on mental ill People [Gupta, M., et.al,2017]. The lockdown during Covid-19 is the best way to save lives in the worst pandemic situation. The things happen to go smooth in terms of studies and office work due to non-disrupting teaching learning and online working mediums. The students not only learn but also give online test as well as other assessments like summer internships, online trainings and module learning [Mehta, M., et.al,2020]. Is the lockdown period the only effective means of combating the epidemic and how does it save lives? Using online resources such as webinars, online teaching, online learning, internships, and much more, students can learn how to manage their studies and other activities. All of this is made feasible by the faith that things will return to normal eventually. investigating many factors that influence the prognosis of depression by gathering data via questionnaires, social media posts, verbal exchanges, and in-People interactions [Priya, A., et.al, 2020]. This paper presents the commonly used algorithms with their properties and performances which plays the guiding role to select appropriate and correct model for the disease prediction. Machine Learning serve as a conduit or platform between People' shame about discussing their issues and doctors' critical shortcomings of the therapy [Saral. B., et.al, 2019]. A text analytical tool to study Anxiety and depression with the help of a sensor and a self- testing camera used in smart devices [Shrestha, A., et.al,2019]. Machine learning model is applied to study stress level patterns of working Peopleals and stressedolder People to find the factors responsible for stress to give a increased knowledge of stress levels [Kiranashree, B., et al., 2021]. Research on the emotional support of a specific People with a mental illness is conducted using advanced artificial intelligence (AI) technologies and machine learning models in a tailored system [Vikhrov, L., et al., 2021]. The suggested algorithm for categorising and categories types of mental illness, its stages and other features [Kouris, I.N., et.al,2005].

The proposed methodology is the reflection of the results of various models applied on different dataset. For this, the bipolar dataset was portioned into two distinct

groups: test and training datasets. Separate machine learning applications are used on data to forecast the best model for Bipolar disorder diagnosis. Finally, the conclusion is measured on Recall, Precision, accuracy and F1-score of ML algorithms, i.e. Random Forest, Support Vector Machine, Logistic Regression, K- Nearest Neighbor for Bipolar and control People. The results of the study give the reason that bipolar Some groups used Emotional Valence Stimuli to score relatively differently from other groups. Compared to other models, Linear Regression LR is the most effective method for predicting bipolar disorder, according to the findings. which works fine on other few outliners.

2.2 Review on machine Learning Techniques to predict bipolar disorder

Mood Disorder is a complex mental illness which has affected millions and millions of People around the globe. This disorder is an alternate oscillations of mood swings of People's changing state of mind between depression state and mania state. These swings occur due to various psychological and physical features. These psycholinguistic features include change in behaviour, mood changes and brain related illness which are to be recorded time to time to provide feedback of effected People for wellness. This work is performed to understand the levels of unidentified stress levels in the brain of a human and solve the issues related with it. This study focuses on prediction of bipolar disorder prediction and other behaviour of mood disorder using various other techniques.

For research, we review articles and papers related to similar study and analysed this data with statistical tools and techniques. Visualised data to gather and extract meaningful and useful information from a complex and vast data to optimise and predict data for day-to- day analysis. The study focuses on research papers and articles having different models like k-nearest neighbours, random forest, logistic regression, support vector machine, naïve bayes and decision tress analysed and related in study of mental health detection in a group of target audience. The study reveals that if the condition is

known in advance then it is easy to resolve any difficulties and limitations that become and obstacle in solving mental disorder.

One of the leading organisation world health organisation WHO relates that a People with healthy mind and adhere to a physically fit body are the ones that can be considered as a healthy human being. The modifications in mental behaviour and process with age are very common these days around the world. With the increase in age, there are consequences of depression and many vulnerabilities of increase in anxiety [de Oliveira, L., et.al, 2019]. The advancement in data science analytics and technologies gives rise to more attention towards prediction of this disorder. Many studies and researches with large dataset concluded that if risk analysis and classification improves in place of some selected attributes analysis as studied earlier [Subhani, A. R., et.al, 2107]. People having bipolar disorder have mood swings on daily or weekly basis. This is the result of increase in disease reoccurrences with time as well as the indication that there is risk of disease being still active. For this the regular monitoring of People to monitor its symptoms and also to correlate the disease [Mateo-Sotos, J., et.al,2020].

The applications which involves bulk of data to process are using machine learning techniques in all system. One such field is in medical aid which is the one most affected by data science techniques. The machine learning algorithms having classification and regression algorithms helps in predicting different illnesses, administration of drug and many more. Machine Learning is used to create models on different features to predict values [Vuppalapati, C., et.al,2018]. The review in this study uses Machine Learning for mood detection and disease prediction. For this study, the dataset of both healthy and unhealthy People are viewed, that are taken from surveys for applying algorithms for prediction of disease.

2.2.1 Categories of Mood Disorder

A lifelong mental illness is bipolar disorder occurs with mood swings between Depression and Mania. Even People who are on regular treatment for long lime have

issues about the same problem. All these categories of mood disorder are treated and identified based on their behaviour as depicted in Figure 2.1.

- **Mood-I Disorder:** This subset of bipolar disorder has symptoms depending on fluctuation of mood episodes from maniac to depressive states. This is further being diagnosed on the basis of manic episodes which should exist for at least seven days and leads to psychotic behaviours.
- **Mood-II Disorder:** This particular category of bipolar disorder leads elevation of mood from the milder ranges of hypomania episodes which keeps on occurring alternatively win line with severe depression.
- **Cyclothymic Disorder:** This category has symptoms in the form of brief episodes of People suffering from hypomania along with depression. They don't last for long and are not extensive. It is a brief from of mood disorder that has few cycling mood swing with it.

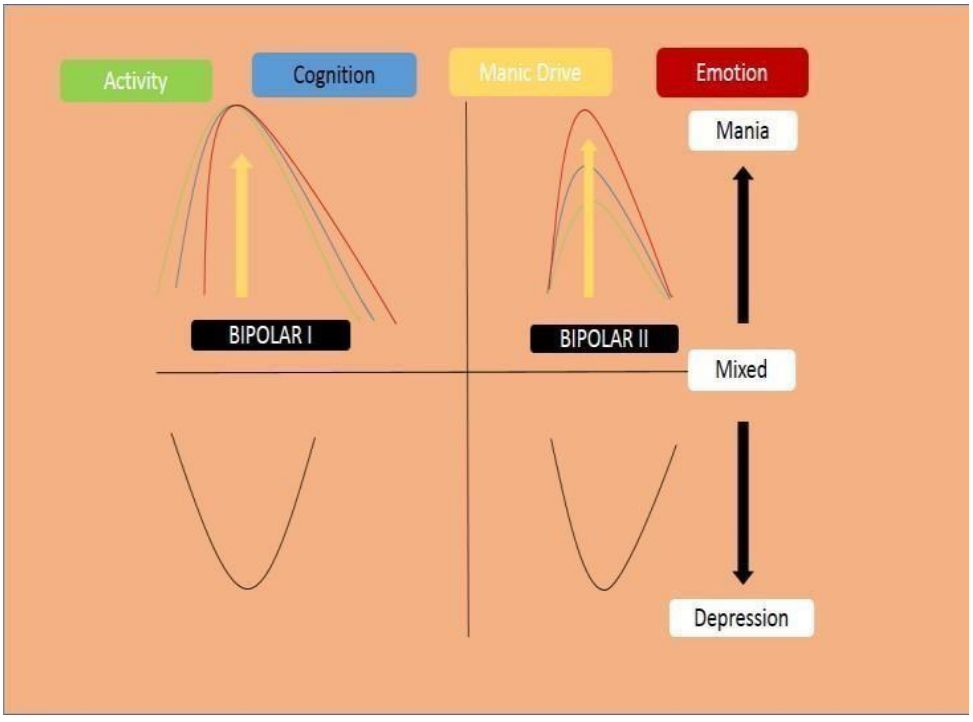

Figure 2.1. Diagram to show different types of disorders

- **Mixed Features:** It is the combination of different episodes such as mania, depression and hypomania. Some of the symptoms of mixed feature are lack of sleep, high levels of energy and unnecessary cluster of random

thoughts. In this feature, the People start feeling helpless, irritated and depressed and are not happy with their life.

- **Rapid cycling:** It's a condition of a yearlong suffering from different phases of mood episodes. It can range from people experiencing mood fluctuations at a very high level to very low level in one-week period during their illness. This can have different patterns of severe depression and though of suicide.

This is an over discussed question whether this is a clinically approved method to disintegrate types of disorder disease prediction. There are some examples in which they are combined as a single disorder as a broader category. There is an example in which Autism and Asperger's syndrome in DSM-% into ASD [Lee, H.-J., 2019]. The merits of Merging and distinction are summarised as in Table 2.1.

The benefits of merging and disintegrating can be summarized in Table 2.1.

Table 2.1. Merging and Disintegrating Mood-I Disorder and Mood - II Disorder

Merging and Disintegrating Mood-I Disorder and Mood - II Disorder	
Merits of Merging Mood –I Disorder and Mood- II Disorder	**Merits of Disintegration of Mood –I Disorder and Mood- II Disorder**
• In this a true clinical reflection for confirming clinical dimensions is needed. • This provides consistency throughout the treatment approaches. • To encourage People's mood thinking and research spectrum are coherent. • A mixed state accommodation and permits differential clinical expression for bipolar disorder.	• To maintain consistency when evidence is lacking in support of changes. • Family and People undergoes disturbances. • Acknowledges differences in clinical changes. • Dominance of depression in mood disorder. Switching of episodes is differently susceptible.

2.2.2 Techniques of Machine Learning to Predict Bipolar Disorder

The methodology used gives a brief and comprehensive study about various algorithms applied to detect the symptoms of bipolar disorder. The study focus on providing a valuable and concise insight to Researchers and clinicians to reduce the extreme conditions of stress, anxiety, depression and mania. The Machine Learning data processing steps are depicted in figure 2.2. The processing steps includes five steps, Planning and Background Analysis, Data Acquisition, Data analysis, Implementation of Data Mining Process and Performance Evaluation as in figure 2.2.

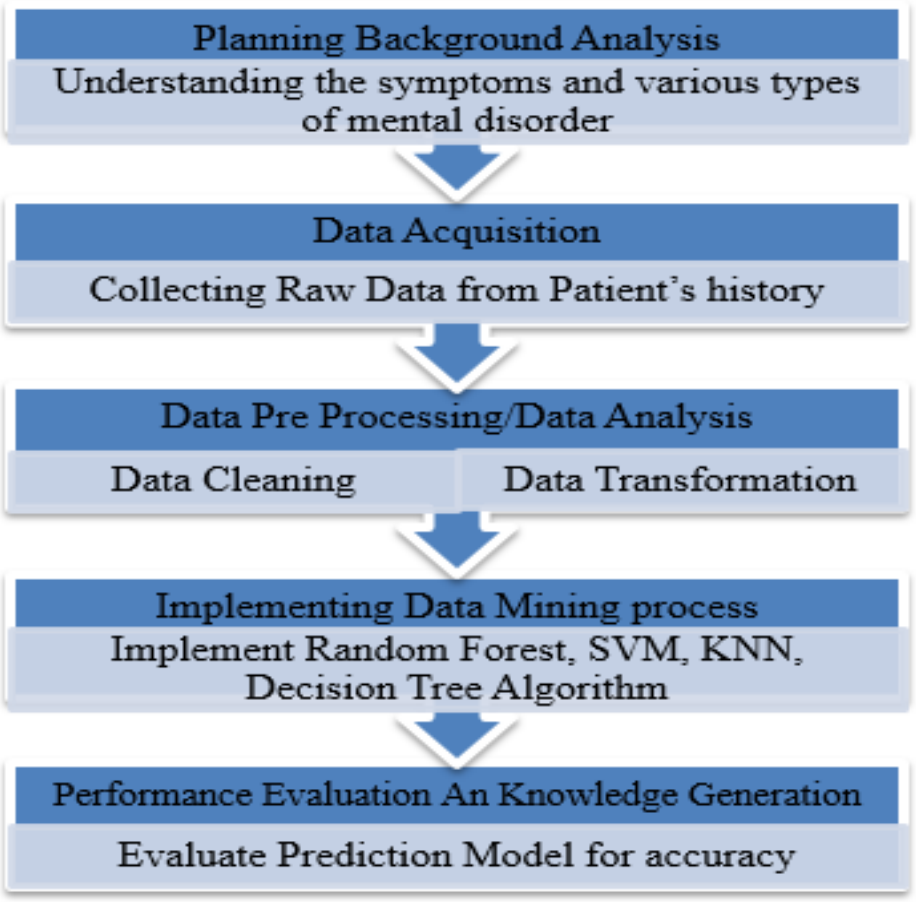

Figure 2.2. Machine Learning Data processing steps

2.2.2.1 Analysis Through Background Check and Planning

In this step, it includes gathering of Peopleal and health related information like qualitative factors including demographic information, Peopleal information, theirmental symptoms, socio demographic characteristics and disease related issues. Peopleal information relates that family status, job security, gender, sex, age, marital status, past history, etc. to relate the reason of depression and anxiety for detection in aged People [de Oliveira, L., et.al, 2019]. These are common in all age groups these days [de Oliveira, L., et.al, 2019].

2.2.2.2 Collection or Acquisition of Data

From different sources, dataset is built on the basis of information provided by People. These data are analysed for detection of different mood related, anxiety and depression disorder. This data is collected from questionnaires, surveys, feedback and other social media platforms. [Vuppalapati, C., et.al, 2018] The sources of data can be summarised as follows: -

- Surveys are conducted related to well-being and mental health, Interviews and surveys were analysed through different recognised institutions and organisations such as World Health Organisation (WHO). In one example, PSS, a scale for measurement of stress, was realised by a questionnaire based on same methodology. It measures features like heartbeat, respiratory frequency, skin conduction, response rate etc.

- In this review Facebook user comments are a great source of data to detect the behaviour of People and exploration of the depression dataset [Priya, A., et.al,2020].
- A Q sensor and Motion logger are sensors attached to a specific body part, wrist, were used to collect psychological data. The data recorded was temperature of human body, conduction by skin, ambient light to monitor the daily sleep and wake up patterns, measure stress index and other parameters for further analysis.

- A mobile application was used for analysing social interaction. This help to analyse and monitor app usage, lactation of the People, timings of call and their messages [Geetha, G., et.al,2020].
- A smartphone is used to record audio and physical activities of running, jogging and walking, identifying sense such as voice, any kind of noise, and silence. Not only this, but when the call started or ended, lock applied on the phone and its coordinates were monitored too [Mateo-Sotos, J., et.al,2020].

2.2.2.3 Data Pre-processing- Feature Selection

In data collection and acquisition phase, raw data is pre-processed in a readable from by applying two methodologies, cleaning of dataset and transforming the dataset. These methodologies will help to understand change in People behaviours and then selecting the best feature that can solve their medical condition. To differentiate depressive and non-depressive tweets, comments and posts, various other features were studied for applying algorithms.

- **Cleaning of Dataset:** Cleaning of data is required to filter irrelevant data in People prescription. Linguistic enquiry and word count is taken for psychological vocabulary by the reviewer. Written and verbal data in correspondence for intellectual, etymological and affective parts are perceived for study.

- **Transforming the Dataset:** The data gathered was modified into readable format for its implications. The nullify values were rejected from the dataset.

2.2.2.4 Classifying Data Processing Methods

The motive of our research is based on finding out or presenting a classifying technique for predicting mood disorder. To analyse this thoery [Grünerbl et al.,] [O'Donovan, C., et.al, 2020] examined 466 People suffering from mood disorder that found a relationship between detecting and predicting bipolar disorder. The different machine learning algorithms are K- Nearest Neighbour, Decision Tree, Random Forest,

support vector machine. The performance of different algorithms was compared by using accuracy methods to detect disorder. Some of the commonly used methods are [O'Donovan, C., et.al, 2020].

- **Random Forest**

Random Forest is a compilation of different decision trees which groups different models used in the prediction of outcome of a whole entity rather than any individual model. In this model, each single decision tree is involved in predicting the outcome of the all the individual models and the one with maximum votes is considered as random forest model. [Deisenroth, M. P, et.at, 2020]. To maintain the accuracy, it is important to maintain minimum dependency of each of decision trees on each other. This can be achieved with the help of feature selection and bagging process.

- **Support Vector Machine**

This subset of machine learning model is a non-probabilistic and linear binary classifier which helps to resolve and detect any anomalies present. This particular model is helps in reducing some amount of noisy data which further provide the best results and resolve decision making concerns. It is basically used as both a classifier and regression model. [Deisenroth, M. P, et.at, 2020]. This model is known for its different parameters and each of its parameters are plotted in a n-dimensional space with a specific coordinate assigned to them. It helps in building a hyper plane that can isolate the entire dataset into two different classes via a high dimensional feature space and this hyper plane can further disintegrate close training datasets by calculating the desired margin.

- **K Nearest Neighbor**

. This model of machine learning can be used for both the methods, i.e. regression and classification. It helps to find the nearest neighbours of all the existing data points by calculating their distance from the existing data points [Jo, T., 2021]. All the classes are

assigned with data points in relation with the highest number of points present among all the k-neighbours.

- **Decision Tree**

The Decision Tree classifier can be used for both the regression and classification problems. By dividing the dataset into various different homogenous sets on the basis of the defined attributes which help in disintegration of the data effectively. The criteria for selecting the attributes is by calculation of information gain and entropy which will split the dataset. [Deisenroth, M. P, et.at, 2020]. Entropy helps in calculating the impurity of any variable and information gain is difference of the entropy of parent node the child nodes. The attribute which results in highest information gain is chosen as the attribute used for splitting dataset.

2.2.2.5 Evaluation and Prediction Analysis

- Precision is a technique that is applied to measure the amount of positively predicted data. Maximum value attained in precision shows whether a particular model is able to solve people requirements [Sau, A., et.al,2017]. To understand this, a model is created to disintegrate healthy and unhealthy People.
- By highlighting whether a particular post is depressive or non-depressive and taking them into consideration will help to resolve People issue. The major task in this is label such kind of comments and post.
- The results are calculated lastly as an outcome. To gain best results, from the different models applied their other parameters can be taken in consideration and contrasted with different models and the one with the most accurate results can be taken in consideration.

2.2.3 Machine Learning Methodologies for Predicting Mood Disorder

The literature provides a clear understanding and study by investigating machine learning model to predict symptoms of bipolar disorder. The theory will further help to

reduce the reoccurrence of anxiety, stress and depression at early stage. This results in significantly minimizing the hospitalisation and improves their quality of life and reduction of hospital fees to a large ratio. The study is divided in three different steps as depicted in figure 2.3.

- In First stage, we study and reviewed around a total of 125 papers that were found directly associated to bipolar diorder and machine learning models via sources such Springer, MDPI, IEEE, etc. In addition to this 25 articles from other different sources are referred. From these selections almost 31 papers were linked directly by bipolar disorder.
- In the next stage, 12 papers were read which are shown in Table 2.2, were based on detection and prediction of the disorder and they are further understood through their titles and abstract.
- In third stage, related literature is thoroughly examined and studied during this stage for literature study. Different techniques such as data input and measuring different techniques were put in use to gather important information.

Many studies depending on mental health prediction and symptom diagnosis as shown in Table 2.2. In this area of crisis prediction and mental health disorder theories based in this field where clinicians try to find out a route through this pathway created.

[Subhani, A. R., et.al,2017] determined algorithm of decision tress in structured and unstructured manner by proportioning out data through different algorithms. In the study they predict a 94.8% accuracy of the chances of disease occurrence in People. Axel Junestrand Leal. [Rios, A. C., et.al, 2015] A Machine Learning technique is developed to implement the model of prediction by using a dataset depending on People data. These research papers [de Oliveira, L., et.al, 2019] and [Grünerbl, A., et.al, 2015] shows the diagnosis of depression and anxious nature in individuals by finding their socio demographic and different point of concerns by applying various different algorithms [Grünerbl, A., et.al, 2015] and [Geetha, G., et.al,2020].

Using methodologies to understand changes in bipolar disorder People using classification in manic and depressive state using smart device sensors. [Doryab, A.,

et.al, 2015] With the application of machine learning algorithms, the author found out ranking features as the crucial attribute in mental health concerns. [Grof, P., et.al, 2006] For monitoring the People a mood charting is prepared, and to show the state of mood observation and appropriate understanding of mental health conditions are daily

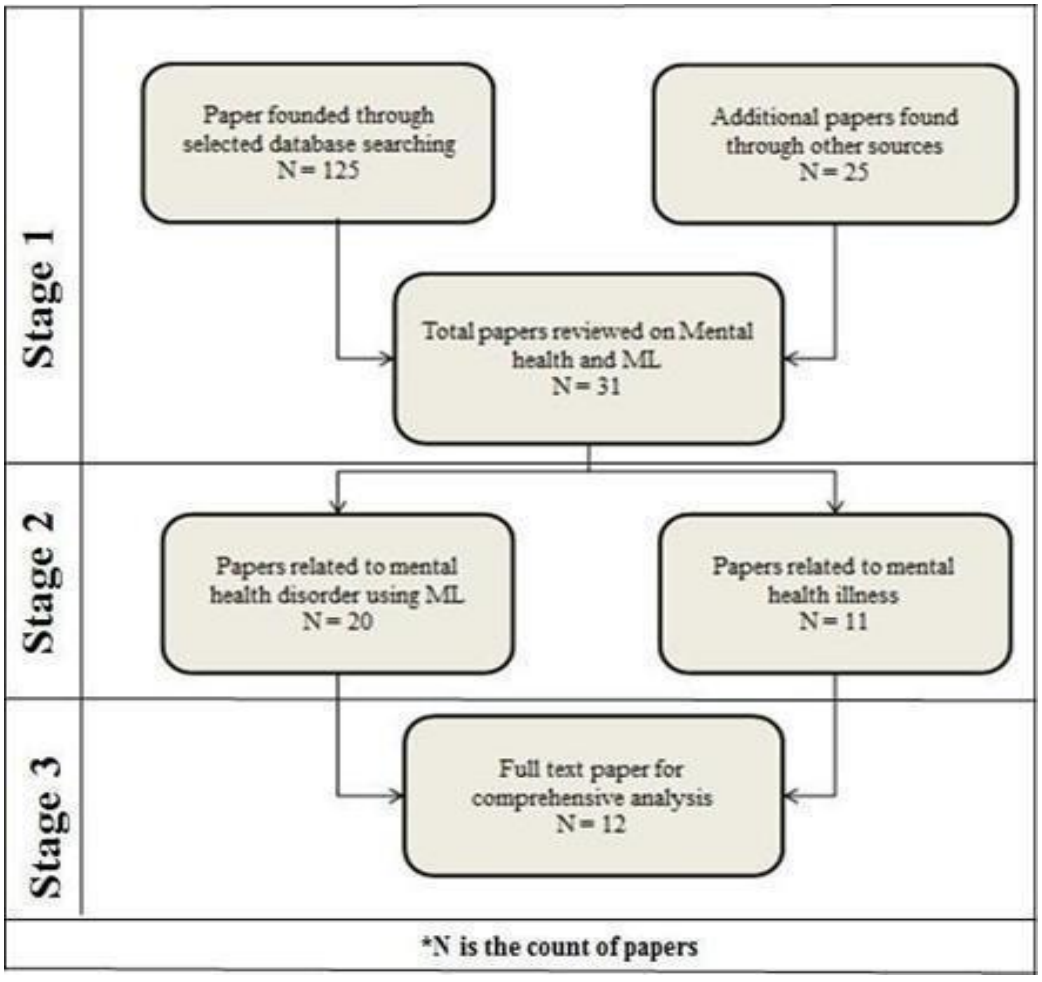

Figure 2.3. Flow Diagram of review literature

analyzed. [Faurholt-Jepsen, M., et.al,2018] this study reveals the characteristics and features of BD by collecting data through smart devices, the physical and social activities are written by People in a specific duration or time period. [Kumar, A., et.al,2019] An approach is applied to predict Anxiety and Depression on real world via online tweets posted. The mood or mental disorder, Anxiety and Depression are based thought process, sleeplessness and being restless.

[Sau, A., et.al, 2017] A methodology is suggested to evaluates the methods of

Machine Learning detection of depression through minimum intervention of the human beings by data processing. [Liu, D., et.al, 2021], Using Machine Learning a comparison study was prepared to predict whether the People is suffering from stress or anxiety and which tool can help to solve the health concern. [Islam, M. R., et.al, 2018] To identify quality solution using machine learning techniques for mental health problems by Facebook users through their comments and posts. Feelings and behavioral changes like sadness, love and affection etc. were monitored as they use online communication methods for communicating with the world. [Shatte, A. B. R., et.al,2019] This study gives a brief about incorporating machine learning algorithms in the field of mental health by focusing on the detection and prediction of the illness. [Sun, Q., et.al, 2019] This theory provides techniques about neuroimaging at early stage through psychopathology estimation and objectives in young adults for clinical assessment. [Saylan, C., et.al, 2016] This paper provides a guidance to researchers by predictions using Machine Learning Techniques.

These Machine Learning applications gives a clinical administration to support treatment, support and diagnosis of disease. [Gupta, M., et.al, 2020], The findings show the way to reduce or overcome stress and depression during lockdown period. How students come up with online method of teaching and learning, online pattern of exams, online admissions and summer training internships. This shows how we react to depression or peer pressure to avoid heat related problems. The data is collected using online medium like questionnaires and interview by People through monitoring their online post, and social media responses and even facial expressions in videos. [Gupta, M., et.al, 21021] The techniques, possibilities and alternates in help to present an appropriate model used to describe performance of algorithm to deduce the gap created between psychiatrist and the People to reduce their embracement and reveling their health problems.

[Shrestha, A., et.al 2019] The benefits and use of Artificial Intelligence applications using analysis methods to provide aid in mental disorder condition with different methods and inclusion of technology via a smart device. Ac camera sensor is used and scales based on self-testifying methods perform to detect depression and anxiety. [Gupta, M., et.al, 2021] For professionals working, a pattern was analyzed about

stress to reduce levels of stress by machine learning models. The study is done on 2017 mental health People that includes answers as response. [Kiranashree, B., et.al,2021] This study focuses on system providing emotion care and special support using Artificial Intelligence and Machine Learning. [Khan, M. S., et.al, 2108] In this, a mood disorder is solved using classification algorithm.

Table 2.2. Studies related to dataset classifiers and Machine Learning Approaches

Aim of the Paper	**Authors**	**Approaches of Machine Learning**	**Data Source**	**Mental Health Condition**	**Keywords**
Effects of the disastrous pandemic Covid-19	Anuradha Khattar et al.[23]	R and Python for Visua lization, MS-Excel	Survey And Questionari es'	Stress	Covid-19, Pandemic, Mental Health and social life,
Analysis of Machine Learning Algorithms for	MS.Purude Vais halietal.[25]	Feature dynamic history histogram (FDHH,	Social media posts, questionnair e, verbal	Depressio n	ML, Mental health and predictive analysis
The Identificati on research of Mood	Qiu Sun et al.[20]	CNN	Samples and SNP	Mood Dis-order	Mood disorder, big data
Mental Disorder Detection: Mood Disorder	Ranjana Jadhavet al. [20]	SVM, Decision Tree	Questionnair e	Mood Dis-order	Machine Learning, MDQ, Mood disorder

Machine learningin mental health: A systematic	AdrianBRShatte[1]etal.[21]	SVM, Decision Tree, Unsupervised	Survey and Questionnaire	Anxiety and Depression	Big data, Machine Learning , Mental health,
Surveying Machine L earning algorithms on EEG	ElaGoreetal.[25]	EEG signal	EEG Signal Data of masculine and feminine	Depression	EEG Signals, Machine Learning,CNN
Monitoring Mental Health Using Smart Devices	Norah Saleh Alghamdi [27]	SVM	Using sensor, text analyzing tools	Depression and Anxiety	Depression , Test Analysis, Stress, Anxiety
Mental Health Monitoring System using Artificial	Vidhi Mody, Vrushti Mody [29]	SVM Model and RBF Kernel	Technological attributes like smart watch or	Depression and Anxiety	Artificial Intelligence, Machine Learning, Expert
Machine Learning Techniques For Stress Prediction in	U Srinivasulu Reddy et al.[28]	Bagging and Boosting, random Forest,	Employees responses	Stress	Stress Prediction, Boosting, ML, Decision
Supporting the Treatment of Mental Diseases	Shahidul Islam Khan et al.[30]	Random Forest, SVM , KNN	Bangladesh NMH Hospital records	Anxiety and psychosis	Classification Algorithm, Data Mining,

A system to detect mental stress using Machine learning and	Chandrase khar Vuppalapat Et al.[23]	SVM, KNN	Twitter sources in different forms such as tweets,	Stress	EEG Biosensors, ML, Mental Stress, Mobile
Intelligent health risk Prediction systems using	Mr. Santosh A. Shinde et al.[17]	AD Tree and KNN	Inputs collec ted throu gh	Psycho-logical condition	ealth risk predic tions and record

The challenges to researchers is to categories the bipolar disorder and its type to handle the bulk of data. This will be a great challenge to interpret dataset quality and categories it in different attributes and symptoms. Privacy and security of Peopleal information is one of the major challenge, to avid this safety precaution is required and data should be end to end encrypted using authentication protocols. One main challenge is to maintain accuracy and precision while manipulating data.

The information gathered from Online Social Networks [Bauer, M., et.al, 2018] gives immense potential to provide researchers with bulk of data to be explored. The research focuses on finding out bipolar disorder symptoms with the help of research, that a researcher refer for further studies.

1. The major challenge is to make these People feel that they are normal human being and they will be treated as normal ones while interacting with them. Do not isolate them as if they are not normal human beings [Shatte, A. B. R., et.al, 2019].
2. These People are involved in their own shell, and having negative thinking and judgement and are depressed with their [Priya, A., et.al, 2020].

3. One more point of concern is that People doesn't know how to emote their feelings in correct manner. As analysed on various social media platforms they send aggressive and very negative posts [Bauer, M., et.al, 2018].

4. In Online or Non face to face interactions there is problem to detect the type and seriousness of disorder [Bauer, M., et.al, 2018].
5. The data science approach helps researchers and clinicians in determining possibilities of existing mental health condition behind barriers [Priya, A., et.al, 2020].

These challenges can be summarised as bellow:

- The interpretation and quality of dataset.
- Timely prediction of mental illness problem.
- Categories the brain illness and disorder.
- Data pre-processing or acquisition.
- Generalisability and quantity of data.
- Ethical codes and data sparsity.

2.2.4 Conclusion

The study shows through the advancement in medical science with the help of technology can help to solve a lot of medical research and one of such is the introduction of machine learning to cure bipolar disorder illness. This could be easy to differentiate between stress, depression anxiety and mania. It will help in controlling the emotional conditions with time and save People not to turn into pathological situations. All these are quite challenging to treat but possible with advance diagnosis using machine learning algorithms. If these disorders are not treated in time then they lead to severe harm in body like suppression of immune system, various infectious disease, increase in blood pressure and even diabetes. To help People deal with these abnormalities we monitor the day to day activities of such People using different models as routine check-ups.

CHAPTER-3

PREDICTING THE SYMPTOMS OF BIPOLAR DISORDER USING MACHINE LEARNING

3.1 Introduction

In Today's fast-paced modern lifestyle, there is high prevalence of psychological mental illness issues like Anxiety, Depression and stress among the people worldwide. This gives in immense increase in effective mental health care and explorations of Machine Learning in diagnosis, detection and prognosis of mental health problems. Bipolar Disorder, is one of a kind of mental health illness which has affected a lot of people around the world. This is related to changes in People's mood swings and behaviour with occurrence of oscillations in two different states. i.e. mania and depression. Machine Learning can play a vital role in detecting People suffering from bipolar disorder and predicting the seriousness of the illness in People by learning through different patterns of human behaviour, identifying symptoms related to mental health and risk factors associated with it. Researchers all over the world are trying to extract and analyse data and ongoing researches working on incorporating machine learning in the field of bipolar disorder. This paper aims to present commonly used algorithms in machine learning such as Logistic Regression, Random Forest, Support Vector Machine, Naïve Bayes, Decision tress and K-Nearest Neighbours and analyse their properties and results which can provide an advantage in the ongoing research of the technicians and it will help to deal with the People's problems in a better way. Identifying and selecting features from data and then developing suitable Machine Learning algorithm for mental health issues is the prime task.

Various scientists, clinicians and researchers around the globe are using different algorithms of machine learning to provide correct and accurate treatment to the People by identifying some of the significant symptoms of the illness. It will help the psychiatrist to predict that whether the People is at a higher risk of falling into the category of bipolar disorder or not. In the current scenario, there isn't a lot of data available which can be

compiled and studied to get better results. This leads to the increase in the demand of using machine learning algorithms in the present times as clinicians are understanding the diagnosis depending upon the group averages and statistics over the entire population as said by a Psychiatrist [Sun, Q., et.al, 2019].

"Machine learning really meets a specific need that we have in psychiatry — and that's the need for Peoplealization". For decades, we've been working on group averages and statistics that apply to populations who may have the same diagnosis but don't translate as well to an individual People. Machine learning allows us to get at individual predictions in a way we haven't been able to before. — David Benrimoh.

World Health Organization WHO says that if an individual is living a healthy life and has a healthy mind is considered to be healthy People. Individuals with growing age can see changes in their though process and it can also reflect in their mental health. One such kind of mental disorder categories are depression and anxiety and they tend to get worsen with increasing age [de Oliveira, L., et.al, 2019]. The rapid change in the dynamics of technology and big data has resulted in providing more accuracy in disease prediction. A large number of dataset is being studied and researched around the world which further helps to increase efficiency of the results achieved by applying machine learning algorithms to understand mental health illness [Subhani, A. R., et.al,2017]. People suffering from mental health illness can frequent mood changes periodically. This unstable behaviour of People's mood results in relapse of the illness and reoccurrence of the risk associated with time, which indicated that the illness still prevails. The basic purpose of monitoring, analysing and predicting the symptoms of disorder is to correlate the symptoms of disorder and complete its further investigation [Mateo-Sotos, J., et.al,2020].

Machine learning has literally entered in all the domains present around or involved in human life that helps to process and gather bulk information or data and process it to provide valuable information. Especially in the field of medicine, machine learning algorithms have largely impacted a lot of researches to provide cure to human illness. Machine learning algorithm are designed in specific manner by applying regression and classification theorems for diagnosing different diseases, providing drug administration and recommendation [Vuppalapati, C., et.al, 2018]. This paper analyses machine learning

techniques for predicting bipolar disorder in People. The Data of healthy and unhealthy individuals have been reviewed through a survey which can apply various machine learning algorithm.

3.2 Categories of Bipolar Disorder

Bipolar disorder is a chronic disease which occurs due to changes in different mood episodes from mania to depression. Even after being completely cured with the illness, it is not necessary that the People can't suffer from these symptoms again. Each category of the disorder needs to be identified first and then treated accordingly. A lot of time this question pops out that is there a clinical way to distinguish different categories of bipolar disorder or not [Agnihotri, N., et.al, 2021]. And, sometimes this disorder is merged together as a broad category under one bubble.

3.2.1 Fluctuation of Mood Episodes

This subset of bipolar disorder has symptoms depending on fluctuation of mood episodes from maniac to depressive states. This is further being diagnosed on the basis of manic episodes which should exist for at least seven days and leads to psychotic behaviours.

3.2.2 Elevation 0f Mood Episodes

This particular category of bipolar disorder leads elevation of mood from the milder ranges of hypomania episodes which keeps on occurring alternatively win line with severe depression.

3.2.3 Hypomania with Depression

This category has symptoms in the form of brief episodes of People suffering from hypomania along with depression. They don't last for long and are not extensive. It is a brief from of mood disorder that has few cycling mood swing with it.

3.2.4 Mixed Feature

It is the combination of different episodes such as mania, depression and hypomania. Some of the symptoms of mixed feature are lack of sleep, high levels of energy and unnecessary cluster of random thoughts. In this feature, the People start feeling helpless, irritated and depressed and are not happy with their life

3.2.5 Cycling of Mood Episodes

It's a condition of a yearlong suffering from different phases of mood episodes. It can range from people experiencing mood fluctuations at a very high level to very low level in one-week period during their illness. This can have different patterns of severe depression and though of suicide.

3.3 Proposed Research Work

This research focused on diagnosing Bipolar disorder using Machine Learning algorithms for which online bipolar dataset was studied on the basis of categories of bipolar disorder such as Unipolar(UN) disorder, Bipolar Disorder-I, Bipolar Disorder-II, etc. Data is collected through MiniPons, which was based on interPeopleal Accuracy found through dynamic nonverbal signals recognition.

The proposed methodology aims to build a deep level of understanding through the analysis of the data which we are working with and is essential for the application of machine learning algorithms. We can also conclude that data is the key factor in the entire study as bulk amount of data will help to make accurate predictions. Similarly, a deep level of understanding is important while performing each algorithm used in this study for understanding about their effect and implications.

Machine learning algorithms and methodology applied in this study, will provide a comprehensive and concise knowledge on their application and implementation in the research which will help to identify bipolar disorder People separately from healthy People [Gitlin, M., et.al, 2020]. It will further provide the symptoms of People suffering from mental illness for the researchers and clinicians around the world. The Machine

Learning techniques undergo the following data processing steps includes planning and background Analysis, Data Acquisition, Data Analysis, Implementing Data Mining process and Performance Analysis.

3.3.1 Planning and Background Analysis

Through this step, a lot of information, attributes and symptoms are collected corresponding to the People and analysed to classify the type and seriousness of disorder. As some of the disorders can be examined and cured at very early stage. These attributes can be used as predictors for predicting the disorder [de Oliveira, L., et.al, 2019].

3.3.2 Data Acquisition

Data Acquisition is collecting the raw data of People of healthy and depressive People. This data can be collected from different sources like Online surveys, questionnaires and many other social media sites like Facebook, Twitter, WhatsApp. Many apps are designed to gather People's data [Chen, M., et.al, 2017].

3.3.3 Data Pre-processing or Data Analysis

From the data acquisition phase, a lot of data is collected and then transformed into readable form. This transformed data is used to study various behaviour and symptoms of People. Data pre-processing can be done by two methods:

- Data Cleaning: This step is performed to reject irrelevant or unwanted data provided in the People's history and is of no use for diagnose is filtered.
- Data Transformation: The raw data gathered is modified in an understandable form for further implications on it.

3.3.4 Implementation and Data Mining Process

This phase analyses the dataset by examine classification algorithms to predict mental health disorder and its type at early stage. For this many machine learning models

are applied like Random Forest Logistic Regression Support Vector machine, Decision Tree and K-nearest neighbours. These algorithms are compared on the measure of performance and accuracy to detect Mental disorder.

3.3.5 Performance Evaluation

A novel model is built to measure the positive predictions in Data Mining to help and identify those who are in need. This is constructed to classify major and minor disorder by studying different psycholinguistic features of People.

3.4 Literature Review

This literature review aims to understand a provide a clear picture about the disorder that can be treated with the help of techniques of machine learning. It further helps to reduce the repetition of anxiety disorder or its prevalence in any from by providing an early detection of the illness. This will help to minimize the need of hospitalization, improving People's health and help in saving their unnecessary expense on healthcare. This review has for different steps implemented which are identifying the illness, screening of People's record, selection of required literature and including them in the further course of research.

- During the identification stage, we reviewed around 120 papers for studies related to mental disorders, their classification and machine learning Techniques in their prediction by reviewing through different database searching.
- At the second stage, all 120 articles were screened by studying their abstracts and titles. In this around 50 records are excluded.
- In next phase, 34 papers that were directly related to prediction of bipolar disorder with ML techniques were included by reviewing their full-text. We excluded 36 papers.
- The last stage, involved the thorough examination of the included studies, in order to acquire essential information for prediction methods and tools used

for the Research, the accuracy achieved and the conclusions drawn. Their reference lists include 14 papers for literature review studies.

3.5 Research Methodology

The machine learning theory, provide a deep analysis of incorporating various algorithms of machine learning that can help in the detection of the symptoms of mood disorder. This can help to provide valuable information for further research and studies in the future. Then the machine learning algorithms like, Logistic Regression, Support vector machines, Naïve bayes, random forest, Artificial neural network and K-nearest neighbours was studied on the basis of categories of bipolar disorder. On the basis of questionnaires responses of surveys and other assessment scales collected from minipons based on interPeopleal nonverbal accuracy of dynamic signals.

3.5.1 Dataset

Dataset taken in consideration represent following data variable given in figure 3.1.

- Group: Bipolar, Control, Depressive.
- Type: BD- I, BD- II, Control, Depressive.
- Right_answers: Number of right answers to the MiniPONS assessment.
- MiniPONS assessment scales - Audio_ prosody, Combined_ channel, Face_ video, Body_ video, Positive_ valence, Negative_ valence, Dominant, Submissive

	Group	Type	Age	Right_answers	Audio_prosody	Combined_channel	Face_video	Body_video	Positive_valence	Negative_valence	Dominant	Submissive
0	Bipolar	BD I	47	40	9	11	9	11	18	22	23	17
1	Bipolar	BD I	49	49	13	13	11	12	24	25	24	25
2	Bipolar	BD I	45	43	9	11	13	10	21	22	24	19
3	Bipolar	BD I	53	44	10	10	12	12	25	19	24	20
4	Bipolar	BD II	50	50	14	13	11	12	23	27	23	27
5	Bipolar	BD I	31	54	13	14	14	13	28	26	26	28
6	Bipolar	BD I	45	53	13	13	14	13	24	29	27	26
7	Bipolar	BD I	48	43	8	13	10	12	24	19	21	22
8	Bipolar	BD I	57	41	13	11	9	8	23	18	22	19
9	Bipolar	BD II	50	53	14	14	12	13	26	27	29	24

*A higher score in those scales means a better performance.

Figure 3.1. Dataset representing categories of disorder

3.5.2 Classification

Python 3.6 was used to apply the Python language to machine learning techniques, as Figure 3.2. illustrates. Based on the degree of severity, this predicted the individuals with bipolar illness. The training and test sets of the database were further divided into particular ratios of 75:25, respectively. The following sections provide a description of each machine learning algorithm's working principles.

	Age	Right_answers	Audio_prosody	Combined_channel	Face_video	Body_video	Positive_valence	Negative_valence	Dominant	Submissive
count	277.000000	277.000000	277.000000	277.000000	277.000000	277.000000	277.000000	277.000000	277.000000	277.000000
mean	48.718412	47.079422	11.425993	12.339350	11.794224	11.519856	23.555957	23.523466	23.454874	23.624549
std	12.452524	5.231680	2.122800	1.931903	1.693199	1.912147	3.215893	3.132981	3.125796	3.033003
min	21.000000	28.000000	3.000000	6.000000	8.000000	5.000000	13.000000	10.000000	12.000000	13.000000
25%	39.000000	44.000000	10.000000	11.000000	11.000000	10.000000	22.000000	22.000000	22.000000	22.000000
50%	50.000000	47.000000	12.000000	12.000000	12.000000	12.000000	24.000000	24.000000	24.000000	24.000000
75%	58.000000	51.000000	13.000000	14.000000	13.000000	13.000000	26.000000	26.000000	26.000000	26.000000
max	78.000000	58.000000	16.000000	16.000000	15.000000	16.000000	30.000000	30.000000	31.000000	30.000000

Figure 3.2. Statistical study of dataset

Logistic Regression

The logistic correction, or logit regression, or logit model is a regression model in which the variable dependency is a phase. Logical regression covers the issue of binary dependence i.e., where it can only make a choice between two values, "0" and "1", representing results such as pass or fail, win or lose, life or death, healthy or illness. Situations where variable depends on more than two outcome categories are analysed in large deflation or when multiple phases are used then in a systematic retrieval [Thieme, A., et.al, 2020].

Support Vector Machine

This model, which is a subset of machine learning techniques, is commonly employed in classification and aids in further data segregation and classification. Because the technique may successively split data into two categories—negative and positive hyperplanes—it is widely employed in various programmes. A maximum separation between two categories ought to exist. Examples of SVM use cases include points in space and mapping, where distinct categories are divided by as large a distance as feasible. By using this technique, new models can be projected based on the hyperparameter category and presented in that space.

K- Nearest Neighbor Algorithm

This model of machine learning can be used for both the methods, i.e. regression and classification. It helps to find the nearest neighbours of all the existing data points by calculating their distance from the existing data points [Jo, T., 2021]. All the classes are assigned with data points in relation with the highest number of points present among all the k-neighbours. If the value of K is an odd number, it will help to eliminate the chances of occurrence of a tie. As compared to other models, this algorithm is comparatively expensive as each point distance is calculated with each and every single data point.

Artificial Neural Networks

Artificial neural networks work very much similar to our human brain. This consists of neurons like our nervous system which is the important unit of neural networks. This helps these networks to solve facial recognition, speech matching and other which is done by blood brain. ANN is having three layers input layer, hidden layer and output layer. The input from input layer is given to each nodes of hidden layer and then to each nodes of output layer. There are number of nodes per layer and similarly any number of hidden layers before passing to the output layer. For any problem it is important to choose the right number of nodes and layers.

Naïve Bayes

A straightforward machine learning approach called Naive Bayes is used to build classifiers that assign class labels in difficult scenarios. These classifiers are represented as veneers of value elements, with class labels drawn from a small set. Because of the class's flexibility, there is no one algorithm that can be used to train these kinds of dividers. Instead, all Bayes dividers operate under the assumption that a given element's value is more independent of all other factors.

3.5.3 Result and Discussion

Using these Machine learning algorithms, we calculated the efficiency of all the models to understand which is best suited for bipolar disorder diagnosis. The output as shown clearly showed that SVM is the most efficient method according to test processing for recognition of Bipolar Disorder with a score of 97.65.

The mental health disorder is difficult to categorize as researchers are implementing different strategies for the feature selection process which occur as one of the major challenges to conquer such as maintain the quality of dataset and interpreting it to get results. Various factors need to maintained such as accuracy of data and its precision because if the data is imprecise it can lead to failure of the entire proposed system. There are more important challenges to be dealt with while building the models like its security, safety and privacy and to avoid these issues, different safety precautions need to be taken, for e.g. implementing user authentication mechanisms and encryption of data. The information provided through Online Social Networks [22] also has a bulk amount of data which has a significant potential in the research field. And to understand this, extraction of the data is done and analysed to perform evaluation metrics and understand its potential.

Different challenges that occur through these analyses are summarized below:

- Maintaining the quality of the dataset and interpreting its output in different models
- Categorizing different subsets of mental health problems
- Diagnosis of mental health in line with time
- Pre-processing data accordingly
- Handling bulk data and generalizing it according to the requirement.

3.6 Conclusion

The research concludes according to the clinical heterogeneity of the sample of People's data with mental health issues is known to advance by implementing different applications of Machine Learning techniques which is a helping hand for researchers and psychiatrics in diagnosis of disease and its treatment. These techniques are used for

predicting various issues concerned to mental health disorder that gives significant solutions and further can be explored and studied. With time if emotional conditions get worsen and are not controlled then anxiety can increase every single day and may results in difficult situations which is very challenging to treat with [Saral,B., et.al,2019]. This conditions if become severe then it can harm our body to a large extend and results in degradation of the immune system which can further lead to various other heath related problems.

CHAPTER-4

BIPOLAR DISORDER: EARLY PREDICTION AND RISK ANALYSIS USING MACHINE LEARNING

4.1 Introduction

In today's society, mental illness has become a significant contributor to functional and social challenges in our daily lives. According to neuroscience, the brain plays a crucial role in generating mental stress, anxiety, and depression. Fluctuations in mood and chronic conditions within the brain can lead to various physiological disorders, including bipolar disorder. This mood disorder encompasses distinct stages, ranging from manic episodes to severe depression. Clinical and research data emphasize that delays in treatment contribute to elevated stress levels and episodes of mood swings, with potential complications such as cardiac arrest, brain stroke, heart attack, and deepening depression. This paper aims to assess mental states by employing feature selection, classification, and cross-validation techniques. To achieve this, the paper introduces a Machine Learning-based framework designed to identify bipolar disorder in its early stages, providing a computer-based predictive and diagnostic tool for mental and stress detection. Furthermore, the paper explores various transformations, such as the transition from depression to mania, from depression to bipolar disorder (BD), and from BD to hypomania. The objective is to pinpoint pre- bipolar depression. Employing machine learning algorithms like K-nearest neighbors, Naïve Bayes, Support Vector Machine, and Logistics Regression, the study analyzes risk factors and accuracy in obtaining output. Different algorithms are utilized to scrutinize risk factors and accuracy in detecting mental stages. Precision, accuracy, F1 score, and recall value analyses are performed on the dataset to predict the desired results.

Bipolar disorder stands out as a particularly perilous and life-threatening condition within the realm of psychiatry. Although significant strides have been made in the field of medical science, the arena of psychiatry still faces substantial challenges.

This paper concentrates on the identification of risk factors for prediction and early detection of bipolar disorder, emphasizing the crucial need for proactive intervention [Subhani, A.R., et al., 2017]. The progressive nature of bipolar disorder underscores the importance of early intervention strategies. Various models leveraging machine learning algorithms, operating on both test and train data, have been proposed to assess an individual's mental condition. Neuroimaging modalities, such as electroencephalography (EEG), are utilized to capture and analyze brain state and functional variations in response to mental stress [Mateo-Sotos, J., et al., 2020]. Through the assessment of stress, physiological features are extracted, and machine learning classification models are employed to predict quantitative differences between stress and control conditions, as well as different stress levels. Datasets encompassing diverse features and attributes related to the mental state of People are considered. Analysing the work of various researchers reveals that timely study and analysis of symptoms, in consultation with physicians, can provide proper guidance and treatment, preventing severe mental conditions such as brainstorms, anxiety, depression, and bipolar disorder from escalating to critical levels [O'Donovan, C., et al., 2020].

Globally, a significant number of people grapple with serious mood disorders. The classification, characterization, analysis, and modeling of these mood disorders hold paramount importance in clinical research. Selective features are applied to machine learning classifier models, including Logistic Regression (LR), Naïve Bayes (NB), Support Vector Machine (SVM), and K-Nearest Neighbor (K-NN). A computer-based mental arithmetic test is employed to assess stress levels in both stressed and controlled individuals [Subhani, A.R., et al., 2017].

4.1.1 Identifying Risk Factors Related to Bipolar Disorder Onset and Course

Identifying risk factors at early stages are an important key for treatment and need less interventions [Vieta, E., et.al., 2018]. Episodes of depression with psychotic symptoms and an early onset gives result which can inform about the effect of bipolar disorder in People. The combined interaction between prodromal symptoms and risk

factors can further result in bipolar disorder. Still the real mechanism of this remains unknown. There are three types of Risk factors affecting bipolar disorder People as shown in Figure 4.1., they are Environmental Risk Factors, Biological Risk factors and Prodromal Symptoms.

Detecting risk factors in the early stages is a crucial element for effective treatment and the potential reduction of interventions required [Vieta, E., et al., 2018]. Instances of depression accompanied by psychotic symptoms and an early onset can provide insights into the impact of bipolar disorder on individuals. The intricate interplay between prodromal symptoms and risk factors may contribute to the development of bipolar disorder, although the precise mechanism remains elusive. Figure 4.1. illustrates three categories of risk factors influencing individuals with bipolar disorder: Environmental Risk Factors, Biological Risk Factors, and Prodromal Symptoms.

4.1.1.1 Environmental Risk factors

Numerous environmental risk factors for bipolar disorder have been suggested, as outlined by [O'Donovan., et al. 2020]. These factors encompass life-threatening events, such as substance use (e.g., alcohol or cocaine), antidepressant use, and experiences of sexual abuse [Vieta, E., et al., 2018).

4.1.1.2 Biological Risk Factors

Biological risk factors, as identified by [Vieta, E., et.al, 2018], may involve a family history of bipolar disorder or other neurodevelopmental factors, such as delays in child development. Family history details play a significant role in understanding the major risk factors associated with bipolar disorder.

4.1.1.3 Prodromal Symptoms

Prodromal symptoms, falling under a heterogeneous category, exhibit mixed features like anxiety, mood lability, subjective sleep patterns, psychosis, and depressive symptoms. These symptoms serve as predictors of dimensional factors in bipolar

disorder, with the presence of subthreshold hypomanic symptoms being a crucial and common factor. Initial exploration involves identifying the clinical characteristics of People initially experiencing depressive episodes, later developing episodes of mania and hypomania [O'Donovan, C., et al., 2020]. Symptoms of this prodromal category can be heterogeneous i.e. this has mixed features of anxiety, mood lability, subjective sleep, psychosis and depressive symptoms as predictors of dimensional factors of bipolar disorder. The most important and common factor is the presence of hypomanic subthreshold symptoms. Initially we have gone through the identification of clinical characteristics of People having depressive episodes who subsequently develop episodes of Mania and Hypomania [O'Donovan, C., et al., 2020].

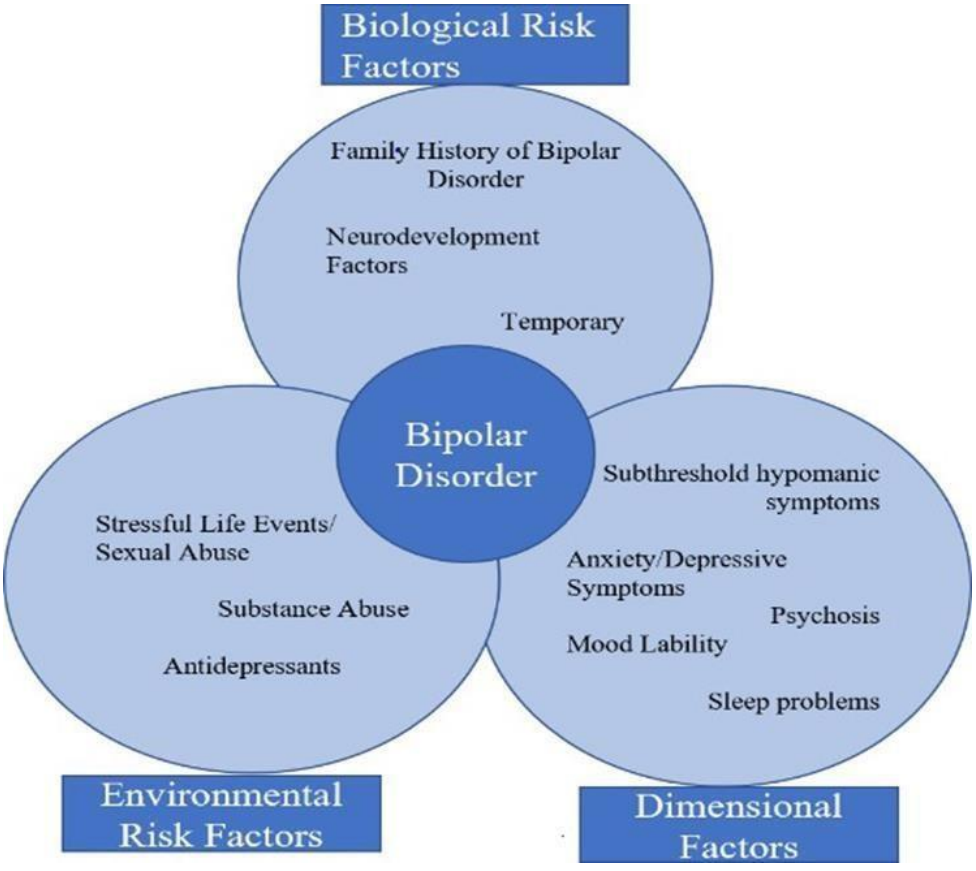

Figure 4.1. Risk factors affecting bipolar disorder People

The progression of these depressive episodes undergoes a series of stages, evolving as follows. The transition can occur through the following avenues:

4.1.1.4 Onset Polarity and interval from Initial depression to Mania

Onset Polarity and Time Interval from Initial Depression to Mania Individuals experiencing depressive episodes may progress into manic states. Their history indicates that hereditary traits can influence the polarity at onset, categorizing them into distinct types or subtypes of genetic bipolar disorder. This transformation is notably common among individuals with depressive tendencies [O'Donovan, C., et. al., 2020].

4.1.1.5 Conversion from Major Depression to Bipolar Disorder

Transition from Major Depression to Bipolar Disorder Major depression, a severe mental illness, is manageable with timely treatment [O'Donovan, C., et al., 2020]. Longitudinal observations of individuals with major depression reveal that over time, a significant number transition to BD-I and BD-II. Factors associated with the risk of conversion from depression to bipolar disorder include:

- Family history and details of bipolar disorder.
- Early onset polarities.
- Typical features related to the disorder.
- Psychomotor retardation.
- Functional impairment.
- Mixed features.
- Initial hypomanic symptoms.

4.1.1.6 Bipolar Depression in Absence of Hypomania

Numerous studies indicate that not all individuals experiencing bipolar depression necessarily manifest manic episodes [O'Donovan, C., et al., 2020]. Family history emerges as a crucial factor, signifying distinct types of depression. The clinical features play a key role in identifying pre-bipolar depression, highlighting a transformation preceding the confirmed diagnosis of Bipolar Disorder and Unipolar Depression [O'Donovan, C., et al., 2020]. Clinicians must ascertain whether individuals with depression symptoms exhibit signs of bipolar depression and, if so, anticipate the subsequent effects or outcomes of clinical management.

Early-stage assessment of the family history of bipolar disorder People is vital, revealing the interplay of environmental and biological factors in the context of genetic disorders [O'Donovan, C., et al., 2020]. Analysing the course of illness, including medication history, prolonged illness, and other relevant factors, is integral to the assessment. Clinicians face challenges in determining the onset and recurrence of depressive episodes, considering hormonal status and seasonality. The modification in illness over time demands meticulous attention throughout the entire duration using a specified methodology [O'Donovan, C., et al., 2020].

In cases where there is a family history of bipolar disorder or an early onset, assessing mixed symptoms becomes crucial. These mixed symptoms, encompassing both depressive and bipolar episodes, serve as valuable examples that researchers use to offer comprehensive guidance through the literature [O'Donovan, C., et al., 2020]. The study also delves into the pragmatic management of potential pre-bipolar depression. Recognizing the distinct treatment approaches for unipolar and bipolar disorders is essential, especially considering the possibility of simultaneous occurrences of bipolar disorder I & II, each responding differently to antidepressants [Agnihotri, N., et al., 2022].

Given that the existing data is extrapolated, specific guidelines for the bipolar disorder group remain elusive. Clinicians are urged to exercise vigilance in distinguishing between various categories of bipolar disorders [Agnihotri, N., et al., 2022].

4.1.2 Related Study

The review extensively explores existing literature on depression, bipolar disorder, and the utilization of machine learning algorithms for detecting and predicting associated risk factors with bipolar disorder. Its primary objective is to minimize the impact of anxiety disorders through early prediction, aiming to improve People health and well-being by reducing healthcare delays and medical costs.

Numerous studies have investigated the identification of bipolar disorder People using machine learning frameworks, incorporating features like EEG extraction, tenfold cross-validation, and classification. Noteworthy discoveries include a 94.6% accuracy in two-level stress prediction and an 83.4% accuracy in multiple-level prediction [Subhani, A.R, et al., 2017]. Recognizing bipolar disorder stages, facilitating early treatment, and conducting thorough analysis are crucial for preventing unfavorable outcomes [Rios, A. C., et al., 2015]. Identifying hypomania-related symptom patterns in the brain can assist in early risk prediction among the youth [de Oliveira, L. et al., 2015].

Certain studies highlight the effectiveness of machine learning models, particularly Extreme Gradient Boosting (XGB), in predicting bipolar disorder using EEG signals [Mateo-Sotos, J., et al., 2020], [Chen, M., et al., 2017]. Applying various Machine Learning models on People's data also helped in creating a prediction model of various symptoms [Leal, J., 2018]. Predictive models for depression and anxiety in aged People have been established using diverse machine learning techniques [Sau, A., et al., 2018]. Researchers have explored the integration of smartphone sensors to classify depressive and manic states, while others have investigated the significance of monitoring specific health features using machine learning [Grünerbl, A., et al., 2018] [Doryab, A., et al., 2018]. Mood charting models and daily analyses contribute to a comprehensive understanding of People health [Bauer, M., et al., 2018].

The literature underscores the potential of machine learning in mental health, spanning from predicting mood disorders to utilizing online tools for brain disorder solutions [Shrestha, A., et al., 2019], [Gupta, M., et al., 2020], [Islam, M. R., et al., 2018]. Studies on the impact of lockdown on students during the pandemic reveal a shift to online platforms for education and concerns about examinations, admissions, and internships [Mehta, M., et al., 2020]. Machine learning algorithms have been explored for predicting depression based on diverse parameters, including questionnaire data, social media posts, verbal communication, and face-to-face interactions [Mehta, M., et al., 2020].

The proposed work centers on evaluating the performance of various machine learning models on bipolar disorder datasets, with a focus on accuracy, recall, precision, and F1 score. Linear Regression emerges as the optimal predictor, while SVM, KNN, and Random Forest demonstrate effectiveness with minimal outliers in predicting bipolar disorder.

4.2 Materials and Methods

Data from individuals diagnosed with bipolar disorder and a group of mentally healthy individuals were collected, downloaded, and visually documented for the purpose of extracting meaningful information through intricate data and everyday prediction analysis, as indicated by [Vuppalapati, C., et al., 2020]. Each participant underwent both stress and control conditions on separate days with a one-week gap to mitigate the impact of learning on performance. Notably, half of the participants experienced stress conditions followed by control conditions, while the other half followed the opposite sequence.

For both stress and control conditions, participants were given specific rest times at the beginning, as well as habituation and recovery phases. This structured approach aimed to standardize the experimental conditions. The time taken to complete a test during the stress condition was observed to be shorter compared to the response time during the practice session, as reported by [Subhani, A. R., et al. in 2017]. Figure 4.2(a). and 4.2(b). illustrate the habituation, rest, and recovery times associated with mental stress and control conditions

Mental Stress Condition

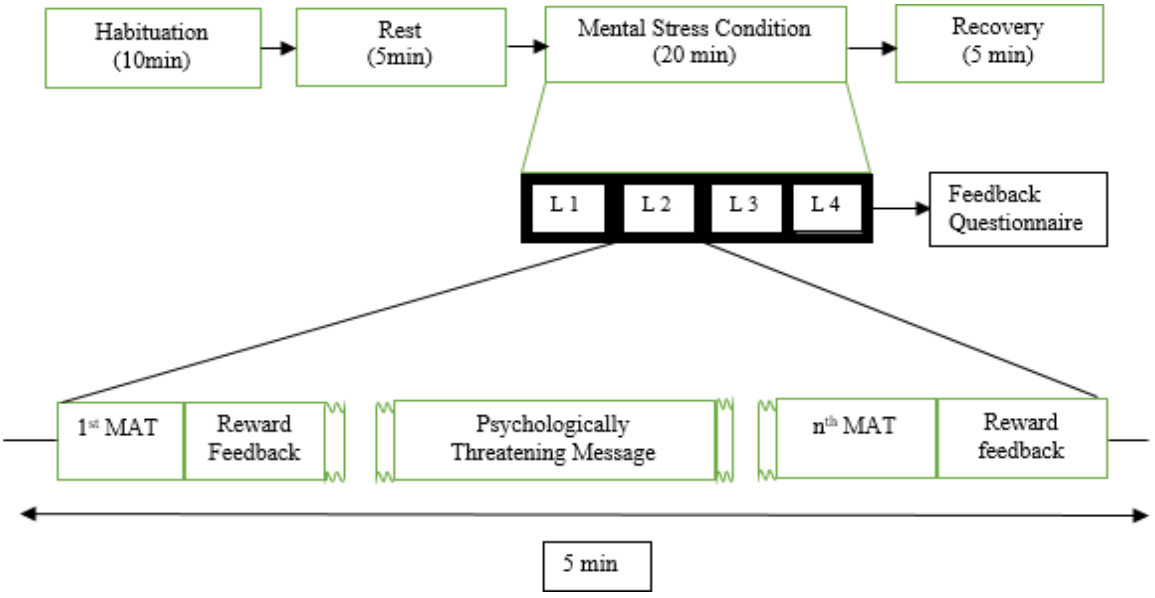

Figure 4.2(a). Phases of Mental stress condition of participants

Control Condition

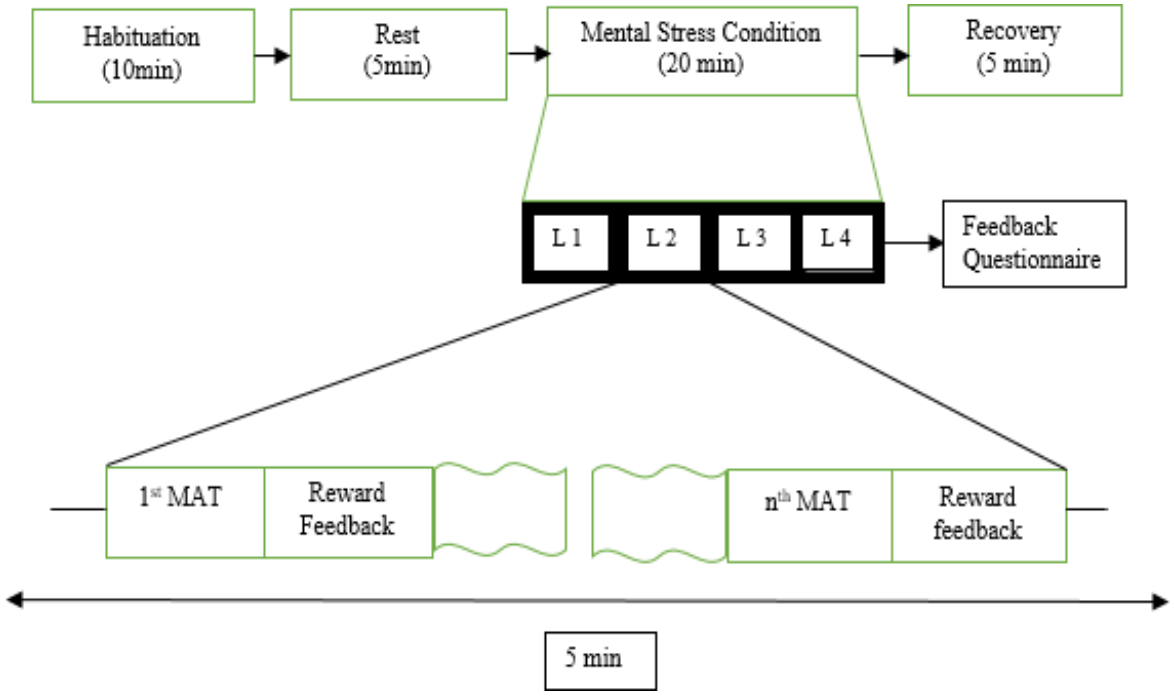

Figure 4.2(b). Phases of Control condition of participants

The methodology comprises four main stages: data acquisition, data pre-processing, feature extraction, and model classification, as illustrated in Figure 4.3. In this process, the readings of People with Bipolar Disorder I and II and Unipolar Disorder were analyzed using MiniPons. The results were then compared with data from healthy individuals without any mental disorders. Data pre-processing played a crucial role in studying the intricate states of the suffering People through nonverbal channels, allowing us to eliminate interference.

During the analysis, different features were examined based on the emotional valence of the People's stimuli across various channels. Following the pre-processing stage and the establishment of the database, Machine Learning algorithms were applied to study bipolar People.

4.2.1 Data Acquisition and Pre-processing

The dataset considered for analysis originates from the data source "Theory of Mind in Remitted Bipolar Disorder Participants." It comprises information gathered through questionnaires and surveys administered to People via MiniPons, a tool designed to assess interPeopleal accuracy for nonverbal dynamic signals. MiniPons is instrumental in precisely evaluating the meaning of nonverbal cues.

The dataset was organized based on a 2x2 design, combining affective valence and dominance, and categorized into video channels of three types and two audio channels. Stimuli were presented through a computer application, and participant responses were recorded. During recording, individuals selected the subject from two possible options [Espinós, U., et al., 2020].

The dataset is segmented according to the following factors:

- Group: Bipolar, Control, Depressive.
- Type: BD-I, BD-II, Control, Depressive.
- Right_Answer: Number of correct answers in the MiniPons assessment.
- Assessment scales: Audio_prosody, Combined_Channel, Face_video, Body_video, Positive_valence, Negative_valence, Dominant, Submissive.

Raw data collection involved retrieving historical information from both healthy and depressive individuals. Various applications have been developed for collecting People data [Vuppalapati, C., et al., 2020]. The data processed during the acquisition phase is presented in a readable format, as illustrated in Figure 4.3.

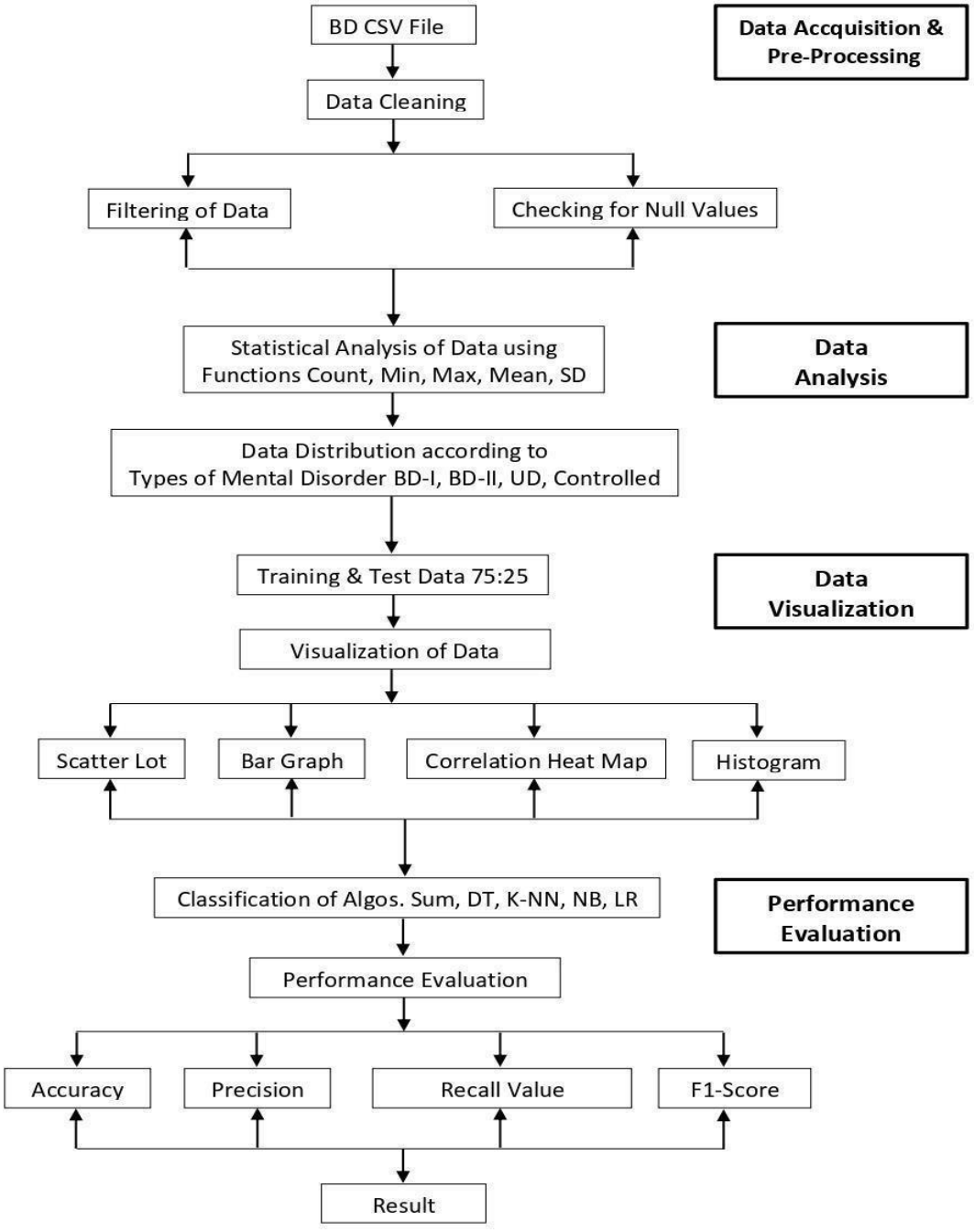

Figure 4.3. Proposed Machine Learning Framework for identifies

This is required to study various symptoms and behaviours of People as shown in Figure 4.3. This is done by following methods:

4.2.1.1 Data Cleaning

To eliminate irrelevant or unnecessary information in People' prescriptions that does not contribute to the diagnosis, a filtration process is implemented [Agnihotri, N., et al., 2022].

4.2.1.2 Data transformation

The raw data collected undergoes transformation to create a comprehensible dataset for implementation [Agnihotri, N., et al., 2022].

4.2.1.3 Checking for Null values

Verification is conducted to identify null or missing fields in the data. Table 4.1. of the study reveals the participation of 7 individuals, with 119 diagnosed with Bipolar Disorder (BD) (F=56, M=63). Among these, 70 were diagnosed with BD I (F=30, M=40, Mean age=44.50, SD=11.50), and 49 with BD II (F=23, M=26, Mean age=49.90, SD=11.50). Additionally, 39 euthymic People diagnosed with Unipolar Depression (UD) (F=33, M=6, Mean age=62.90, SD=9.71) and 119 healthy People (F=65, M=54, Mean age=46.10, SD=10.80) were included for data comparison. Notably, the occurrence of depression was twice as high in women compared to men in UD. The age of UD People was higher, as UD typically manifests a decade later than BD [Espinós, U., et.al., 2020]. The dataset was found to be devoid of null values.

4.2.2 Data Analysis

Data analysis is employed as an explanatory approach to summarize the main characteristics of datasets. Preliminary investigations of the data are performed to identify different behaviors, check the study hypotheses, and establish relationships

through descriptive and graphical analysis, incorporating both statistical and visual methods.

4.2.2.1 Training Data

The machine learning model is categorized into training and test datasets. The training dataset facilitates the creation of a model trained to execute various machine learning algorithms.

4.2.2.2 Testing Data

The test data evaluates the dataset's performance. The dataset, comprising 277 observations, is divided into a 75:25 ratio. Thus, 207 observations are allocated to the training dataset, and 70 observations form the test dataset for comprehensive analysis.

Table 4.1. Comparing UD and BD People according to the clinical conditions

	Bipolar Disorder I (n=70)	Bipolar Disorder II (n=49)	Uni-Polar Disorder (n=39)	ControlPeople (n=119)
Male [n(%)]	40(57.10%)	(Islam et al., 2018) (53.10%)	6(15.40%)	65(54.60%)
Female [n(%)]	30(42.90%)	23(46.90%)	33(84.60%)	54(45.40%)
Age	44.5≤age≤56.5	49.90≤age≤60.50	62.90≤age≤71.71	46.10≤age≤55.71
Onset age	20.23≤age≤24.13	(Islam et al.,2018).50≤age≤35.80	33.47≤age≤41.9	

4.2.3 Data Visualization

The visualization of data plays a crucial role in the application of machine learning models. Various methods, such as histograms, scatter plots, bar graphs, and

heat correlation matrices, can be employed for this purpose. These visualization techniques offer a comprehensive examination of the dataset across all specified parameters.

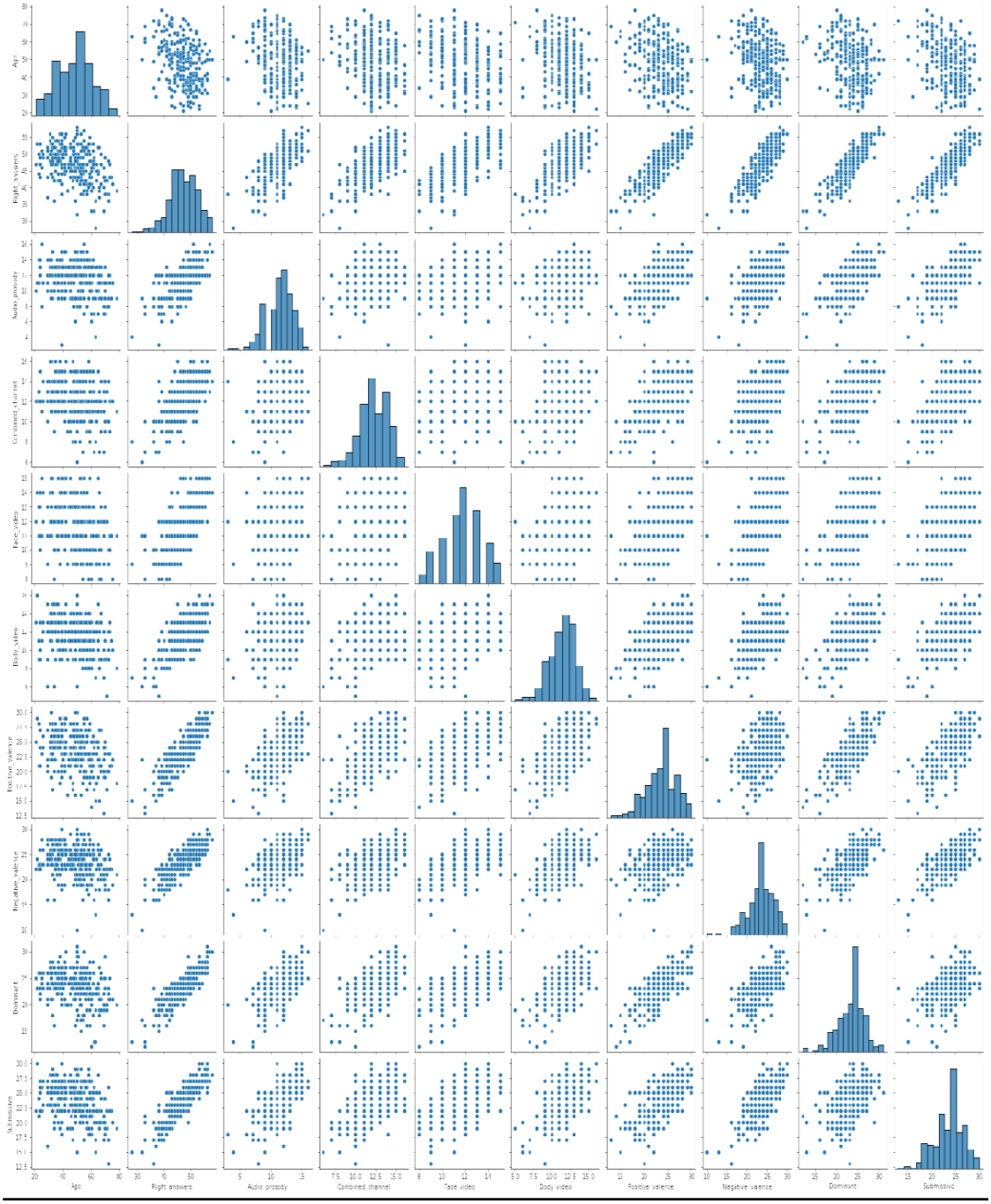

Figure 4.4. Data visualization through Scatter and Density Plot

Scatter Density Plots: A valuable tool for understanding the distribution of values within a dataset is the scatter and density plot. This method proves effective in analysing data characteristics and provides insights into the dataset's behaviour to a certain extent. In Figure 4.4., the behaviour of 11 different attributes has been explored by associating them with the type of disorder.

4.2.4 Classification of Algorithms

The implementation of machine learning algorithms in Python 3.6 involved the prediction of bipolar disorder severity levels. The dataset was divided into training (75%) and test (25%) sets. The subsequent sections outline the operational principles of each employed machine learning algorithm.

- **Logistic Regression(LR)**

LR, a two-fold regression model or Logit model, addresses binary dependency issues (e.g., pass/fail, win/loss). It is adept at handling scenarios where variables exhibit dependencies on more than two outcome categories, employing bulk deflation or systematic retrieval. Logistic Regression yields dual outcomes [Sun, et al., 2019].

- **Decision Tree (DT)**

The DT model constructs a decision tree that predicts attribute values. It iteratively forks in tree structures until a definitive decision is made for a given dataset. Decision trees are versatile models for grouping and regression methods, known for their expeditious and precise nature [Saylan, C., et al., 2016].

- **Support Vector Machine (SVM)**

SVM, a widely-used classification algorithm, segregates and classifies data by creating hyperplanes with maximum distances between categories. It excels in solving cases where points in space need to be categorized and segregated with a clear gap. Numerous models are considered within this space, categorized based on the specific criteria they meet [Rahman, R. A., et al., 2020].

- **K- nearest neighbors' algorithm(K-NN)**

K-NN is a straightforward classification and regression model. It determines the output based on the votes obtained from the nearest neighbors in the training dataset. For classification, the item is assigned the majority vote of its neighbors, and for regression, the output is the average of all values when k equals the nearest neighbor count.

- **Artificial Neural Networks(ANN)**

ANN structures mimic the information processing of biological brains. They are instrumental in problem-solving tasks like facial recognition. Input is fed from the input layer to each node in the hidden layer and subsequently to each node in the output layer. The selection of nodes and layers is crucial when applying neural networks to specific problems.

- **Naïve Bayes(NB)**

Naïve Bayes is a straightforward process used for constructing classifier models that assign class labels in problematic situations. It assumes independence between the values of different factors, given the class flexibility. Although not a singular algorithm, Naïve Bayes encompasses a group of algorithms based on the same principle (NB).

4.2.5 Performance Evaluation Matrices

Once the algorithms are applied, it is important to validate and undergo performance evaluation to finally conclude which model is the best. Performance evaluation is done by calculating recall, precision, F1- score, and accuracy for each model and the model with highest value fits the best [Mateo-Setos, J., et al., 2020].

For performance evaluations, there can be four types of outcomes for the test data i.e. true positives, true negatives, false positives, false negatives.

4.2.5.1 Accuracy

Accuracy is computed by assessing the percentage of correct predictions

made in relation to all predictions for the test data.

$$Accuracy = \frac{No.of\ correct\ predictions\ in\ test\ data}{No.of\ predictions\ in\ test\ data}$$

4.2.5.2 Precision

Precision value identifies the number of relevant data points from the test data. It indicates the number of true positive predictions made out of the sum of true and false positives.

$$Precision = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

4.2.5.3 Recall

Recall value give the percentage of correctly identified true positives. It is calculated by considering no of true positives divided by sum of true positives and false negatives.

$$\text{Recall} = \frac{True\ Positives}{True\ Positives + False\ Negatives}$$

4.2.5.4 F1- Score

The F1 score is derived from the harmonic mean of precision and recall, providing a consolidated metric for evaluating model performance.

4.2.5.5 Area Under ROC(AUROC)

AUROC aids in distinguishing between classes, with a higher AUROC value indicating improved classification between positive and negative classes [Mateo-Sotos, J., et al., 2020].

4.2.5.6 Matthews Correlation Coefficient(MCC)

MCC is utilized for assessing the quality of binary and multiclass classification, offering insights into the disparities between predicted and actual values [Mateo-Sotos, J., et al., 2020].

4.2.5.7 Cohen's Kappa

Cohen's Kappa values are employed to determine the level of agreement between two raters assessing the same predictions. This method requires the assumption that each rater rates at least one trial from every considered sample [Mateo-Sotos, J., et.al., 2020].

4.2.6 Model validation

To validate the models, the technique used is K-Fold cross-validation, the whole dataset is partitioned into K parts of equal size. Each partition is called a "Fold" as shown in figure 4.5. So as we have K parts we call it K-Folds. One Fold is used as a validation set and the remaining K-1 folds are used as the training set. The technique is repeated K times until each fold is used as a validation set and the remaining folds as the training set. The final accuracy of the model is computed by taking the mean accuracy of the k-models validation data as shown in Table 4.2. and Table 4.3.

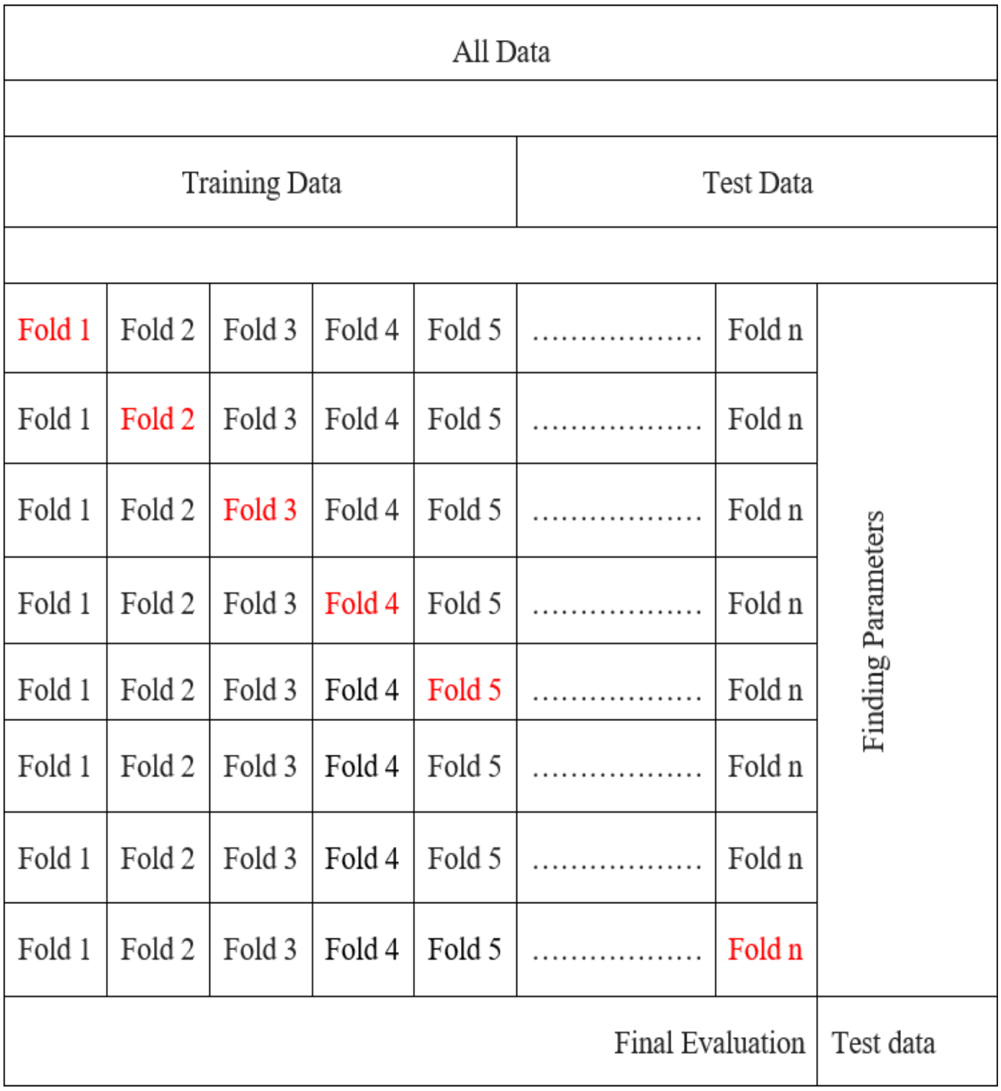

Figure 4.5. K Fold Cross Validation

Table 4.2. The K-Cross validation for Different Models for K=5,10,15,20

Models	Score before applying K-fold	Score after K Cross fold validation			
		CV=5	CV=10	CV=15	CV=20
Logistic Regression	**0.9781**	**0.9592**	**0.9259**	**0.9398**	**0.9776**
SVC	**0.4111**	**0.3129**	**0.4819**	**0.5224**	**0.5385**

Random Forest	**0.9611**	**0.9722**	**0.9415**	**0.9543**	**0.9648**
K-NN	**0.9257**	**0.0390**	**0.0290**	**0.0318**	**0.3231**
Linear Regression	**0.9567**	**0.9193**	**0.9456**	**0.9457**	**0.9458**

Table 4.3. Parameter tuning for K Cross Validation for RF

Estimators	CV=15	CV=10	CV=20
5	**0.9036**	**0.8809**	**0.9036**
20	**0.9570**	**0.9393**	**0.9570**
30	**0.9609**	**0.9399**	**0.9609**
40	**0.9626**	**0.9404**	**0.9626**

4.3 Result

It seems like you've provided an overview of a section discussing the results obtained through MiniPons records for the classification of bipolar disorder. We compared various machine learning algorithms, such as K-nearest neighbors, random forest, linear regression, and support vector machine, based on different aspects.

Linear regression is highlighted as the best-suited model according to the results obtained. We also mentioned that you studied the models by calculating balanced precision, recall, F1-score, and accuracy for People with bipolar disorder, unipolar disorder, and controlled People.

Table 4.4. Table representing Precision, Accuracy, Recall and F1 Score calculated through mean and standard deviation of these models for the proposed machine learning algorithm.

Methods	Precision	Accuracy	Recall	F1-Score
Support Vector Machines	83,54±0.76	84,49±0.81	83,98±0.36	84,65±0.48

K-nearest neighbors	84,65±0.43	84,09±0.28	84,76±0.56	83,45±0.39
Random Forest	88,35±0.45	88,98±0.34	87,99±0.87	88,89±0.87
Logistic Regression	97,37±0.46	97,65±0.34	97,87±0.65	97,67±87

It appears that the analysis in Table 4.4. compares the performance of different machine learning models for classifying People with Bipolar Disorder, specifically focusing on Support Vector Machines (SVM), K-nearest neighbors (KNN), Random Forest, and Linear Regression.

Here's a summary of the findings:

1. Support Vector Machines and K-nearest Neighbors:

These models resulted in lower classification values, around 84%. This suggests that SVM and KNN may not be as effective for this particular classification task compared to other methods.

2. Random Forest:

Random Forest yielded moderate classification values, approximately 89%. While it performed better than SVM and KNN, it seems to be outperformed by other methods.

3. Linear Regression:

Linear Regression emerged as the most successful model, achieving an accuracy of up to 97%. This is the highest accuracy among the models considered, indicating that Linear Regression is particularly well-suited for classifying People with Bipolar Disorder in this context.

4. Precision, Recall, and F1 Scores:

The Linear Regression model consistently outperformed other models in terms of precision, recall, and F1 scores, all around 97%. These metrics are important for

evaluating the model's ability to correctly identify true positive cases while minimizing false positives and false negatives.

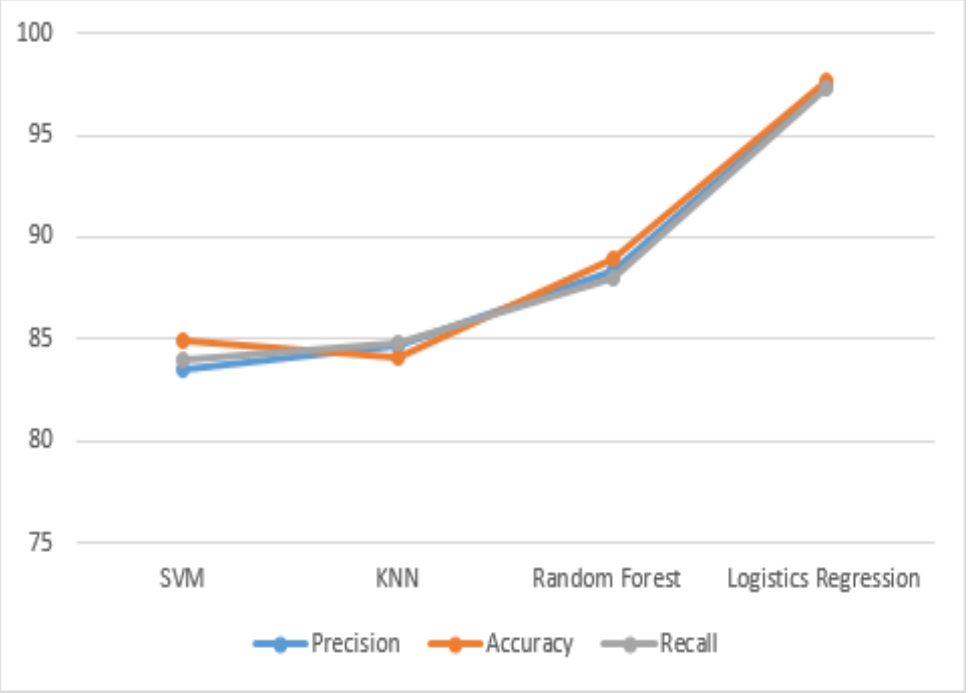

Figure 4.6. Graphical Representation of Precision, Accuracy and Recall for all the models.

For better understanding and analyses, the dataset was studied through various other parameters as well such as Area Under ROC, MCC and Cohen's kappa Method to verify whether Linear regression model is the best suited model or not in Table 4.5. These methods analyse the better functioning of all the models while classifying them into two different classes.

Table 4.5. The Area Under ROC, MCC and Cohen's Kappa Method calculation through mean and standard deviation method for all the models.

Methods	AUROC	MCC	Cohen's Kappa
SVM	84,45±0.23	84,29±0.67	84,18±0.12
K-NN	84,75±0.45	85,18±0.21	83,69±0.87

Random Forest	91,75±0.34	91,38±0.87	91,55±0.16
Logistic Regression	96,88±0.41	96,19±0.84	96,67±0.25

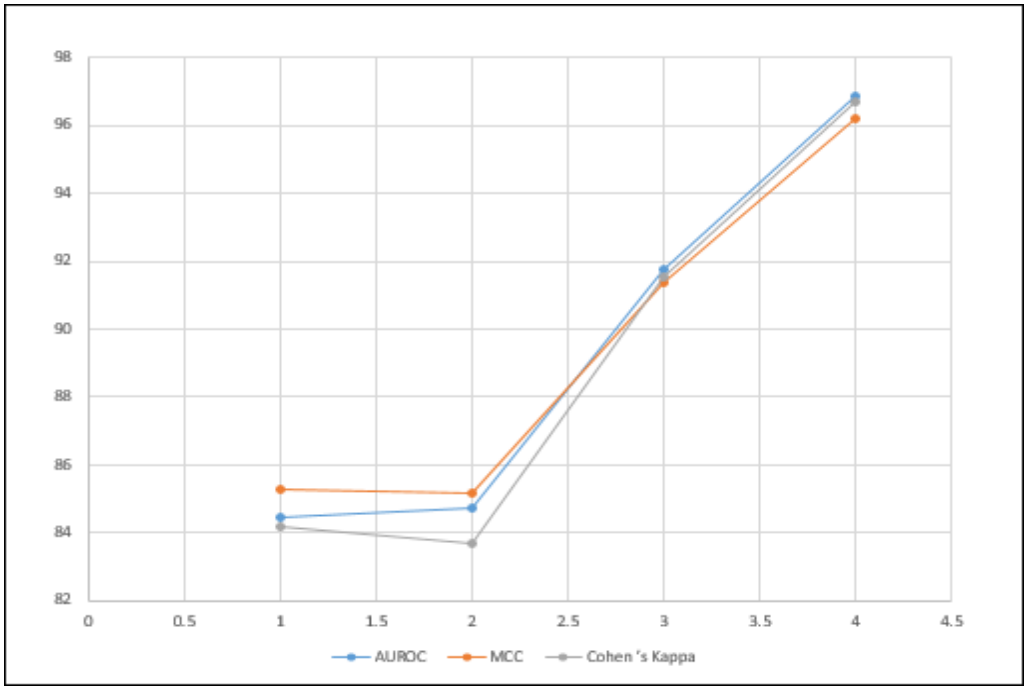

Figure 4.7. Graphical Representation of Area Under ROC, MCC and Cohen's Kappa method for all the models

Upon evaluating our machine learning models using various parameters, the Matthews correlation coefficient (MCC) emerged as the most accurate predictor. The MCC values indicate superior performance, especially when considering true and false positives, as well as true and false negatives in the confusion matrix.

In the MCC analysis, the linear regression model stood out with an impressive value nearing 96%, while the random forest model demonstrated a moderate value around 91%. On the other hand, SVM and KNN models yielded lower results, approximately 85%.

Figure 4.6., presents a graphical comparison of the linear regression model with other models, focusing on precision, recall, and accuracy values. Additionally, Figure 4.7., explores the values of the linear regression model against others using MCC, Cohen's Kappa method, and Area Under ROC.

The results suggest that the linear regression model excels in classifying Bipolar disorder values. These findings hold significant implications for medical clinicians, enabling them to predict the early risk of bipolar disorder in their practice.

4.4 Discussion

Predicting Bipolar Disorder or any other mental disorder is a very challenging task as their diagnosis in itself is very difficult. But this selected model can help the clinicians for better study and understanding about People's health. Our selected model Linear Regression has shown the best accuracy for distinguishing between People suffering from bipolar disorder and controlled People through MiniPons data with a maximum accuracy around 97 % as compared to other models. The comparison of the Linear regression model with the other models such as SVM, KNN and Random Forest proved us that linear regression model can perform well with even higher dimensions of data even through avoiding any sort of over training.

The proposed systems will help to give a deep insight to the clinicians and technicians for future related studies and proves to will work as an aid in the prediction of bipolar disorder. In the future work further research can be done to implement deep learning modals to study each and every activities and day to day changes in People. This includes face recognition and different feature selection algorithms.

4.5 Conclusion

Our study concludes that the proposed Linear Regression model offers a robust approach to understanding the behaviour of People with bipolar disorder compared to controlled People. Through a comprehensive comparison with SVM, KNN, and Random Forest models, Linear Regression consistently demonstrated superior accuracy, recall, and precision. This model holds promise for automatic analysis in bipolar disorder diagnosis, contributing to informed decision-making for clinicians and technicians in the field.

CHAPTER-5

IMPLEMENTING MACHINE LEARNING TECHNIQUES TO PREDICT BIPOLAR DISORDER

5.1 Introduction

Bipolar Disorder is a mental illness which is understood by alternate mood changes between different categories is very common these days. The classification, modelling and characterization and diagnosis of these mental disorders is important in medical research. An unexpected and unexplored area in Bipolar Disorder is to judge the nonverbal behaviour of People accurately. This paper used dataset from MiniPons to test the nonverbal behaviours like various facial expressions, voice recordings and body gestures of mentally ill as well as healthy People in a whole spectrum. Machine Learning models can potentially provide new horizons in diagnosing and treating with brain disorder care. The research aims to present commonly used algorithms like Logistic Regression, Support Vector Machine, Decision Trees, and K-nearest neighbours etc. and give a brief about their different features which can provide guidance to the clinicians. Records of people suffering from bipolar disorder, Unipolar and controlled People are downloaded as well as recorded visually to extract and identify meaningful information and information through the data by everyday data analysis of People. This research shows that people with controlled state behaves significantly different as compared to Bipolar Disorder People in their InterPeopleal Accuracy(IPA). This develops a new training program to improve better understanding and psychosocial functionality in their rehabilitation.

Bipolar disorder, a complex brain disorders is prevailing across the world and is has impacted people all over the world. The disorder is alternate oscillations caused by People's mood swings between mania and depression states. These mood swings are due to different physical and psychological features. These set of behavioural changes, varying mood swings and psycholinguistic features are used for feedback analysis of People. Mental illness like depression, Anxiety, stress, restlessness, aggression and other mood related

changes can affect and disturb any one in some situations, events or circumstances. This all collectively results in mental disorder which Physical and emotional changes.

As stated by World Health Organization (WHO), an individual possessing a healthy mind along with physical fitness is considered as a healthy human being. Modifications in mental health are a natural thing that tend to occur with increasing age. Many People with bipolar disorder suffers from an everyday or every week mood swings [Sau, A., et.al 2017]. This mood instability impairs daily functioning over time and increases the risk for relapse or its recurrence, thus indicating that the illness is still active. Growth in big data analysis in medical and health care sectors, the data analysis of medical data helps in providing an early detection of illness, its diagnosis different community services. Machine Learning algorithms have resulted in different mood swing states like emotional state, sad moments, facial expression and audio-based analysis. [Chen, M., et.al,2017]. Numerous healthcare technologies help physicians to monitor behaviour and provide an efficient guide for selecting the Machine Learning algorithms. These algorithms aid to visualize the required information from complex database to predict and optimize the routine development of People's health and wellbeing [Islam, M. R., et.al, 2018], BD is a brain disorder caused due to mood swing between two states Mania and Depression and each of these states are considered differently. People even being treated are having symptoms brain disorder. They are of various categories, Mental disorder be stated as bellow and specifically bipolar disorder.

- Bipolar Disorder-I(BD-I): This type of disorder has symptoms of two states with mood swings between Mania and Depressions on periodical intervals.
- Bipolar Disorder II(BD-II): In this type hypomania episodes are tending to occur at milder rate alongside severe depressive outbreaks on alternate periods.
- Cyclothymic disorder: This disorder has small period of hypomanic and depressive symptoms which are not for long time. But if this is not treated on time then it will lead to severe mental disorder. This type has mixed symptoms of all Mania, Depression and hypomania along with high levels of energy, racing thoughts and sleepless nights. In this People feel like committing suicide, helpless, quite irritated and depressed.

- Rapid Cycling: In this during the course of 12- months the sufferer experience all types of mood swings with high and low polarities.2018).

5.2 Literature Review

The related literature provides a brief and precise background of literature and also machine learning algorithms for analysing symptoms of disorder, the review of various literature aims to deduce any chance of anxiety by an early detection, to give a direction in improving the mental life of such People by reducing the delay in health care and also by reducing the cost. The literature review has following steps

- In the initial step, a total of 125 papers have been reviewed, associated with health concerns and applying machine learning applications to resolve these health issues by different publishers such as research gate, IEEE, springer, etc. With this a total of 25 articles more are studied from various other sources. From the total papers, 36 papers were related to issues regarding mental illness and brain disorders and by going through their titles and abstract were studied.

- In next step, out of the total articles around 12 articles were found which are related directly in prediction of disorder were studied thoroughly by reading their full text and are also summarized by brief explanation below. This is done for extra text related studied and for referencing some facts and figures.

- The final stage, was associated in proofreading of the incorporated studies which have utilised vital information, performed thorough data analysis methods, various other detection and prediction techniques used for these analysis and the summary and conclusions made.

The related studies states that researchers attempt to find out People suffering from Bipolar Disorder. [Chen, M., et.al,2017] has discussed different machine learning techniques of Structured and Unstructured data with respect to right proportioning of data. They have achieved a 94.8% faster speed to considering the possibility of occurrence of

the disease in report format. [Junestrand Leal A., 2018] applied Various Machine Learning models on People's data which add to create prediction model of different symptoms. [Sau, A., et.al 2017], [Martínez, A., et.al, 2018], they developed a prediction model to detect Using machine learning techniques, researchers may examine the clinical and demographic characteristics of older adults with depression and anxiety. [Grunerbl, A., et.al, 2015] and [Nicholas, J., et.al, 2015] They uses smartphone to classify the two state depressive state and manic states using an integrated sensors technology. [Doryab, A., et.al, 2014] To monitor and investigate the importance of highest feature in mental health using Machine Learning applications for ranking symptoms of Bipolar Disorder. (Bauer, M., et.al, 2006) developed a chart based on People's mood by monitoring People behaviour on everyday basis. [Faurholt-Jepsen, M., et.al, 2018] The correlation between the mental health symptoms gathered from smartphones and the recommendation that daily logs of social and physical activities be kept for a specific amount of time is made. [Kumar, A., et al., 2019] created an AD model that used real-time tweets to predict a depressed condition. In order to reduce human intervention in data gathering and labelling, [Liu, D., et al., 2021] proposed an approach to assess machine learning techniques.

[Muhammad, A., et.al, 2020], he gave a review of the literature by utilising machine learning techniques to identify anxiety in individuals in order to support their care and early prognoses. In [Islam, M., et al., 2018], he presented a machine learning model that uses online resources like Facebook, Twitter, and others to provide high-quality treatments for brain disorders. In [Shatte, A., et al., 2019], he concentrated on the use of machine learning to psychology and mental health disorders, as well as a range of mental health issues. [Lee, H., 2019] presented findings regarding the use of neuroimaging technology in children's clinical assessments employing qualitative estimation of a review of the literature by utilising machine learning techniques to identify anxiety in individuals in order to support their care and early prognoses. In [Islam, M., et al., 2018], He introduced a machine learning model that offers top-notch treatments for brain illnesses using internet resources like Facebook, Twitter, and others. He focused on the use of machine learning to psychology, mental health illnesses, and a variety of mental health concerns in [Shatte, A., et al., 2019]. Researchers [Lee, H., 2019] reported findings on the application of neuroimaging technology in paediatric clinical assessments using qualitative estimation of Students utilise online platforms such as online teaching learning, webinars, internships,

and many more to manage their studies and other activities. All of this is made feasible by the faith that things will return to normal eventually.

[Priya, A., et.al, 2020 examining several factors that influence the prognosis of depression by gathering data via questionnaires, social media posts, verbal exchanges, and in-People interactions. In 2019 [G, B., et al.] The algorithms are shown here They are frequently employed; their characteristics and functions always serve as a reference when choosing the best model for the diagnosis. In machine learning, the People's discomfort over disclosing their issues and the psychiatrists' crucial flaws in the therapy serve as a platform or bridge. [Shrestha, A., et.al, 2019] The project focuses on a text analysis tool that uses a camera and sensor to allow users to self-test scales on smart devices to identify depression and anxiety. In [Kiranashree, B., et al., 2021], he used a machine learning model to analyse the stress patterns of adults who were employed and under stress in order to identify the variables that affect stress levels. [Vikhrov, I., et al., 2021] developed an in-People system that focuses on providing emotional support for a specific individual dealing with mental illness utilising cutting-edge AI technology and a variety of machine learning techniques. [Kouris, I.N., et al., 2021] developed an algorithm to categorise and analyse the many types of mental health disorders.

5.3 Methodology

The research focuses on diagnosing BD and its various classifications using Machine Learning Techniques. BD has effected millions of people these days which is characterized by People’s mood swings occurrence. ML techniques provide new directions for learning human behaviours, patterns and mental health symptoms to reduce risk factors to develop prediction model for optimizing and Peoplealizing therapies. The Machine Learning techniques help to fulfil the gap between the People and clinicians and provide possibilities to reveal them in a better way. This includes the following: -

5.3.1 Research Framework

- This focused on diagnosing mental illness and its type using Machine Learning algorithms for which the identifying and selecting features from MiniPons to examine People's behaviour and potential to cope with complex stages through perception of nonverbal channels.
- The data from the dataset taken into consideration was studied according to categories of bipolar disorder such as Uni-polar(UN), Bipolar Disorder –I & II. Through the investigation and questions asked to the People collected using Minipons, based on recognition of interPeopleal and dynamic nonverbal signals accuracy.
- Data is recorded from participants and downloaded as well as recorded visually to gather meaningful data and information from various datasets on everyday basis. This paper aims to present commonly used algorithms such as K-nearest neighbours, logistic regression, random forest, support vector machine, etc.

The different models of machine learning undergo through the following data processing steps which includes planning and background Analysis, Data Acquisition, Data Analysis, Implementing Data Mining process and Performance Analysis.

Planning and Background Analysis: In this step, a lot of knowledge, attributes and symptoms are gathered about the People and analysed to classify the type and seriousness of disorder. As some of the disorders can be examined and cured at very early stage. These attributes can be used as predictors for predicting the disorder [Sau, A., et.al, 2017].

Acquisition of Data: The collection of People's history for both healthy and depressive People. This data can be collected from different sources like Online surveys, questionnaires and many different social media sites like Facebook, Twitter, WhatsApp. Many Apps are also developed to gather People's data [Islam, M., et.al, 2018].

Data Pre-processing or Data Analysis: From the acquisition phase a lot of data has been collected and processed in readable format. This is required to study various symptoms and behaviours of People. This is done by two methods:

- Cleaning of Data: This step is performed to deduce any unnecessary or unwanted data in People's prescription which is of no use in diagnose is filtered.
- Data Transformation: The raw data from the datasets is collected and transformed in such a format which is understandable for further implications.

Implementation and Data Mining Process: This phase analyses the dataset by examine classification algorithms to predict mental health disorder and its type at early stage. For this various ML Techniques are applied like Decision Trees (DT), Support Vector Mechanism(SVM), Logistics Regression (LR), K-Nearest Neighbors (KNN), etc. The Algorithms are compared on the measure of performance and accuracy to detect Mental disorder.

Performance Evaluation: A prediction Model is built to measure the positive predictions in Data Mining to help and identify those who are in need. This is constructed to classify major and minor disorder by studying different psycholinguistic features of People.

5.3.2 Characteristics of Participants

Both healthy and bipolar disorder People are participants of the research and their responses are used for pre-processing of data to filter out the unwanted data as shown in figure 5.1.

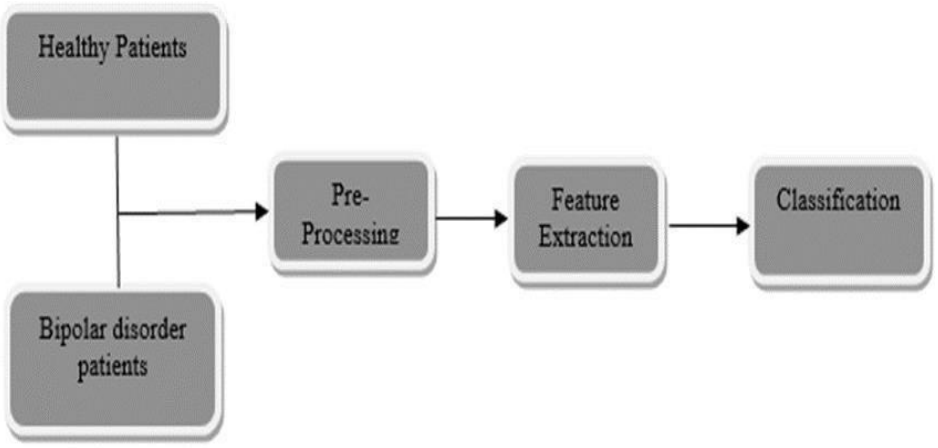

Figure 5.1. Steps of proposed system to detect People with bipolar disorders

5.3.2.1 Data Acquisition

based on surveys and questionnaires given to the participants that MiniPONS collected; the accuracy of the system was determined by identifying nonverbal cues. The following data variable is represented by the dataset under consideration:

Type: BD I, BD II, Control, Depressive; Group: Bipolar, Control, Depressive. Right_answers: The quantity of correct responses to the Mini PONS evaluation; Assessment scales: Dominant, Submissive, Face, Body, Combined channel, Positive, Negative, and Audio prosody.

The data was administered and responses were recorded with the aid of a computer programme that represented stimuli. People were prompted to choose the subject from the two alternatives while recording their response.

5.3.2.2 Data Planning and Pre-Processing of Data

Among the participants in this investigation, as shown in Table 5.1., 119 had a diagnosis of BD (F=56, M=63). F=30, M=40, Mean age=44.50, SD=11.50) and 49 out of 119 were diagnosed with BD II (F=23, M=26, Mean age= 49.90, SD = 11.50) respectively out of the 119 total. In UD, women were reported to experience depression twice as frequently as males. Given that UD often manifests ten years after BD, UD People tended to be older than BD People.

Table 5.1. Comparing Unipolar Disorder and Bipolar Disorder People.

	Bipolar Disorder I (n=70)	Bipolar Disorder II (n=49)	Uni-Polar Disorder (n=39)	Control People (n=119)
Male [n(%)]	40(57.10%)	26(53.10%)	6(15.40%)	65(54.60%)
Female [n(%)]	30(42.90%)	23(46.90%)	33(84.60%)	54(45.40%)
Age	44.5≤age≤56.5	49.90≤age≤60.50	62.90≤age≤71.71	46.10≤age≤55.71
Onset age	20.23≤age≤24.13	26.50≤age≤35.80	33.47≤age≤41.9	

5.3.2.3 Descriptive Statistics

To analyse data is an explanatory approach towards feature oriented characteristic study of information. The crucial step of undergoing through proof reading of data present to understand different behaviours which can testify the assumptions and hypothesis to monitor and made through descriptive statistical and graphical mode i.e. with statistical and visual methods. The various attributes of dataset are statistically analysed.

5.3.2.4 Visualization of Data

Data visualization are important tools for identifying a qualitative understanding of dataset which helps in exploring the data and extract important information or to identify patterns, outliners or corrupt data. In python various libraries come with lots of different features that enables users to make customised, elegant and interactive plots [Agnihotri, N., et.al,2021]. In this we have used Matplotlib for easy visualization of data. The datasets has different types of techniques used in visualisation:

- Histogram: A histogram visualizes the data distribution over a continuous interval or certain period of time. The histogram plot is used to describe the

distribution of data in a dataset and it depends on the bins or attributes chosen for x and y having the co-ordinates which has the classified data. This isn't the best representation of data because the whole data is not plotted in each histogram and we need to have no of plots as in Figure 5.2(a). Histograms are pictorially representing data about age and right answers, similarly Figure 5.2(b). shows histograms analysing the attributes combined channel and face video, Positive and Negative valence are analysed in Figure 5.2(c)., Audio prosody and Body video are analysed in Figure 5.2(d). and, Submissive and dominant attribute is analysed in Figure 5.2(e).

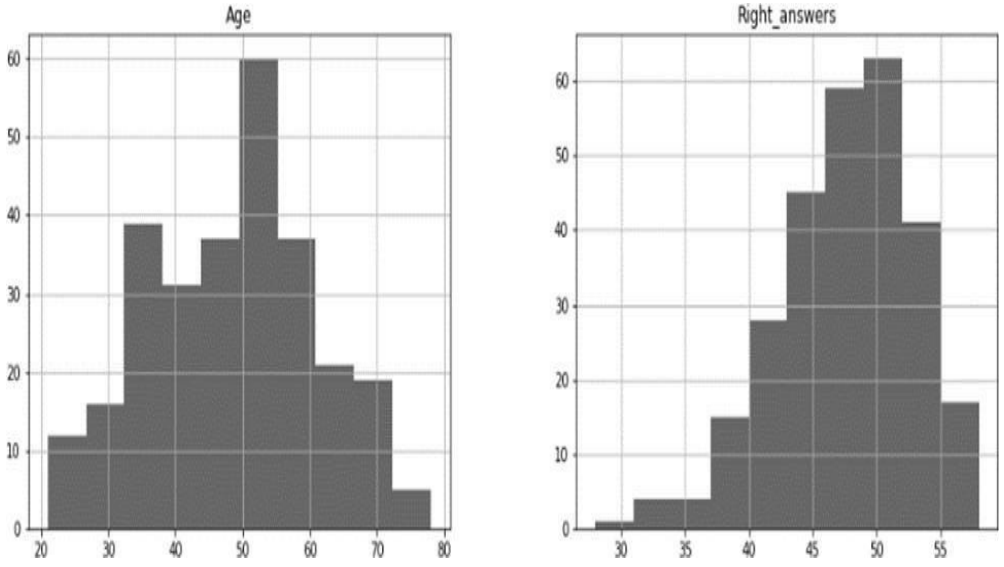

Figure 5.2(a). Histograms of Age and Right Answers

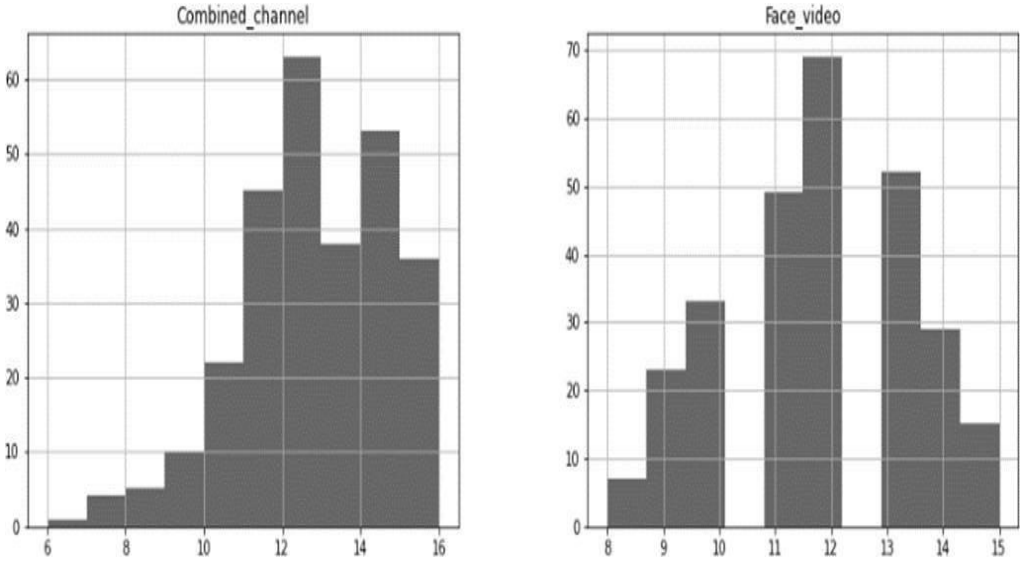

Figure 5.2(b). Histograms of Combined Channel and Face Video

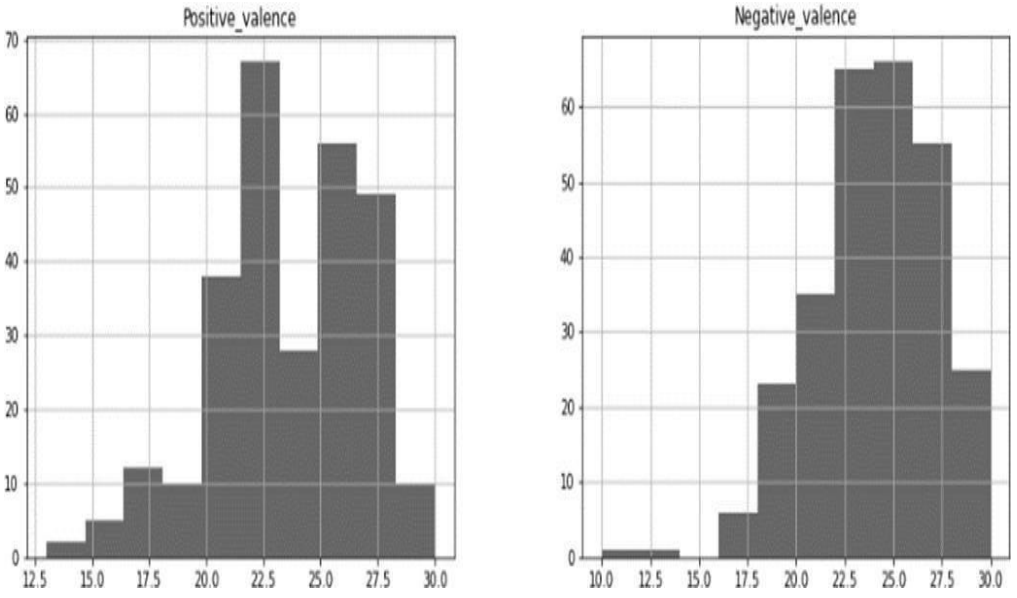

Figure 5.2(c). Histograms of Positive Valence and Negative Valence

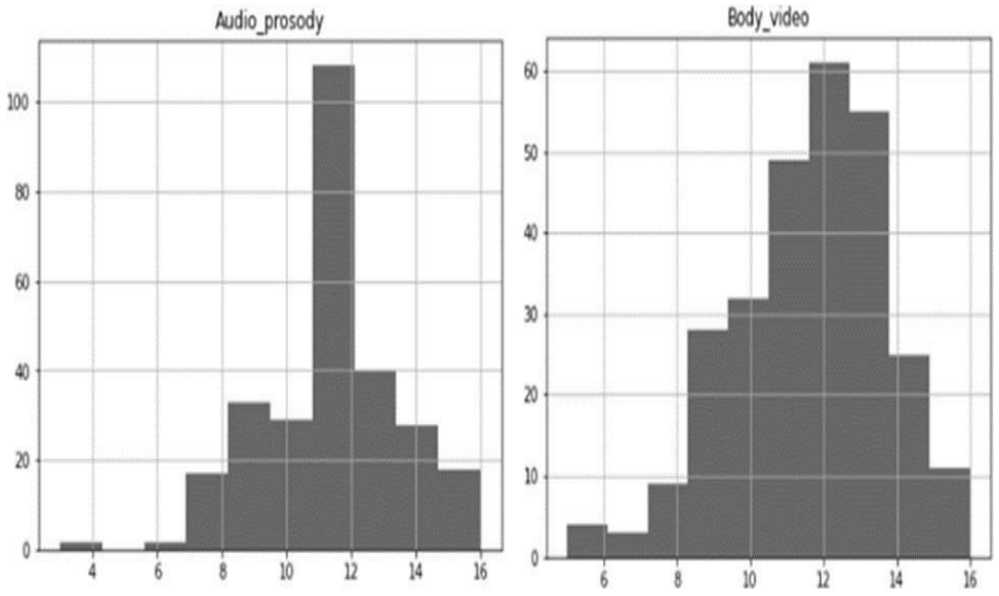

Figure 5.2(d). Histograms of Audio Prosody and Body Video

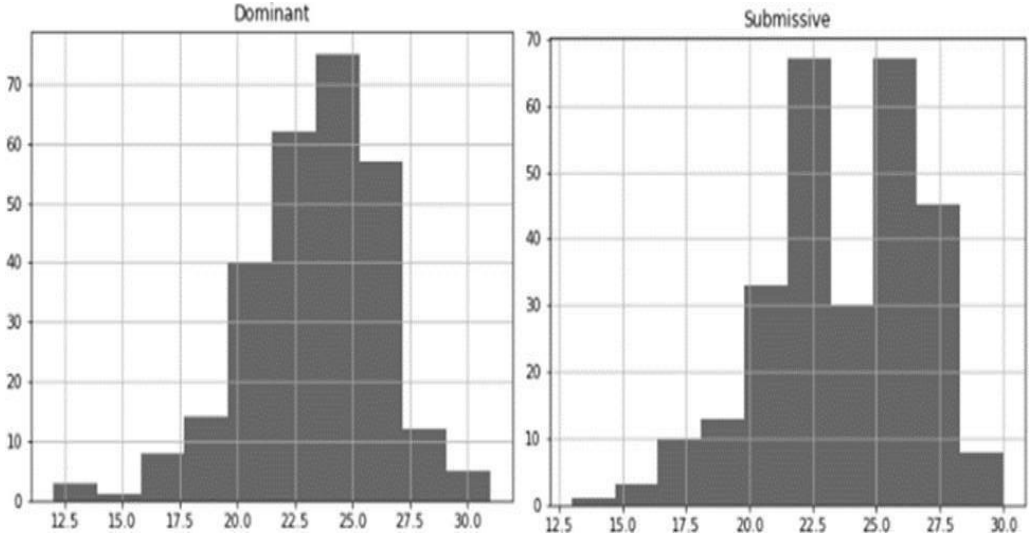

Figure 5.2(e). Histograms of Dominant and Submissive

- Heat maps: A heat map is a data visualization tool where individual values contained in a matrix through variations in colouring. The heat map shows how the datasets can be correlated. The colour scale is used to represent a higher or

lower correlation among the features of dataset. In the heat map, we have used Correlation heat map using matplot library in python shown as in Figure 5.3.

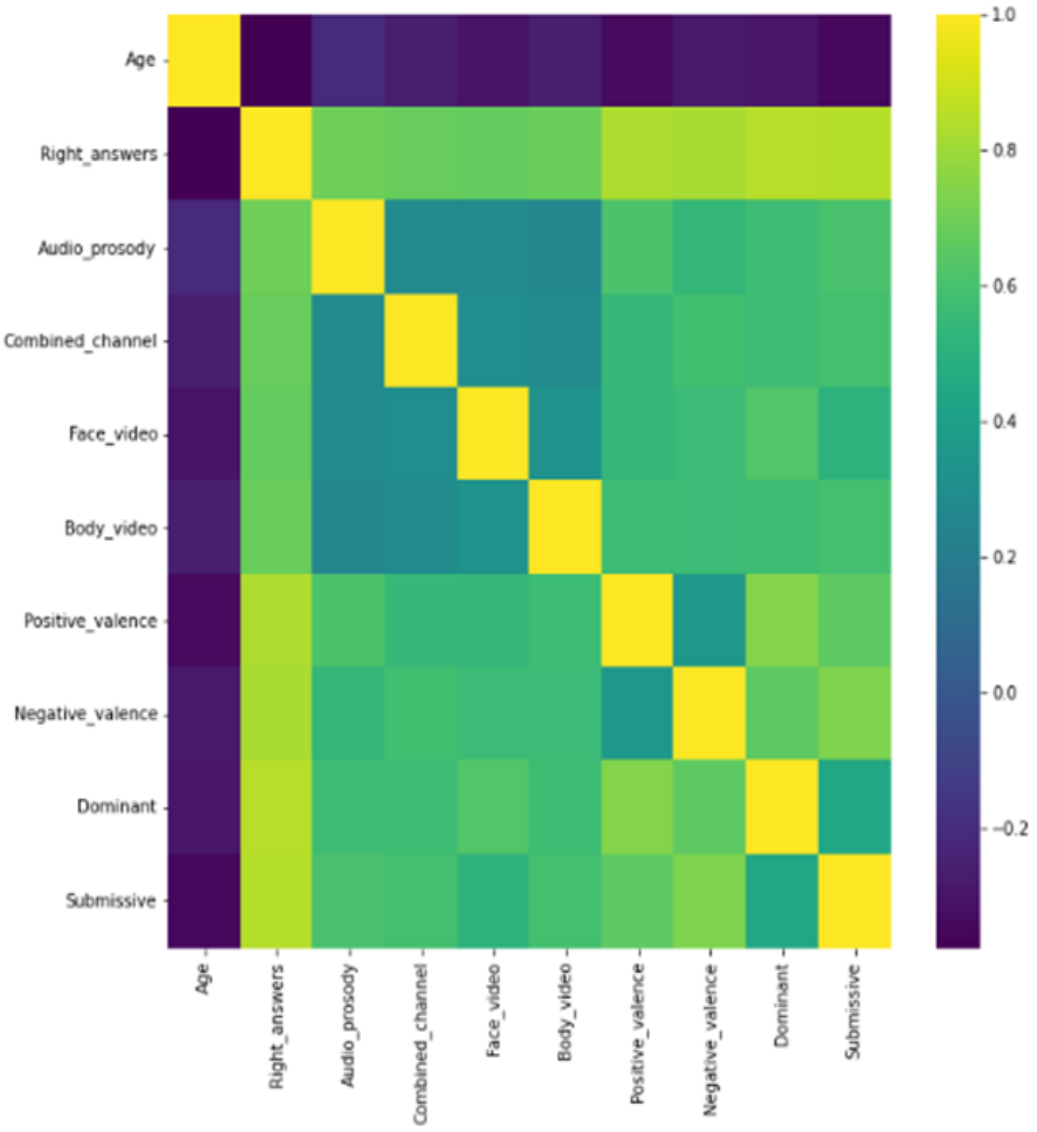

Figure 5.3. Correlation heat map

- Graph: Different types of graphs are used for data visualization. Bar charts are one of the commonly used and popular in data visualizations [Agnihotri, N., et.al,2022]. They are used to compare different attributes of dataset, outliners, trending highs and lows, historical data and other. It is also used to visualize data to be split into multiple categories. In Figure 5.4. Bar Graph is used to represent which age group is most effected by bipolar disorder.

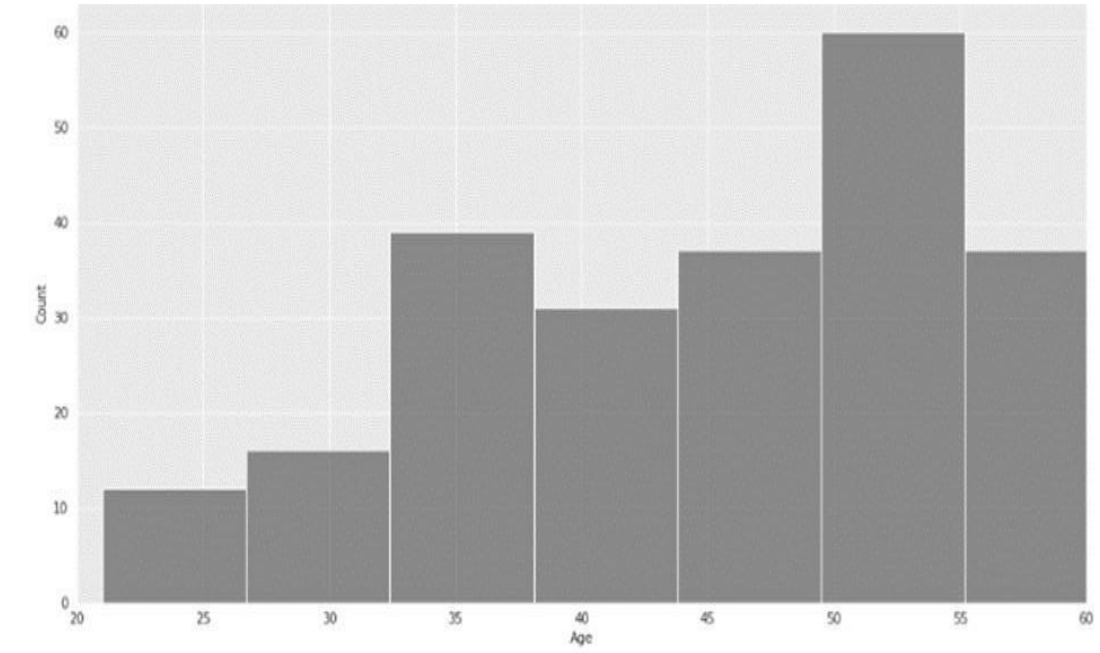

Figure 5.4. Bar Graph depicting which age group of people suffered most with BD

5.3.3 Process Description

We have applied Python Language using Python 3.6 for the visualization and analysis of data for Machine Learning. This predicted the people suffering from bipolar disorder, according to the level of severity. The dataset is segregated in two different portions Training set and Test set on the raio of 75:25 respectively. The working principles of these algorithms are as described below.

5.3.3.1 Logistic Regression

The logistic correction, or logit regression, or logit model is a regression model in which the dependency of variable is a phase. Logistic regression is used in issue of binary dependence which means it can only take up to two values, "0" and "1", representing results such as pass / fail, win / lose, death/life and health / illness [Geetha, G., et.al,2020]. Reasons in which variables depend on more than two results categories can be analysed in bulk deflation, or, if multiple phases are ordered, in systematic retrieval.

5.3.3.2 Support Vector Mechanism(SVM)

This model of machine learning is a non- probabilistic and linear classification method which leads to the reduction in anomalies. As compared to other models present, SVM is one of the most popular method but expensive for computation. This model helps in the reduction of noisy data and further helps to make better decisions. SVM is also known as statistical model can be further used in the classification and regression challenges [Deisenroth, M. P, et.at, 2020].

5.3.3.3 K-Nearest Neighbor(K-NN)

K-Nearest Neighbors(KNN), a machine learning model depending on regression and classification between the models and is known as the simplest method for the same. The closest training examples for featuring space are included in the input, and the outcome is dependent on the regression, classification for which K-NN is used. In this an item is divided by their neighbouring objects, the most common object chosen is the one which is the closest neighbor and is usually K. The object can be assigned as the closest K-NN neighbour if K=1 [Mateo-Sotos, J., et.al, 2020]. The result is calculated by the average of nearest neighbours.

5.3.3.4 Artificial Neural Networks(ANN)

Because Artificial Neural Networks are inspired by the organisation of the human nervous system, they may process information in a manner similar to that of our biological brains. A typical structure of Artificial Neural Network (ANN) has 3 layers Input layer, The quantity of output and hidden layers. The first hidden layer receives inputs, while the final hidden layer produces the output. Before being given to each node in the output layer of an artificial neural network, input is first received by each node in the hidden layer. Hyperparameters of a network are appropriately configured for improving its performance. These are parameters of a model which can be set manually while creating a model but cannot be trained. Random and Grid Search methods are used for optimization of neurons, input layer, hidden layer, Activation Function and Learning rate.

5.3.3.5 Naïve Bayes (NB)

Classifier models that offer class labels in difficult scenarios are constructed using the straightforward Naive Bayes machine learning paradigm. These models are represented as veneers of value elements, with class labels drawn from a restricted set. Given the flexibility of the class, all Bayes dividers assume that the value of a given element is more independent than any other factor. This means that there isn't just one technique used to train these dividers, but rather a collection of various algorithms based on the same principle.

5.3.4 Statistical Analysis

An explanatory method for analysing datasets to highlight their key features is data analysis. The crucial processing stage involves proofreading of the datasets to understand distinct actions to testify their applied theory and to monitor based on assumptions laid with the help of graphical and statistical analysis i.e. with statistical and visual methods [Mateo-Sotos, J., et.al, 2020]. The Python language were applied for categorization of models for machine learning using Python 3.6. To compare various models, we calculated the efficiency of all the models to understand which is best suited for bipolar disorder diagnosis through IPA.

5.4 Result

The result of the proposed system is the calculated by comparing the performances of different models based on the dataset provided. The data was divided into training and test data to be applied on Machine Learning techniques. This is applied separately to each algorithm to conclude the best possible method for detecting bipolar disorder. The final conclusion of the R2 score on the dataset as shown in Table 5.2., has provided the performances of the regression-based model. The R2 score value is also known as r-squared or coefficient of determination. It is calculated by checking the amount of various present in the prediction present in the data.

Table 5.2. R2 score Values of different machine learning models

Model	**R2-Scope**
Linear Regression	1.0
Random Forest Regressor	0.9111363792582583
SVM Regressor	0.889548807236372
K-NN	0.9014261165594151

The R2 score of all the algorithms is given for both BD and controlled People. The R2 score on model LR, Random Forest, SVM, and K-NN lies between 0.8 to 1.0. This parameter helps us to study the correct diagnosis. Through the use of emotional valence stimuli, we examined another goal and discovered that individuals with bipolar disorder scored significantly differently from other groups. The outcome reveals that while SVM, KNN, and Random Forest perform well with limited data, Linear Regression is the best at predicting disorder outliners as can be seen in Figure 5.5. which is a line plot to check variance of the Machine Learning models.

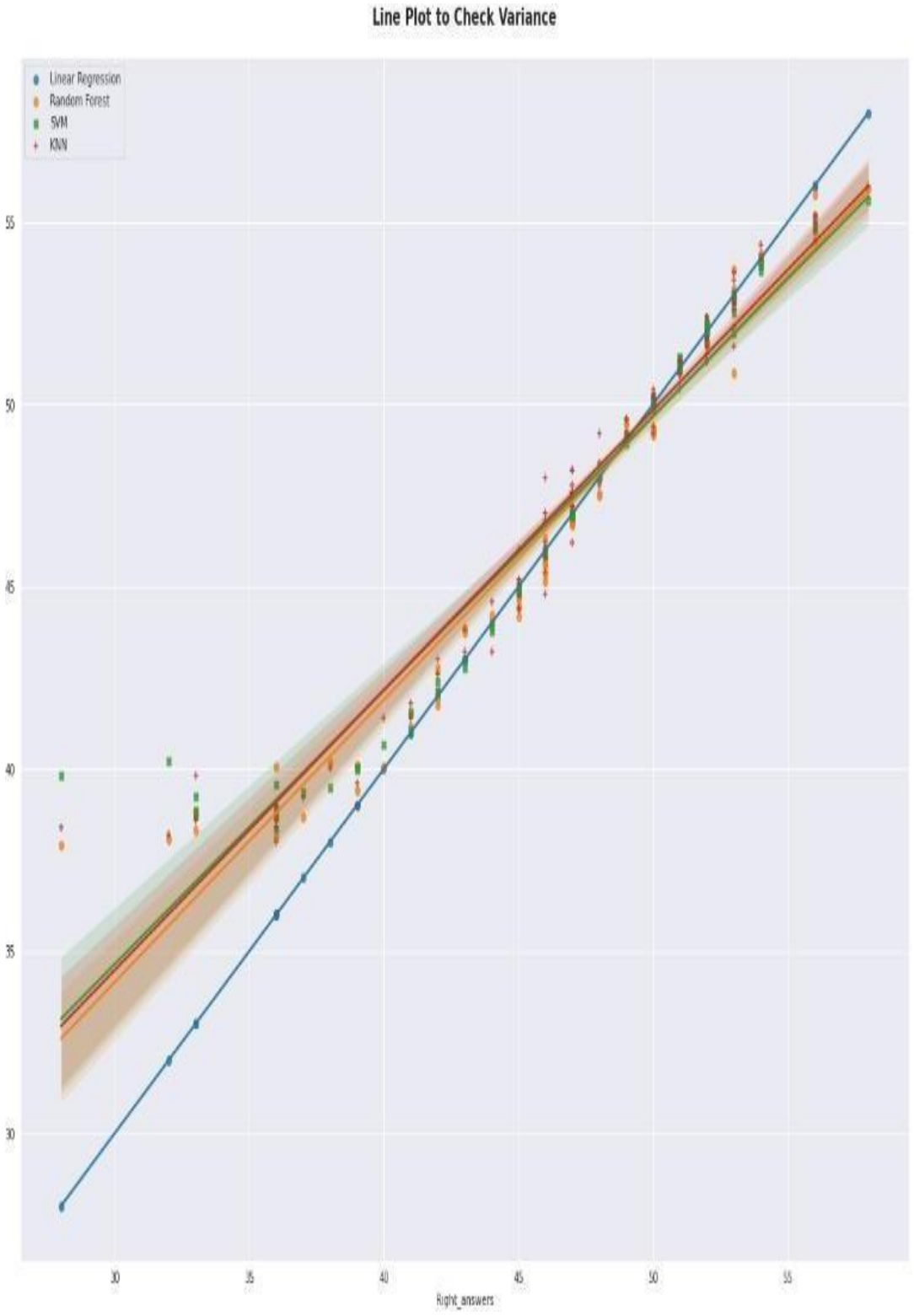

Figure 5.5. Line Plot to check variance

5.5 Discussion

Bipolar disorder or mood disorders are difficult to categorize as a lot of feature selection are implicated by the clinician which come as a difficult task. There are few more challenges such as data interpretation, maintaining its quality, its accuracy and precision. Failure of any of these can lead to the failure in the entire system. Not only this, but the privacy, security and ethical issues are also a major concern. To avoid these kind of issues, researchers has stated out various ways which can be implemented to avoid these issues such as encryption of the data or authentication mechanism [Kumar, A., et.al,2019]. The information found in the online social networks (Rahman, R., et.al, 2020) has given a large amount of data which can be explored to gain meaningful results. As while applying these algorithms, precision can be achieved only in the presence of bulk data. The research found through this study can benefit a lot of clinicians and physicians in the future.

5.6 Conclusion

This study concluded that the prediction and detection of the People suffering from bipolar disorder by applying machine learning algorithm will work as an aid in the future researches for providing better cure and treatment to the People. These algorithms applied for detecting the various categories and severity of the disorder will bridge the gap of research of the application of machine learning algorithms in the medical field. In the future, one major concern is to remember that not having control on our emotions can lead to worsen the condition of anxiety and further lead to degradation of mental health. This further degradation of mental health can lead to harm of the physical human body as well by suppressing the immune system, which can make the People can catch more infectious diseases, diabetes and increase in blood pressure.

CHAPTER-6

ACCURACY ENHANCEMENT WITH ARTIFICIAL NEURAL NETWORKS FOR BIPOLAR DISORDER PREDICTION

6.1 Introduction

Bipolar disorder, an intricate brain condition, is currently impacting millions of individuals worldwide. This disorder manifests through alternating oscillations marked by the People's fluctuation between states of mania and depression. The origin of these mood swings can be attributed to a combination of diverse physical and psychological factors. Behavioral alterations, fluctuating moods, and psycholinguistic features serve as indicators for analyzing and providing feedback on the People's condition. Mental health issues such as depression, anxiety, stress, restlessness, aggression, and other mood-related changes have the potential to disrupt an individual's well-being in specific situations, events, or circumstances, culminating in a complex mental disorder with both physical and emotional ramifications.

To analyze extensive datasets, neural network-based techniques and machine learning can be employed for extracting relevant data and making predictions. The outcomes of an algorithm may vary based on the technology used and the datasets employed. Identifying the optimal model for a given dataset and application becomes crucial. This study adopts supervised learning to predict the disorder, as the goal is predetermined. The algorithm establishes a function that maps various output variables to input variables, encompassing both regression and classification models. In regression models, the output variable is continuous, whereas in classification models, the output variable consists of two or more discrete values.

6.1.1 Contribution of the research

Our study introduces novel contributions, presenting an enhanced Artificial Neural Network model aimed at optimizing and elevating the predictive accuracy of bipolar disorder in People. This improvement is achieved by selecting an optimal combination of epochs and hyperparameters, utilizing the "Theory of Mind in Remitted Bipolar Disorder" dataset sourced from Kaggle. The key aspects of our research include:

- Development of a Bipolar Disorder prediction accuracy model employing Artificial Neural Network techniques for diagnostic purposes.
- Optimization of hyperparameters in the neural network, such as activation functions, neuron layers, batch size, accuracy, loss, and epochs, achieved through both grid search and random search methodologies.
- Validation of results through training and testing validation, along with the application of the 10-fold cross-validation method.
- Exploration of insights into how Artificial Neural Network (ANN) influences prediction accuracy within the dataset.
- Comparative analysis of model performance using various parameters in relation to epochs and hyperparameters.

6.2 Background Review of Related Work

The literature review provides a concise overview of literature and Machine Learning (ML) methods employed in the diagnosis of bipolar disorder. The research introduces a comprehensive model framework that utilizes Machine Learning for classifying mental health features, addressing both its applications and challenges [Saha, B., et.al, 2016], [Sivagnanam, L., et.al, 2022], [Saranya, R., et.al,2022], [Chung, J., et.al, 2022]. This study advocates a hybrid approach, with the Hybrid NaiveBaseTree (NBTree) exhibiting superior accuracy and precision compared to alternative methods [Ceccarelli, F., et.al,2022], [Tomasik, J., et.al,2021], [Yashaswini, K.A., et.al,2022]. Additionally, bipolar disorder detection is explored through the application of radial bias functions in Neural Networks [Luján, M. Á., et.al,2022], and a hybrid classifier combining Naïve Bayes and Decision Tree for prediction [Mahmood, D.Y., 2014].

Supervised machine learning models are evaluated for their efficacy in mental health detection and prediction [Bhagwat,, H., et.al, 2021], [Uddin, S., et.al, 2019]. A proposed hybrid classifier, named Logistic Vector Tree, integrates Logistic Regression and Support Vector Classifier [Rupapara, V., et.al, 2022]. The study also applies a Hybrid Support Vector Machine (SVM) model to identify distinct features with high-dimensional inputs accurately [Ahuja, R., et.al, 2019], [Bekta, J., et.al, 2017]. Logistic Regression and
support vector machine classification models are employed to address mental health issues such as depression, anxiety, stress, restlessness, aggression, and mood-related changes [Agnihotri, N., et.al, 2021], [Agnihotri, N., et.al, 2021].

The research proposes a hybrid model for depression detection and forecasting using deep learning techniques [Vandana, et.al,2023], [Moore, P.J., et.al, 2012]. Comparative analyses involve the convolutional neural network-bi Long short-term memory networks (LSTM) model against Convolutional Neural Network (CNN) and Recurrent Neural Networks (RNN) with baseline approaches [Kour, H., et.al, 2022]. Logistic Regression is identified as the most effective model for disorder prediction [Agnihotri, N., et.al, 2021]. Neural Network approaches in offspring of bipolar disorder parents are explored [Cooper, A., et.al, 2021], along with continuous monitoring of mood swings in elderly individuals [Bellandi, V., et.al, 2022]. Artificial Neural Network (ANN) emerges as the preferred predictive model for bipolar disorder diagnosis [Sarra, R.R., et.al,2022], [Fonseca, M.B., et.al, 2018], [Wessa, M., et.al, 2014].

Genetic algorithms are proposed to enhance accuracy in predicting the survival of heart attack failure People [Rawi, A., et.al, 2023]. Combining Convolutional Neural Network techniques improves feature extraction and classification accuracy, particularly in identifying dysgraphia in children [Ramdhani, Y., et.al, 2023], [Gouraguine, J., et.al, 2023]. The AD-3DCNN model is introdu2012ced with the highest accuracy for predicting different stages of Alzheimer's disease [Begum, A.P, et.al, 2023]. A model incorporating an automatic feature extractor, modified hidden

layer, and activation function is designed [Nayan, A.A, et.al, 2023]. The paper focuses on the automatic detection of strabismus using deep neural models based on different image acquisition methods [Hamid, H.S, et.al, 2022]. An architecture for a Convolutional Neural Network is developed by combining genetic algorithm steps for automatically detecting autism [Nagesh, N., et.al, 2022].

The early detection of Parkinson's disease is approached using speech features with a recurrent neural network and Long short-term memory to enhance classification performance [El-Aal, H. A. A., et.al, 2021]. Bidirectional recurrent neural networks are suggested to yield superior results in cardiac disorder prediction compared to unidirectional ones [Darmawahyuni, A., et.al, 2021]. A study on animal simulation employs the NARX recurrent neural network to record neuron activities [Kifouche, A., et.al, 2020]. A 2D-CNN deep learning model is utilized for the detection of cardiovascular issues in 17 annotated categories of Long Term Electrocardiograms [Al-Huseiny, M.S., et.al,2020]. Finally, the study proposes a solution for detecting insomnia sleep disorders using biomedical sensors connected to the Internet of Things, aiming for cost-effectiveness and time efficiency [Azman,N., et.al, 2020].

6.3 Proposed Model for Data Analysis

This section shows how the research methodology is performed on the dataset using deep learning model and the flowchart to predict the bipolar disorder. This is subdivided in five sections, data acquisition, data pre-processing, parameterisation, model selection, optimal combination of hyperperameters as given in flow chart.

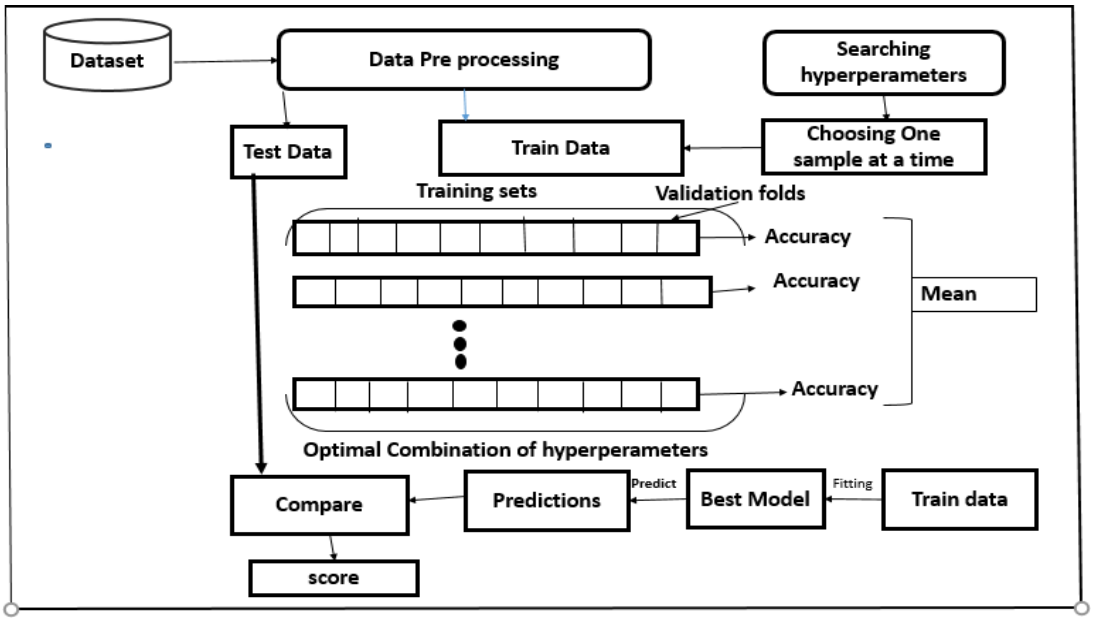

Figure 6.1. Flowchart for disease prediction

6.3.1 Dataset Acquisition and Preprocessing

The dataset under consideration is sourced from Kaggle and is titled "Theory of Mind in Remitted Bipolar Disorder." This online dataset utilizes a device called MiniPons, which employs interPeopleal accuracy to capture People' values across various attributes. The data is systematically recorded to assess input accuracy for both mentally ill and controlled People. The methodology is visually represented in Figure 6.1.

The bipolar disorder prediction model comprises several key steps. The first step involves data acquisition, where raw data is gathered from People with a higher likelihood of being diagnosed with or without bipolar disorder. The MiniPons device is instrumental in recording computational inputs.

To ensure optimal dataset performance, pre-processing is conducted as a vital stage in the data mining process. This involves refining the information obtained from the 12 different attributes present in the dataset, such as group, age, type, body video, dominant, submissive, negative valence, positive valence, face video, combined

channel, audio prosody, and right answers. This pre-processing step aims to enhance the overall quality and reliability of the dataset.

6.3.2 Parameterization of Regression Function for Data Analysis

The process of selecting a regression model involves various critical steps, with one viable approach being the utilization of Regression, a fundamental challenge in deep learning spanning applications from robotics to time series analysis, optimization, image processing, video animation, and automatic video annotation. To find a regression model requires a variety of selections which includes the following:

- Model Selection and Parameterization: Opt for the appropriate model type and determine its parameters for the regression function.
- Loss or Objective Function: Define the loss or objective function, a pivotal element in training the model effectively.
- Overfitting and Model Selection: Address overfitting concerns and make informed decisions during the model selection process.
- Relationship between Loss Functions and Parameter Priors: Grasp the correlation between loss functions and prior assumptions about model parameters.
- Optimal Combination of Hyper parameters: Identify the optimal blend of hyper parameters to enhance overall model performance.

Given a data set $S = \{xj, yj\}$, design an ensemble, where xj is the input vector and yj is the predicted output. For a dataset, function classes are good candidate to model the data and to choose the particular parameters. The machine Learning Modals are implemented busing the Statistical and data visualization tools. For feature assessment in People data, function classes are considered viable candidates for modeling the data. The implementation of machine learning models incorporates statistical and data visualization tools. A 10-fold cross-validation method is employed for feature evaluation, allocating 75% of People for training and the remaining 25% for testing and validation.

Machine learning models are instantiated based on the created database, and the selection of models, driven by performance metrics, facilitates a comparative analysis to discern the most effective model for explaining training data. Within regression models, parameters, loss functions, and optimization techniques significantly influence the determination of the best-fit model. Probabilistic models often find motivation in the interplay between loss functions and optimization strategies.

Hyperparameters, encompassing factors like activation values, kernel values, and fold numbers, wield a notable impact on machine learning techniques. Bayesian optimization becomes a strategic tool for fine-tuning hyperparameters during training, with the objective of elevating algorithmic performance. The exploration of relationships between diverse hyperparameters and their influence on algorithmic performance is a primary focus.

Machine learning models fundamentally seek to generalize knowledge from provided examples during training. Models exhibiting high variance may tend to overfit, while those with high bias may underfit. Striking a balance between these extremes is imperative, and validation curves offer a valuable means of identifying the optimal model by plotting the model's error function against its tendency to overfit or underfit the data.

6.3.3 Structure of Artificial Neural Network (ANN) Model

Artificial Neural networks are deep learning supervised models similar to our brain. Artificial Neural Network (ANN) is the model that simulates human brain neurons. Artificial Neural Network (ANN) structures get their inspiration from the functioning of our nervous system, allowing the designs to process information in a manner similar to that of our biological brains. As a result, they can be used as tools to address issues like facial recognition, which our blood brain can handle with ease. They are used for regression to learn non- linear relationships among targets and features because of the mathematical activation function in layers to find the output of a neuron. A typical structure of an Artificial Neural Network (ANN) has 3 layers: Input layer, Number of hidden layers and output layer. Inputs are given to the first hidden layer and

the last hidden layer gives the output. In an Artificial Neural Network (ANN), each node in the hidden layer receives input from the input layer before it is sent to each node in the output layer. We need to be cautious while passing before they ultimately arrive at the output layer because there may be a lot of nodes per layer and multiple hidden layers are also there. Each layer has n number of neurons and an activation function associated with each neuron. This function is responsible for non-linearity in the relationship. Each layer has regularizes associated with it which are responsible for preventing overfitting. This has Input layer, Neuron and output layer Layers of network are artificial neurons like us biological brain having weights assigned to them. This is trained using backward propagation to modify the predicted and actual weight as the modified weight. This modified weight is given to testing using forward propagation. In this way error is minimized and an output close to target value.

If the given inputs are X1, X2, X3, …, Xn. The associated weights with inputs are w1, w2, w3, …, wn. Then the weighted inputs are given as

$$\sum_{i=1}^{n} Xi * Wi^{n}$$

The activation Function is applied as

$$\emptyset(\sum_{i=1}^{m} Xi * Wi^{n}) \qquad \textbf{Eqn. 6.1}$$

There are two phases of artificial neural network

- Forward Propogation
- Backward Propogation

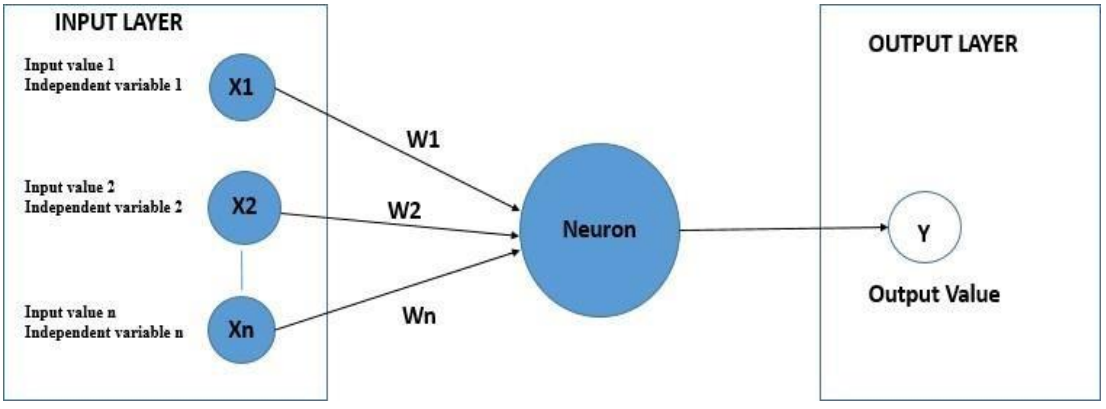

Figure 6.2. Structure of a Neuron

The operation of multiplying weights with each feature and adding them with bias is referred to as forward propagation. On the other hand, the process of updating the weights in the model is known as backward propagation, which involves optimization and loss function [[Ramdhani, Y., et.al, 2023]. The output of a neuron is determined by summing up all the values from neurons in the preceding connected layer [Begum, A.P, et.al, 2023].

We have constructed a neural network for predicting disorders, where the relevant attributes of a mentally ill People are input into the first layer. Subsequently, this information is passed to the initial hidden layer, assigning weighted values for data analysis. The cumulative weighted sum of hidden layers is then forwarded to the output layer, producing the final output through the application of a sigmoid activation function. The sigmoid activation function, depicted as an S-shaped curve in Figure 6.2., transforms values to fall within the range of 0 to 1. Widely used in deep learning models, particularly in Artificial Neural Networks (ANNs), sigmoid serves as an activation function in neurons to introduce non-linearity and navigate intricate decision boundaries.

Sigmoid Function is given mathematically as:

$$f(x) = \sigma(x) = \quad 1/1+ e^{-x} \qquad \textbf{Eqn. 6.2}$$

Sigmoid Derivative is given as:

$$f'(x)= \sigma(x)\,(1 - \sigma(x)) \qquad \textbf{Eqn. 6.3}$$

Table 6.1. Description of the Artificial Neural Network (ANN) parameters

Layers	**Units**	**Activation Function**	**Kernels**
Input (Dense)	5	Relu	Normal
Hidden Layer1	5	Relu	Normal
Hidden Layer2	5	Tanh	Normal
Output (Dense)	1	Relu	Normal

This sigmoid function finds applications in diverse fields such as image recognition, natural language processing (NLP), and speech recognition within Artificial Neural Networks (ANNs).

Table 6.1. illustrates the details of our Artificial Neural Network (ANN) model. In the training phase, the network's weighted connections are initialized randomly. It then processes input data to generate an output, which is subsequently compared with the actual output, and the error value is computed.

Binary Cross Entropy

$$LBCE = -1n\ \Sigma(yi \times log(y\hat{i}\ ))\ +(1-yi)\ ni=1 \times log(1-\hat{yi}) \quad \textbf{Eqn. 6.4}$$

The Binary Cross Entropy (LBCE) formula is employed for error calculation, defined as:

$$\Delta wij = -\eta \partial Error \partial\ wij \quad \textbf{Eqn. 6.5}$$

Where Δwij – weight change, and η – Learning rate. Once all the weights are updated the output is again calculated until the minimum possible error is calculated.

6.3.4 Hyperparameters Tuning Parameters for Cross validation

After processing the entire dataset on the basis of these 12 attributes, it has been further classified to training model and testing model for further performance evaluation with a ratio of 75:25. Hyperparameters of a network are appropriately configured for improving its performance. These are parameters of a model which can be set manually while creating a model but cannot be trained. Random and Grid Search methods are used for optimization of neurons, input layer, hidden layer, Activation Function and Learning rate.

Upon analyzing the complete dataset using the 12 specified attributes, the data has been partitioned into training and testing sets with a ratio of 75:25 to facilitate subsequent performance evaluation. The hyperparameters of the neural network have been fine-tuned to enhance its overall performance. Hyperparameters, being model settings that are manually configured during the model creation but remain static during

training, were optimized using both Random and Grid Search methods. This optimization focused on parameters such as the number of neurons, input layer configuration, hidden layer specifications, activation function selection, and learning rate determination.

Table 6.2. Hyperparameter tuning best configuration

Hyperparameter	**Value**
Inputs	11
Hidden Layers	2
Activation Function	relu
Learning Rate	0.001

To enhance performance and fine-tune the model, a 10-fold cross-validation approach is employed [Begum, A.P, et.al, 2023], coupled with a search mechanism. This involves utilizing an optimization technique to identify the most effective combinations of hyperparameters, as outlined in Table 6.2. The optimization process iteratively tests individual sets of hyperparameter combinations, calculates their respective accuracies, and stores the averages. After evaluating all possible hyperparameter combinations, the optimal solution is determined based on the best-performing combination.

6.4 Results And Discussion

The study is centered on enhancing the accuracy and predictive capability of diagnosing whether a People has bipolar disorder or falls into a controlled category. This improvement is achieved through the utilization of a neural network regression model. The evaluation of the proposed model involves the application of performance metrics, with the assessment being grounded in the accuracy of correct observations and their relevance within the dataset. The determination of performance includes factors such as the number of True Positives in the test data and the harmonic mean of recall and precision values. These metrics are delineated as follows:

a) Accuracy: This metric calculates the percentage of correct observations out of the total observations.

b) Precision: Precision assists in quantifying the relevant number of data points from the test data.

c) Recall: Recall is employed to calculate the number of true positives in relation to the total number of observations.

d) F1 score: The F1 score is utilized to measure the harmonic mean between recall and precision values.

Table 6.3. Performance Metrics of Artificial Neural Network (ANN) Model

Parameter	**Artificial Neural Network**
Precision	0.866397
Accuracy	0.858000
Recall	0.849206
F1 Score	0.857715

Using the four fundamental classification metrics mentioned above, an evaluation of the performance of an Artificial Neural Network (ANN) was conducted, as illustrated in Table 6.3. The deployment of the ANN involved optimization through fine-tuning of hyperparameters, encompassing the input layer, hidden layers, activation function, and learning rate. Following the validation process, the performance of various hyperparameter value combinations was assessed, and the optimal combination was determined.

The hyperparameters considered in the analysis include:

Batch_size = [5,10,15,20]

Epoch_list = [50,100,150,200,250,300]

Upon applying Grid search, the best parameters were identified, resulting in a total time taken of 2 minutes. The optimal hyperparameter values obtained from the Grid Search are as follows:

Total Time Taken: 2 Minutes

Grid Search Best parameters

{'Optimizer_trial': 'rmsprop', 'batch_size': 10, 'epochs': 10}

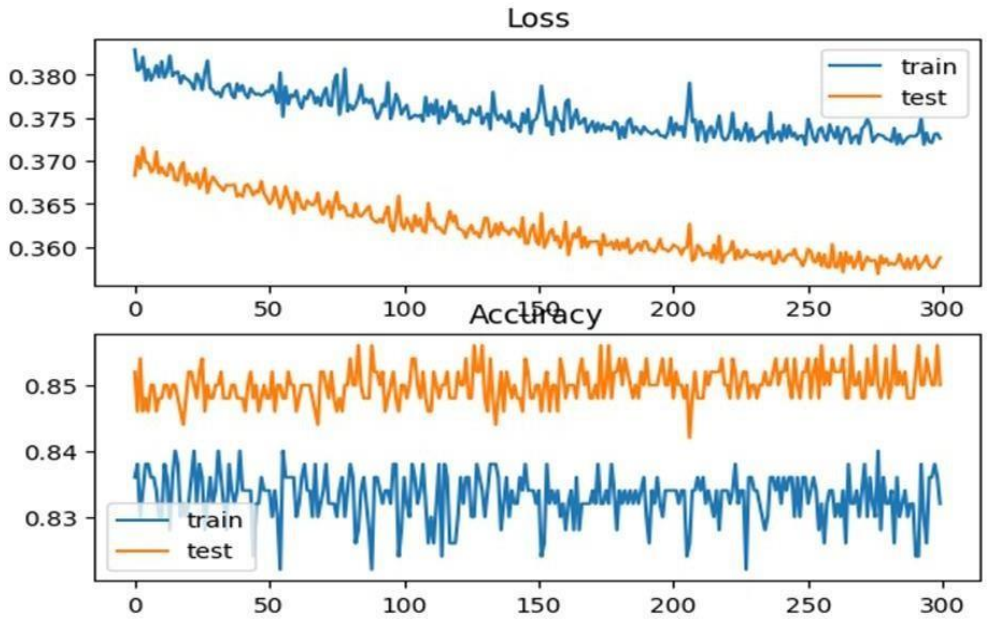

Figure 6.3. Loss and Accuracy graph for ANN

To assess and monitor the training and validation datasets, we employed the Accuracy and Loss metrics for each epoch. As illustrated in Figure 6.3, the progress of accuracy and loss for both training and validated test data is depicted. The Training Accuracy and Validated Test Accuracy exhibit a consistent upward trend until reaching a minimum threshold, after which they stabilize. In contrast, Training Loss plateaus at a specific percentage, maintaining stability, while the validation test loss mirrors the behavior of the Training Loss.

Table 6.4. Calculating Mini-batch accuracy and loss

Epoch	Iteration	Mini-batch accuracy(%)	Mini batch loss
1	1	83	0.3728
50	50	85	0.3525
100	100	83.8	0.3686
150	150	84.6	0.3682
200	200	83.8	0.3524
250	250	83.8	0.3532
300	300	83.8	0.3518

Additionally, a graphical representation is generated within the text, depicted in Figure 6.4., illustrating that the optimal accuracy occurs when the batch size is set to 15 and the epoch to 50. This is further compared with other hyperparameters outlined in Table 6.4. Artificial Neural Networks (ANN) play a crucial role in assessing the model's proficiency in predicting bipolar states. The findings indicate that Artificial Neural Networks outperform other models utilized in previous studies, offering a potential enhancement in disease prediction precision. Enhancing the model is achievable by adjusting training and test parameters within the dataset. Model training is conducted to assess performance, relying on predicted features such as F1-score, recall, and precision.

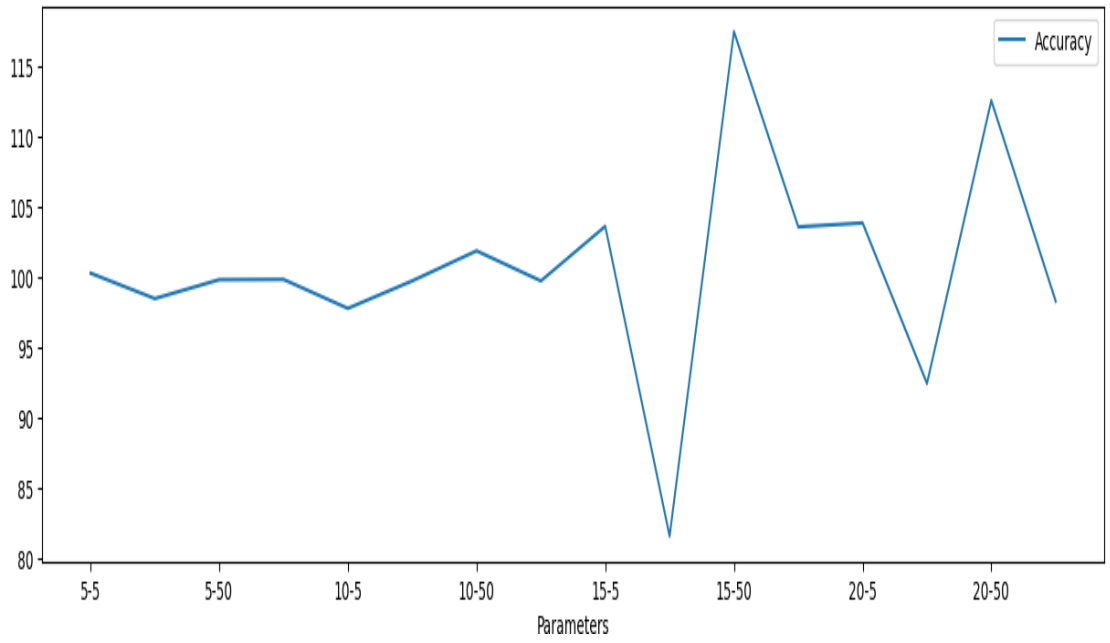

Figure 6.4. Inline plot of Accuracy with parameters

6.5 Conclusion

Given the rising instances of individuals grappling with mental health challenges, accurate and timely diagnosis and treatment are crucial to prevent the exacerbation of People' health conditions. In the contemporary landscape, machine learning models play a pivotal role in achieving superior outcomes within specified timeframes, offering enhanced security compared to cloud systems concerning People data and transactional matters. The objective is to advocate for an optimal approach to detecting and predicting People' conditions with heightened accuracy and framework efficiency, leveraging artificial neural network algorithms. The Deep Learning model, specifically Artificial Neural Network (ANN), yields superior results with increased precision compared to traditional machine learning models, presenting a valuable resource for clinicians in future assessments.

CHAPTER-7

A HYBRID LSVR-LOGISTIC SUPPORT VECTOR REGRESSOR MODEL IS DESIGNED TO PREDICT BIPOLAR DISORDER IN PEOPLE

7.1 Introduction

Bipolar disorder is a mental health condition which in terms of psychiatry is characterized by alternate mood swings between three states mania, hypomania and depression episodes. This is also called as mania depressive mental illness having extreme periods of different states of mind. People with bipolar disorder may experience intense episodes of elevated or irritable mood, less requirement of sleep, grandiosity, impulsivity, negative thoughts, as well as increased energy in manic states, while experiencing feelings of hopelessness, sadness, restlessness or pleasure, not able to concentrate and even modulations in their sleep and appetite patterns during depressive episodes. The disorder can be managed with medications, therapy, and lifestyle changes, but it is a lifelong condition that requires ongoing care and attention. The hybrid LSVR-Logistic Support Vector Regressor model is a machine learning algorithm designed to predict bipolar disorder in People. It combines two different types of models, namely the support vector regressor and the logistic regression model, to leverage their respective strengths in predicting the presence of bipolar disorder in People (Saha, B., et. al, 2016). The support vector regressor model is used to predict the severity of bipolar disorder symptoms while the logistic regression model is used to classify People as either having or not having bipolar disorder (Sivagnanam, L., et. al, 2022). The resulting hybrid model is designed to provide accurate predictions of bipolar disorder in People by combining the strengths of two complementary machine learning models.

Machine learning has shown promising results in predicting bipolar disorder in humans by analyzing large datasets of clinical and biological markers. By using algorithms to learn patterns in these datasets, machine learning models can identify

early signs and risk factors associated with bipolar disorder before the onset of symptoms. For example, one study used machine learning to analyze MRI brain scans of people with bipolar disorder and healthy controls and found that the model was able to accurately predict which individuals had bipolar disorder based on brain connectivity patterns. Additionally, machine learning models can integrate multiple sources of data, such as genetic, behavioral, and environmental factors, to provide a more comprehensive risk assessment. As a whole machine Learning helps and automate physicians in early detection, Peoplealized treatment, leading to better outcomes for individuals living with bipolar disorder condition.

7.1.1 Hybrid-LSVR Model

The hybrid LSVR-Logistic Support Vector Regressor model designed to predict bipolar disorder in People has several benefits. Firstly, it utilizes the strengths of two different models to improve the accuracy of predictions (Chung, J., et. al,2022). The support vector regressor model is good at handling continuous variables and can predict the severity of bipolar disorder symptoms, while the logistic regression model is better at handling binary classification and can predict whether a People has bipolar disorder or not. Secondly, this model is based on machine learning techniques, which means it can learn and adapt to new data as it becomes available, potentially improving its accuracy over time. Finally, accurate prediction of bipolar disorder can lead to earlier diagnosis, appropriate treatment, and improved People outcomes, highlighting the potential clinical benefits of this hybrid model (Saranya, R., et.al, 2022).

The technique used to estimate and understand the objects category and class is based on its characteristics and attributes, and is called classification. Classification is used in various fields like industry, medical, banking and many more (Saranya, R., et.al, 2022). Classification is usually a method used for making decision with problems having large databases and critical issues. Classification methods like Support Vector Machine (SVM), Logistic Regression(LR), Naïve Bayes(NB), K-Nearest Neighbor(KNN), Rule based Methods, Neural Network (NN) and other statistical

classification like Logistic Regression (LR). Many researchers have evaluated the performance of classification method logistic regression.

This paper is divided in various sections, as Section II is related to background and related study of literature on Bipolar disorder and its prediction, Section III revels the proposed methodology of hybrid model, Section IV gives the findings and result, section V dhows the performance evaluation, Section VI is discussing Conclusion and future scope.

7.1.2 Contributions

Machine Learning Algorithms are of two types Supervised and Unsupervised. Here, we used Supervised Learning which is again of two types, Regression and Classification. In this, two classification models are used namely Logistic Regression and Support Vector Machine which are used to classify data into categories for feature selection. This is helpful to classify the dataset into bipolar disorder and controlled People. LR and SVM are supervised Machine Learning models which sets labelled datasets through which it trains algorithms to get the desired output.

The logistic regression used to identify the most important features in this framework in order to decrease redundancy and the informative feature are selected. LR technique uses a set of independent variables which are used to predict the categorical dependent variables. Support-vector machines are known as associated learning algorithms, sets the data to predict the severity of BP symptoms and features. This is used for classification and regression analysis.LR and SVM are both combined to make the performance evaluation better and have benefits of both. The hybrid model LSVR Logistic Support Vector Regressor provides improved accuracy in prediction of bipolar disorder. This paper has contributed mainly as follows:

- Dataset pre-processing using statistical Analysis.
- Best Features are selected using LR and SVM models.
- Dataset is divided into Training and Test dataset.

- Optimization has been done by combining the models for performance optimization.
- Hybrid LSVR model is used for classification.

7.2 Background Review of Related Work

The related literature provides the findings and work on bipolar disorder disease production and prevention. This gives a clear and concise review on classification and regression models of deep learning and machine learning techniques.

(Saha, B., et. al, 2016) Using Machine Learning techniques, they prepared a combined model framework which helps to classify mental health features that have occurred in social media communities. The dataset also undergoes through empirical validation process and the results exceeded the recent state of the art baselines created by this model. (Sivagnanam, L., et. al, 2022) The study in this [a[er shows a multimodal ML model which is created on different features such as visual, acoustic and textual through performing a cross modality correlation methodology. They have adapted the fisher vector encoded method to develop the model using denoising autoencoder which actually works on multimodal representation. Using the paragraph vector for the textual modality which helps to encode interview series transcripts into proper documentation and helps to capture mental disorder sign. They denoising auto encoder is trained into a 3-layer model with the help of residual neural network classifier.

(Saranya, R., et.al, 2022) The study showcased that deep learning and machine learning model helps in detecting bipolar disorder by involving a methodology that captures the increased BDD accuracy rate. A decision tree regressor model was implemented on a bipolar dataset with a standard scaler and further logistic regressor and random forest helped in choosing optimal features with the feature selection process. Applying convolutional neural networks (CNN) with the help thof long short-term memory (LSTM) through the entire training and evaluation models by inculcating Adam optimization. Using the stacking ensemble algorithm, the study found the best model which can help us to detect bipolar disorder in People.

(Chung, J., et. al,2022) To understand and deduce the systematic review, the study applied the PRISMA methodology which included research of total 30 articles in their initial reviewing and screening stage. They methodology they applied in the initial stage was based on finding researches conducted over mental health issues such as depression, anxiety, bipolar disorder, mental health among children, posttraumatic stress disorder and schizophrenia. After understanding the issues and discussing about them, they worked on the challenges and the limitations occurred by the clinicians all over the world in implementing machine learning to cure mental health issues. They also provided research worthy recommendations and steps of actions that can work as the stepping stones to conduct researches in the future and deploying machine learning models in the medical field. (Ceccarelli, F., et. al, 2021) The researched focus on identifying mental health disorder in People using a correlation in their textual, visual and audio modalities. They implemented recurrent neural networks methodology to include the temporary information in the machine learning process and based on that deploying a model which extract the features based on dynamic evolution. They proposed an efficient late fusion strategy on the basis of a feed forward neural network which they further named as adaptive non-linear judge classifier for the multimodal fusion model. A total of two datasets were studied for entire processing of the machine learning model and on both of them, the experimented results showcased that the proposed methodology perfectly works fine for the state-of-the-art approaches.

By analyzing the importance that each modality has caused in recognizing mental disorder People and finally inferring some concrete conclusions to aid the research, the study fetched some very important results. (Agnihotri, N., et.al,2022) A data analysis on bipolar data set to categories these People and their different types from controlled People by analyzing their features and attributes. Another paper depicts that which model best fits the dataset to predict bipolar disorder using Machine Learning Techniques by studying their performance matrices. (Agnihotri, N., et.al,2022), A study based on comparison between deep learning and machine learning techniques to evaluate which model is more accurate in prediction.

(Tomasik, J, et. Al, 2021) created a diagnostic algorithm which helped in identifying bipolar disorder People in different clinical scenarios with efficient accuracy and helps to perform accurate clinical treatment to People. (Yashaswini K. A, et.al,2022) The study proposed a recurrent decision tree which helped in contributing towards the prediction of bipolar disorder. The results predicted that the proposed methodology outperforms the existing decision tree model.

(Luján, M.Á, et.al, 2022) The study found out that their algorithm in comparison to the preexisting machine learning models which follow Bayesian linear discriminant technique, decision tree or gaussian naïve bayes resulted to accuracy around 97%. This finally concluded that neural network technique could be implemented to diagnosis to predict the bipolar disorder People. (Mahmood, et.al, 2014) The hybrid NBTree showed that the results have better accuracy and precision as compared to the other two approaches. In terns of response time the naïve bayes exceeds the decision tree and NBTree algorithms. (Mahesh, Batta, et.al,2019) The best thing about machine learning algorithms is that once the model is trained in reference to the outputs of data, it can work on automation. This paper provided a brief review and gave a future prospect of how machine learning solves different problems. (Uddin, S., et.al, 2019) is research helps in finding a relative performance study of supervised algorithms of machine learning in predicting various diseases. These results help the researchers in finding the best supervised machine learning algorithm for future studies in this field. (Rupapara, V., et. Al, 2022) For understanding classification studies, a hybrid logistics vector trees classifier (LVTrees) model is performed and analyzed logistic regression, support vector classifier, and extra tree classifier. Apart from these experimentations on these datasets and comparing the methods, performance comparison has made a significant method in preparing an approach for future studies. LVTrees models has exceeded other model implementing ADASYN and Chi2 techniques with an accuracy result of 100%. Conducting a T-test on the research helps to find the efficacy of the proposed algorithm and the k-fold cross-validation also helps to prove the superiority of the model.

(Ravinder Ahuja, et. Al, 2022) In this study, the students mental stress was calculated for over a week in the case of before and after usage of interne in exams. The

aim of the study is to find out how much mental stress does college students undergo at different phases of college life. The pressure they undergo during exams time or the stress that occurs during placement time usually goes unnoticed. The study wanted to perform a comparative study on how these minor factors can affect the overall mental health of students and also correlate these stress levels with the time spent on internet. The dataset was concluded of the students studying in Jaypee Institute of Information Technology and total of 206 participants participated in the study. They implemented four different classification algorithms such as naïve bayes, random forest, SVM and logistic regression and performance metrics were calculated for the same. (Jale Bektaş, et.al, 2017) A Hybris SVM model was applied to find out the distinct features and calculated high -dimensional inputs with proper accuracy. (Widodo, et. Al, 2017) This study found out that SVM has comparatively best performance in classification as compared to logistic regression method as compared to the different types and the background of these datasets.

(Widodo, et. Al, 2017) This study reflected that SVM model has better performance in classification as compared to logistic regression model in both training and testing datasets. (Vandana, et.al, 2023) This paper researched about the comparative study in the performance of different models by implementing different types of background of the datasets taken in consideration and transformation of these models according to the categorical scale in these predicted variables. Further these models were evaluated on the basis of Press'Q statistic and Apparent Error Rate (Aper). (P. J. Moore, et. Al, 2012) In this research, two different models are employed in the forecasting of data; Gaussian process regression and exponential smoothing. None of them provided an improvement in persistent baseline. This finally concluded that the depression time series based on the bipolar disorder People's dataset are fairly heterogeneous and resulted in constraints of the accuracy of different forecasting based on automated mood forecasting in the People.

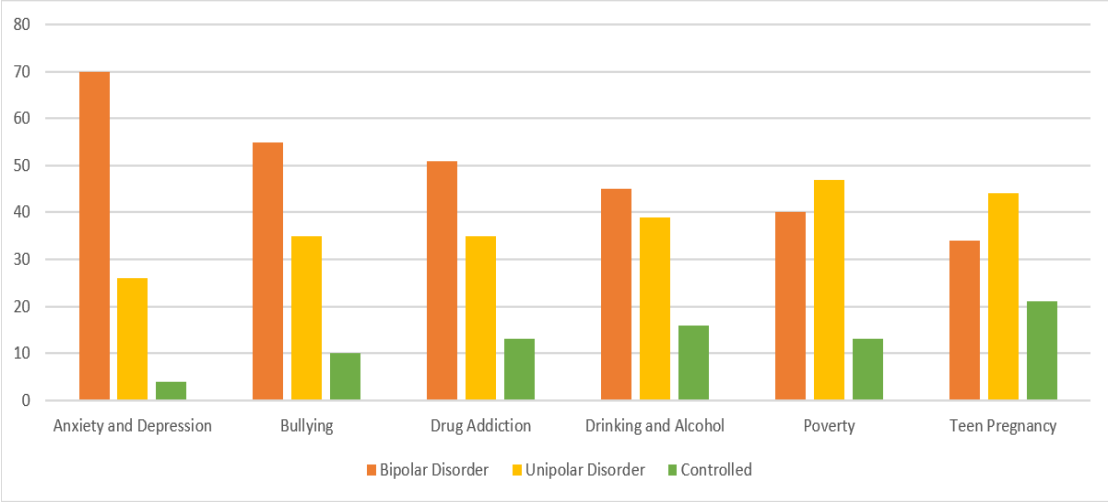

Figure 7.1. A Survey of U.S. showing BD as a major problem in the young population in 2018 [23]

(Harnain Kour, et.al, 2022) This study compared the CNN-bi LSTM model with the existing CNN and recurrent neural networks (RNN) with the baseline approaches. The experimented results predicted that this model helps to provide better predictive performance as calculated through various performance metrics. To analyze the performance more significantly, various visualization approaches and statistical techniques were employed which proves a great difference between non-depressive content and linguistic representation of depressive.

As shown in figure 7.1. young one are suffering with depression Anxiety and other mental illness. All the above related study also depicts the percentage of people suffering with mental illness and their types.

7.3 Logistic Regressor & Support Vector machine hybrid model for predicting bipolar disorder in People

The programmed algorithms of Machine Learning are used to optimize and learn the operations by input data analysis in order to make predictions in an acceptable limit or range. Using new data programmed algorithms give more accurate results and prediction performance. Machine Learning algorithms are grouped according to inputs and purpose, they are classified in three broad categories. They are Supervised Learning, Unsupervised Learning, Semi-Supervised Learning

(Tomasik, J, et. Al, 2021). Supervised Machine Learning uses labelled training dataset which is first used to train the dataset in underlying algorithm. The outcome of this trained dataset is given to unlabeled test dataset which is categorized into similar groups. The supervised Learning is of two types: Classification problems and Regression problems. Here we are using classification problem, which uses underlying output variable is discrete. (Tomasik, J, et. Al, 2021). The variable is classified in different categories or parts like 'bipolar disorder 'and 'Controlled', BD-I or BD-II etc. The general steps involved in building a hybrid LSVR-Logistic Support Vector Regressor model to predict bipolar disorder in People. The proposed approach has following steps as shown in Figure 7.2.

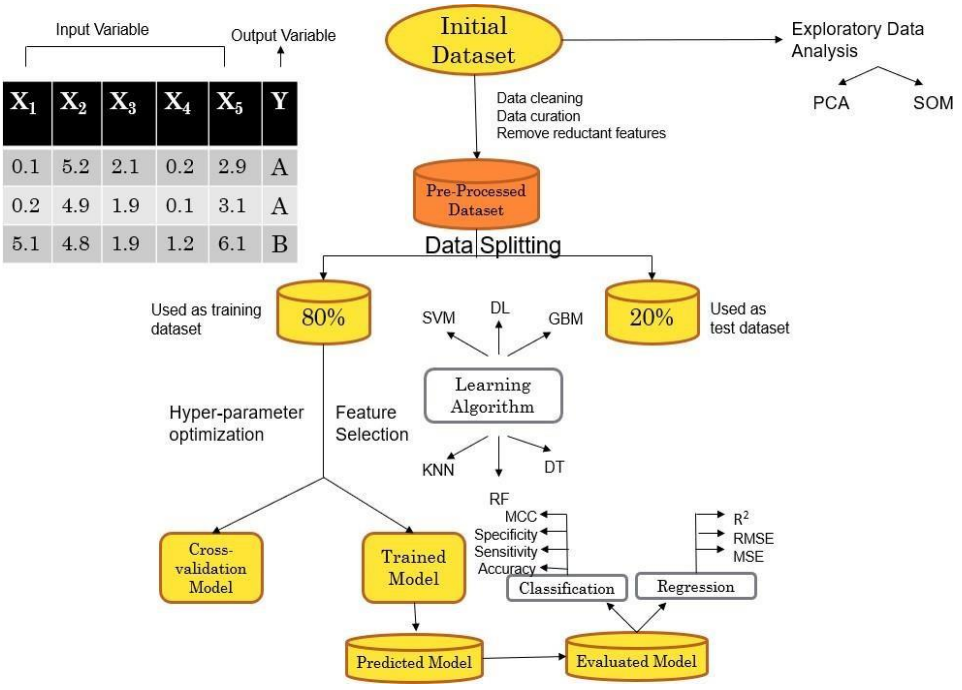

Figure 7.2. Flow Chart for proposed Model

7.3.1 Data Acquisition and Pre-Processing:

Collect data on People with and without bipolar disorder, including demographic information, medical history, and symptoms (Agnihotri, N., et.al, 2022). Preprocess the data by removing duplicates, handling missing values, and transforming the data into a format suitable for modeling.

The dataset under discussion comes from Participants' "Theory of mind in remitted bipolar disorder." MiniPons, which was developed based on interPeopleal accuracy in the perception of dynamic nonverbal cues, is used to collect this data. (Agnihotri, N., et.al, 2021).

The most crucial phase is data pre-processing. The large amount of healthcare data has null or missing data values and containments that diminishes the use of data (Ravinder Ahuja, et. Al, 2022). Preprocessing of data improves the quality and efficacy of the outcomes retrieved through data mining process. Machine Learning algorithms uses dataset to acquire accurate findings and improved predictions. The dataset of Bipolar disorder needs different level of preprocessing.

Normalization of feature set is done by filtering outliners and scaling the variance of unit dataset. The standard score is calculated as follows:

$$Ys = z = x - \mu\sigma \qquad \text{Eqn. 7.1}$$

Where Ys denotes the dataset,

z denotes normalization,

x denotes attributes of number,

μ denotes empty attributes,

and σ denotes number of rows.

Numerous Machine Learning estimators denotes the criteria of dataset standardization which exhibits undesirable behavior, the distributed data is normally standardized if the individual features do not correspond.

The training and test datasets are separated within the dataset: Divide the data into two sections, as seen in figure 7.3., one for model training and other for testing the accuracy. The training set should be larger than the testing set.

- Training Data (Estimate the parameters for the ML models)
- Test data (Evaluate how well the ML models work)

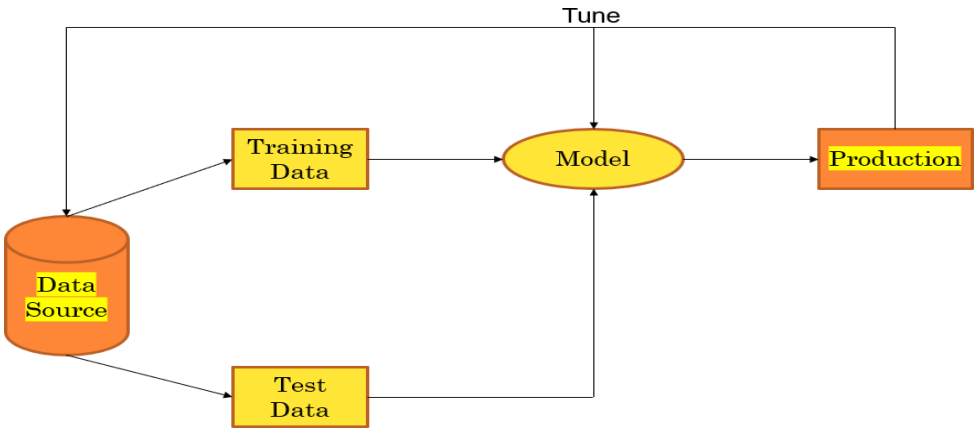

Figure 7.3. Splitting Dataset into Training and Testing Data

7.3.2 Train the Support Vector Regressor: To predict the severity of bipolar disorder symptoms a Support Vector Regressor is trained on training dataset.

- SVM are supervised ML models having associated learning algorithms to analyze data used for regression and classification analysis.
- SVM can perform linear classification as well as they can perform a non-linear classification efficiently by using Kernel trick, in this inputs are implicitly mapped into high dimensional feature space.
- SVM draw margins between the classes. The distance between the margins and classes is maximum as they are drawn in a particular fashion. In this way, the classification error is minimized to a specific instant.

As seen from the figure 7.4., hyperplane are the vectors defined by the support vectors.

The separator function is defined as

$$F(x)=w'x+b \qquad \textbf{Eqn. 7.2}$$

Where w is the vector that defines the optimal hyperplane

x are coordinates of the point

In Support Vector Machine, input vectors are mapped into a high dimensional feature space in which hyperplane is separated by positive and negative optimal

hyperplanes. This distance is the maximum margin which separates negative and positive vectors. Using optimization problem SVM finds the optimal hyperplane.

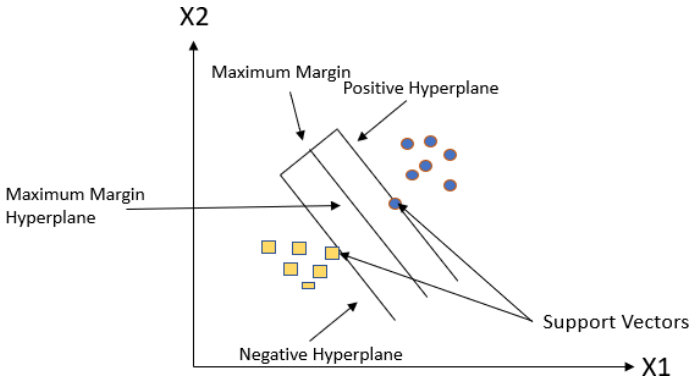

Figure 7.4. SVM Hyperplane

7.3.3 Train the model LR (Logistic Regression): A logistic regression model is trained using training set to classify People as having or not having bipolar disorder. The logistic regression used to identify the most important features in this framework in order to decrease redundancy and the informative feature are selected (Widodo, et. Al, 2017).

- Logistic regression is used for categorical predictions of independent variables by using a set of independent variables. This gives a discrete or categorical value as outcome in supervised machine learning techniques.
- LR gives values between 0 and 1 which is a probabilistic type value.
- They are used in classification problems.
- In LR we fit a S shaped logistic Function instead of a regression line which predicts two maximum values 0 or 1.
- The LR curve as in figure 7.5. shows the likelihood of any medical diagnosis like a People is bipolar disorder or a controlled using logistic function.

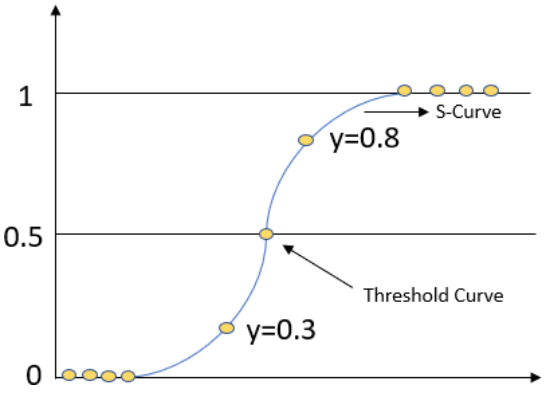

Figure 7.5. Sigmoid Curve

Sigmoid Function

$$f(x) = \frac{1}{1+e^{-(x)}} \qquad \textbf{Eqn. 7.3}$$

Y = F(X)

Where, Y is the Input Independent Variable

X is the Output Dependent Variable

The LR model can also be described as given

Let us suppose Pi is the logit and the explanatory variable x_{ij}, x_{i2}, …x_{ik} where x_i and K denotes the number of features.

$$Pi=11+exp(\Sigma\beta ixijkj=1) \qquad \textbf{Eqn. 7.4}$$

The Linear connection between logit Function (Pi) and Explanatory variables when applying logit transformation is

$$logit(pi)=\log(pi1-pi) \qquad \text{Eqn. 7.5}$$

Where Pi is the logarithm of the probabilities of success for the explanatory variables xi, 1, xi, 2…., xi, k.

7.3.4 Combine the models: Combine the support vector regressor and logistic regression models into a hybrid model. One way to combine them is to use the output of the support vector regressor as an input to the logistic regression model.

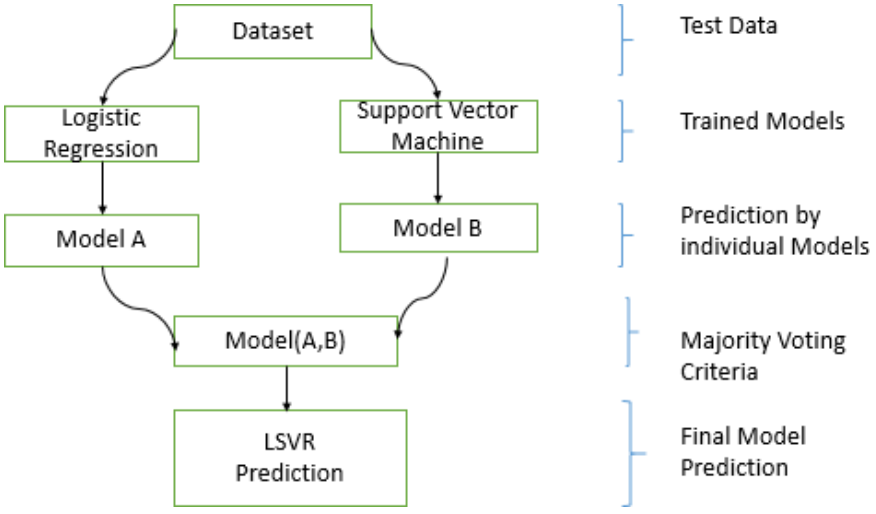

Figure 7.6. Combining ML Models

The research proposes LR and SVM for ensemble based on their performance on bipolar disorder dataset as shown in figure 7.6. The most predicted class is indicated as the final predicted motel on the basis of maximum voting criteria by combining two models. The proposed algorithm for final predicted model is as given in algorithm 1.

Algorithm 1.

Input: Elements of BD Dataset

Output: Predicted Outcomes

$Train_{LR} \leftarrow LR_{Train(Dataset)}$

$Train_{SVM} \leftarrow SVM_{Train(Dataset)}$

For i in NewDataset do

$LR_{predicted} \leftarrow Train_{LR}(i)$

$SVM_{predicted} \leftarrow Train_{SVM}(i)$

$Predicted \leftarrow LSVM(LR_{predicted}, SVM_{predicted})$

End

7.3.5 Performance Evaluation of the model: Evaluate the hybrid model on the testing set to determine its accuracy. Adjust the model's hyper parameters and repeat steps 3-5 as necessary to improve the model's accuracy.

Given a data set $S = \{xj, yj\}$, an ensemble model was designed by

$$\sum_{p=1}^{P} tp\ (xj) = y\hat{j} \qquad \textbf{Eqn. 7.6}$$

Where xj is the vector taken as input and yj is the output predicted. For a dataset, function classes are good candidate to model the data and to choose the particular parameters. The ML Modals are implemented by use of the Statistical and data visualization tools. The evaluation of performance of model is based on performance matrices. To determine which model is the best in the end, it is crucial to validate and put the algorithms through performance evaluation once they have been deployedThere are computations done in order to assess performance. Accuracy, F1-score, Precision, and Recall. The model with the greatest value fits the data for each model best.

Algorithm 2:

Input: *n* (elements of the dataset)

Output: *Pred* (predicted outcome)

Start

For I = 1 to n *(A dataset with n elements)*

If n==err *(Presence of errors err within the dataset)*

n<- S_{val} *(The error substitution e_i th a value of substitution Sval in the dataset)*

A=f_1(n) *(A function f_1(n) having n elements of dataset, into a new matrix A)*

Cval=f_2(A) *(Correlation analysis with respect to all the categorical values)*

Pred=f_3(C_{val}) *(a function f_3(x) is developed to implement ML model)*

End

End

End

7.3.6 Deploy the model: Once the model has been evaluated and found to be accurate, deploy it for use in clinical settings to predict bipolar disorder in People. Hybrid-LSVR (Logistic Support Vector Regressor). We deploy a hybrid classification to calculate inputs in high dimension with accurate manner and to discover specific features.

7.4 Result

To determine which model is the best in the end, it is crucial to validate and put the algorithms through performance evaluation once they have been deployed. To evaluate performance, calculations are made.

- Recall,
- Precision,
- F1- score, and
- Accuracy

For each model, and the model with highest value fits the best as shown in Table 7.2. In Machine Learning, the problem of statistical classification uses Confusion Matrix, it is a special layout for data visualization for evaluating the performance of algorithms. Instances of a class is represented by each row while columns represent the instance of each predicted class Each row of the matrix represents the instances of a true class while each column represents the instances in predicted class. The confusion matrix predicts four values True Positive(TP), False Positive(FP), False Negative(FN), True Negative(TN) in predicted and actual class, where the rows show the value of true classes and the column shows the value of predicted classes respectively as shown in Table 7.1.

The rate of success can be calculated as:

$$r = \frac{TN+TP}{FP+FN} \qquad \text{Eqn. 7.7}$$

It determines the sensitivity and specificity as

- Sensitivity- what % of People with BD were correctly identified.
- Specificity-what % of People without BD were correctly identified.

Table 7.1. Confusion Matrix

	Has Bipolar Disorder	**Does not have Bipolar Disorder**
Has Bipolar Disorder	**True Positive(TP)**	**False Positive(FP)**
Does not have Bipolar Disorder	**False Negative(FN)**	**True Negative(TN)**

TP – Had BD and Predicted with BD FP – Don't had BD but predicted with BD
FN – Has BD and not Predicted with BD TN - Don't has BD and not predicted with BD

The Performance Matrices used to evaluate the performance of ML and combined models are described below

1) Accuracy: Accuracy helps to calculate the percentage of correct observations out of total observations.

$$\text{Accuracy \%} = \frac{TP+TN}{TP+TN+FP+FN} * 100 \qquad \text{Eqn. 7.8}$$

2) Precision: Precision helps to calculate the relevant number of data points from the test data.

$$\text{Precision \%} = \frac{TP}{TP+FP} * 100 \qquad \text{Eqn. 7.9}$$

3) Recall: Recall helps to calculate the number of True Positives(TP) with respect to total number of observations.

$$\text{Recall \%} = \frac{TP}{TP+FN} * 100 \qquad \text{Eqn. 7.10}$$

4) F1 score: F1 score values provide us the harmonic mean value between recall and precision.

$$\text{F1- Score \%} = \frac{Precision * Recall}{Precision+Recall} * 100 \qquad \text{Eqn. 7.11}$$

Table 7.2. Comparison Table for Accuracy, Precision, F1-Score and Recall

Model/Matrices	Accuracy	Precision	Recall	F1-Score
SVR	0.946428571	0.933035714	0.946428571	0.93877551
LR	0.160714286	0.127545249	0.160714286	0.121025584
LSVR	0.96	0.910909091	1	0.952380952

Data visualization are important tools for identifying a qualitative understanding of dataset which helps in exploring the data and extract important information or to identify patterns, outliners or corrupt data.

In python various libraries come with lots of different features that enables users to make customised, elegant and interactive plots. In this we have used Matplotlib for easy visualization of data. Each data set may use three types of visualization techniques:

1. Histogram
2. Heat Correlation Map
3. Bar Graph

For our data Visualization, a bar graph is used to explore the visual prediction of individual models Logistic Regression and Support Vector Regression to be compared with hybrid model- Logistic Support Vector Regressor. The X-axis shows the different matrices of models and Y-axis shows their percentage.

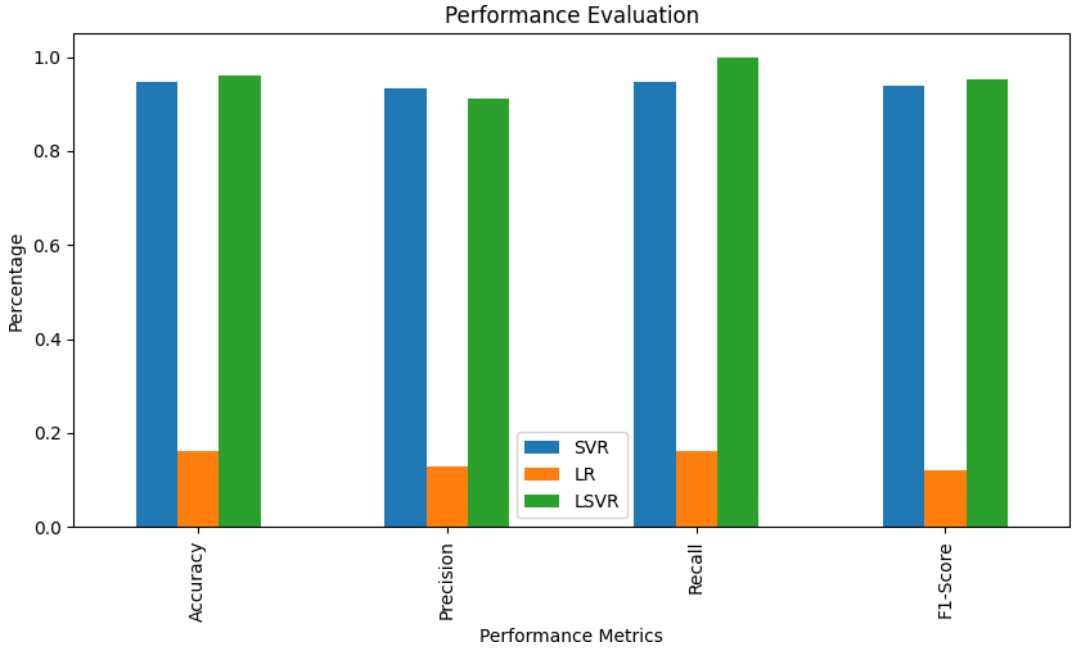

Figure 7.7. Bar graph of LR, SVR, LSR on Performance Matrices

The final conclusion of the R2 score on the dataset as shown in Table 7.3. has provided the performances of the classification based model (Agnihotri, N., et.al, 2022). The R2 score value is also known as r-squared or coefficient of determination. It is computed by determining how many different attributes are included in the data forecast. The ML model comparison displayed in figure 7.7. & 7.8. predict that LSVR gives more accurate values as compared to individual models LR and SVM.

Table 7.3. R2-Score of LR, SVM and LSVR

Model	R2-Score
LSVR	0.9999999957
LR	0.987654322
SVR	0.889765432

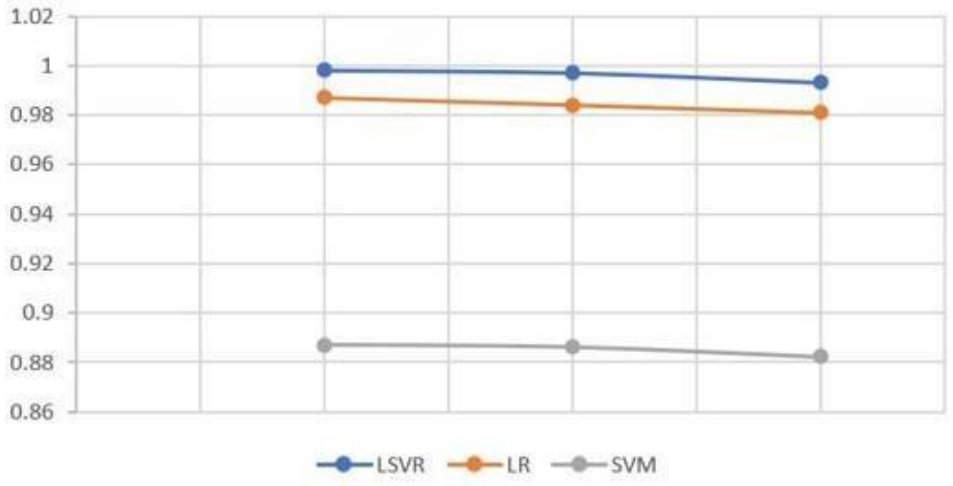

Figure 7.8. ML Comparison Model

After data Visualization and performance evaluation, this is concluded that the hybrid Model LSVR (logistic Support Vector Regressor) is more accurately helping in diagnosis as compared to individual classification models.

7.5 Conclusion

In conclusion, the hybrid LSVR-Logistic Support Vector Regressor model can be an effective tool for predicting bipolar disorder in People. By combining the strengths of logistic regression and support vector machines, the hybrid model can provide accurate and reliable predictions while minimizing the risk of false positives and false negatives. However, the performance of the model is highly dependent on the quality and quantity of the input data, the choice of hyperparameters, and the specific implementation of the model. Therefore, it is important to carefully evaluate the performance of the model and adjust it as necessary to ensure optimal performance. The hybrid model has the potential to improve the early diagnosis and treatment of bipolar disorder, thereby improving People outcomes and reducing the burden of this disorder on individuals and society as a whole.

CHAPTER-8

Results and Discussions

Through the analysis, it can be seen that machine learning is becoming an important resource in providing cure to the people who have been diagnosed with bipolar disorder. The prolonged treatments or the analysis stages of the illness take a lot of time and usually the delay causes the worsening of People's condition but machine learning models can help to provide treatment to the People within the stipulated period of time preventing the worst case scenario of the People's condition [Agnihotri, N., et.al, 2021]. Different machine learning models were evaluated according to the performance metrics to evaluate the performance of different models.

Analysing and finding out the best machine learning model can be done by calculating R2 score value for each model and selecting the best fit model for the illness. R2 score value of each model helps to provide the goodness of fit of a particular model as shown in Figure 18. Our research has ultimately led us to the conclusion that the suggested Linear Regression model, which has been taken into account for understanding people's behaviour when dealing with bipolar disease and controlled individuals, suits the applied algorithm the best. In order to achieve this, we compared the Linear Regression model against the SVM, KNN, and Random Forest models. It is evident that the Linear Regression model was chosen because it offered the best performance metrics. This facilitates the model's application to additional automatic analyses for bipolar illness diagnosis and will aid researchers in their decision-making process. Figure 18 shows how the linear regression model might be concluded as the best fit model that can be used by clinicians and doctors all over the world to treat People suffering from bipolar disorders. To provide more assurance on the selection of model for the detection of bipolar disorder, performance evaluation has been performed by calculating performance metrics score for each model and then checked whether LR is the best suited model or not.

Through the study, it can be seen that LR model has attained the maximum value of different performance metrics parameters such as recall, F1-score, precision and accuracy as compared to various different models. These results show that LR model can be

introduced into the medical world in future for early detection of People suffering from mental illness such as bipolar disorder.

Deep learning model is also a subset of machine learning models and hence is stated as one of the method which provide more deep and profound analysis [Agnihotri, N., et.al, 2022]. Clinicians all over the world are applying deep learning models in the medical field to provide early detection of ailments and required cure to the People. Different researchers are working around the world to understand the application of deep learning models in the diagnosis of bipolar disorder and differentiate bipolar disorder People from healthy People.

Artificial neural network is also a part of machine learning models that works on the basis of input parameters provided through the dataset and run it through n number of neurons to get the results up to maximum accuracy. It works like a human brain as a human brains have n no of neurons and process each information through these neurons to complete or understand a task in the best way possible. ANN use learning algorithms which are capable enough of making independent adjustments or learn accordingly as soon as they receive an input from an external source.

To understand whether ANN model can work better from the Linear regression model, again evaluation has been performed on same parameters to get the desired output and chose one among them.

Through the comparison made between ANN and LR model in, it can be seen deep learning model ANN provide more accurate results as compared to machine learning models and hence can be used by clinicians and technicians for providing best medical assistance to People suffering from bipolar disorder providing an early detection of the illness.

CHAPTER-9

CONCLUSION AND FUTURE WORK

9.1 Introduction

The research concludes according to the clinical heterogeneity of the sample of People's data with mental health issues is known to advance by implementing different applications of Machine Learning techniques which is a helping hand for researchers and psychiatrics in diagnosis of disease and its treatment. These techniques are used for predicting various issues concerned to mental health disorder that gives significant solutions and further can be explored and studied. With time if emotional conditions get worsen and are not controlled then anxiety can increase every single day and may results in difficult situations which is very challenging to treat with [Saral, B., et.al,2019]. These conditions if become severe then it can harm our body to a large extend and results in degradation of the immune system, which is additionally capable of lead to various other heath related problems. The suggested systems seem to be effective in providing technicians with a thorough understanding for related studies of significant help in detecting People suffering from bipolar disorder. With the increasing cases of people diagnosed with mental health issues, correct diagnosis of the illness and its treatment within the time period to avoid worse health conditions in People. In order to propose optimal detection and prediction of the People's condition with greater precision and productivity the framework uses Logistic regression and artificial neural network algorithms. Deep learning model ANN provides better results with more precision as compared to machine learning model and can be further used by clinicians for future reference. In addition, with bigger datasets, performance can be more improved as well for future times.

9.2 Contribution of The Thesis

The main objective of the research is to build a novel model which can decrease the semantic gap for prediction and detection of Bipolar Disorder, thus, to reach the human-level performance. Machine learning and its applications in today's scenario helps to get better results within stipulated time period and is more secure as compare to cloud systems with People's data and transaction concerns. We apply different performance metrics applied on dataset to evaluate the diagnosis for Bipolar Disorder Feature Prediction and Analysis based on both machine Learning Modals and Neural Networks as a novelty of this Research**.** The novel contributions of our research are:

- A Statistical Analysis of Bipolar Disorder dataset to evaluate which age group is mostly effected by bipolar disorder methods to classify the data in categories of Bipolar Disorder Like BD-I, BD-II, etc.
- Classification of Models on the basis of parameters like R2-Score, F1-score, precision, recall, accuracy and other parameters to choose the best ML Model for BD early Predictions.
- A hybrid classification approach has been designed to discover specific features and calculate high dimensional inputs in an accurate manner. Hybrid techniques like preprocessing, and feature selection are used to develop a Hybrid LSVR Model. Best Features are selected using LR and SVM models.
- Accuracy enhancement of prediction using optimized Artificial Neural Network for prediction of bipolar disorder. Hyper parameters of a network are appropriately configured for improving its performance. To evaluate and keep track of the training and validated test data, the Accuracy and Loss parameters were used in each Epoch.
- Training Accuracy and Validated Test accuracy follows a similar increasing pattern until reaching a minimum percentage and then they stabilize. On the other hand, Training Loss reaches a certain percentage where it remains stable and validation test loss follows the same behaviour as Training loss.

9.3 Future Work

The future challenges to researchers is to categories the type of disorder and to deal with the bulk of data. This will be a great challenge to interpret the quality of dataset and categories it in different attributes and symptoms. In the future, more research can be conducted to apply deep learning modalities to examine all activities and daily changes in individuals. This covers various feature selection algorithms as well as face recognition. The security, privacy of Peopleal information is one of the major challenge, to avoid this safety precaution is required and data should be end to end encrypted using authentication protocols. One main challenge is to maintain accuracy and precision while manipulating data. The information gathered from Online Social Networks [Bauer, M., et.al, 2018] gives immense potential to provide researchers with bulk of data to be explored. The future directions in Mental Health Detection includes:

1. Heterogeneity of Symptoms: Bipolar disorder presents with a wide range of symptoms that vary across individuals and even within the same individual over time. This heterogeneity poses challenges for accurate diagnosis and prediction [5].
2. Diagnostic Delay: The average delay between symptom onset and diagnosis of bipolar disorder is estimated to be 5-10 years, resulting in prolonged suffering for People and missed opportunities for early intervention [6].
3. Comorbidity: Bipolar disorder often coexists with other psychiatric disorders, such as anxiety disorders, substance use disorders, and attention-deficit/hyperactivity disorder (ADHD), making diagnosis and treatment more complex [7].
4. Objective Biomarkers: Currently, there are no definitive biological markers or laboratory tests to diagnose bipolar disorder. Diagnosis relies primarily on clinical evaluation and self-reported symptoms, which can be subjective and prone to biases [8].

5. Treatment Response Variability: People with bipolar disorder exhibit significant variability in response to different treatments, including medications and psychotherapies. Predicting treatment response and optimizing Peoplealized treatment plans remain challenging [9].
6. The major challenge is to make these People feel that they are normal human being and they will be treated as normal ones while interacting with them. Do not isolate them as if they are not normal human beings [Shatte, A. B. R., et.al, 2019].
7. These People are involved in their own shell, and are involved in negative thinking and judgement and are depressed with their [Priya, A., et.al, 2020].
8. One more point of concern is that People doesn't know how to emote their feelings in correct manner. As analysed on various social media platforms they send aggressive and very negative posts [Bauer, M., et.al, 2018].
9. In Online or Non face to face interactions there is problem to detect the type and seriousness of disorder [Bauer, M., et.al, 2018].
10. The data science approach helps researchers and clinicians in determining the possibility of existing mental health state behind the barriers [Priya, A., et.al, 2020].

The mental health disorder is difficult to categorize as researchers are implementing different strategies for the feature selection process which occur as one of the major challenges to conquer such as maintain the quality of dataset and interpreting it to get results. Various factors need to maintained such as accuracy of data and its precision because if the data is imprecise it can lead to failure of the entire proposed system. There are more important challenges to be dealt with while building the models like its security, safety and privacy and to avoid these issues, different safety precautions need to be taken, for e.g. implementing user authentication mechanisms and encryption of data. The information provided through Online Social Networks [22] also has a bulk amount of data

which has a significant potential in the research field. And to understand this, extraction of the data is done and analysed to perform evaluation metrics and understand its potential.

While researching about mental health, the clinicians found out that people suffering from such kind of disorder are more likely isolate themselves and do not feel like having any communication with the world. They love being in their own space and avoid any kind of interaction. They don't prefer leading a normal life like other people and create their own bubble [Portugal, L. C. L., et.al, 2019]. It became difficult to make them feel as normal individuals. People suffering from mental health disorder get engaged in negative emotions and religious sentiments [Vuppalapati, C., et.al,2018]. They are so engrossed in their own world. The major concern is dealing with language barriers as while dealing with mental health disorder they create their own set of different languages. The detection and prediction of the various mental health issues incorporated several challenges such as non-face-to-face communication and dealing with different systems of human computer interaction. This is where machine learning plays a vital role in understanding and determining the occurrence of mental health issues in People [Priya, A., et.al,2020]. One of the major issues that researcher and clinicians are concerned about is the security policies related to it and maintaining privacy while data preparation.

Bipolar disorder and other mental disorders are notoriously difficult to diagnose, making prediction extremely difficult. However, this particular approach can assist clinicians in learning more about and comprehending People health. Using MiniPons data, our chosen model, Linear Regression, has demonstrated the best performance, with a maximum accuracy of approximately 97%, for differentiating between individuals with bipolar disorder and control subjects. The ability of the linear regression model to perform well with even larger data dimensions while avoiding overtraining was demonstrated by a comparison with a few other machine learning models, including SVM, KNN, and Random Forest.

List Of Publications

S.No.	Title of the Paper	Status of the Paper	Journal/Conference	Indexing (Scopus, SCI)	Volume
1.	Implementing Machine Learning Techniques to Predict Bipolar Disorder	**DOI:** 10.1504/IJMEI.2022.10052205 (DOI of Abstract) https://www.inderscience.com/info/ingeneral/forthcoming.php?jcode=ijmei	International Journal of Medical Engineering and Informatics Inderscience Publishers) **ISSN:1755-0653 E-ISSN:1755-0661**	2022 Scopus	**Entered Publication Schedule**
2.	Accuracy Enhancement with Artificial Neural Networks for Bipolar Disorder Prediction"	**DOI:10.11591/ijeecs.v32.i3.pp1695-1702** https://ijeecs.iaescore.com/index.php/IJEECS/article/view/33980/17814	Indonesian Journal of Electrical Engineering and Computer Science **p-ISSN: 2502-4752, e-ISSN: 2502-4760**	2023 Scopus/ SCI	**Published** Vol-32, Issue-03
3.	Bipolar Disorder: Early Prediction and Risk Analysis using Machine Learning	DOI: 10.37896/YMER21.08/84 https://ymerdigital.com/archives/?cpage=5&issId=2108	YMER ISSN: 0044-0477	2022 Scopus	**Published** Vol-21, Issue-08
4.	Predicting the Symptoms of Bipolar Disorder in People using Machine Learning	**DOI:** 10.1109/SMART52563.2021.9676247 https://ieeexplore.ieee.org/document/9676247	IEEE International Conference **ISBN**: 978-1-6654-3970-1 **ISSN:** 2767-7362	2021 Scopus	**Published** 10th-International Conference on system Modelling and Advancement in Research Trends,

					SMART 2021
5.	Review on Machine Learning Techniques to Predict Bipolar Disorder.	https://turcomat.org/index.php/turkbilmat/article/view/12189	International Journal TURCOMAT **e-ISSN** 1309-4653	2022	**Published** Scopus Vol-13, No.2
6.	Early Prediction of Bipolar Disorder using Deep Learning Techniques: A Review	**Paper Presented**	In 54th Annual International Carnahan Conference on Security Technology- ICCST-2023,	2023 Scopus – Indexed IEEE Conference	11-15 Oct 2023
7.	A hybrid LSVR-Logistic Support Vector Regressor model is designed to predict bipolar disorder in People	Under Review	International Journal of Electronic Healthcare	2023 Scopus	

REFERENCES

[1] Subhani, A. R.; Mumtaz, W.; Saad, M. N. B. M.; Kamel, N.; Malik, A. S., (2017), "Machine Learning Framework for the Detection of Mental Stress at Multiple Levels," IEEE Access, 5, 13545–13556. https://doi.org/10.1109/access.2017.2723622.

[2] Rios, A. C.; Noto, M. N.; Rizzo, L. B.; Mansur, R.; Martins, F. E., Jr; Grassi-Oliveira, R.; Correll, C. U.; Brietzke, E., (2015), "Early Stages of Bipolar Disorder: Characterization and Strategies for Early Intervention," Braz J Psychiatry, 37 (4), 343–349. https://doi.org/10.1590/1516-4446-2014-1620.

[3] de Oliveira, L.; Portugal, L. C. L.; Pereira, M.; Chase, H. W.; Bertocci, M.; Stiffler, R.; Greenberg, T.; Bebko, G.; Lockovich, J.; Aslam, H.; Mourao-Miranda, J.; Phillips, M. L., (2019), "Predicting Bipolar Disorder Risk Factors in Distressed Young Adults from Patterns of Brain Activation to Reward: A Machine Learning Approach," Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 4 (8), 726–733. https://doi.org/10.1016/j.bpsc.2019.04.005.

[4] Sujatha, R.; Tejesh, K.; Krithi, H.; Shri, H. R., (2021), "Detection of Bipolar Disorder Using Machine Learning with MRI," ISIC.

[5] Vieta, E.; Salagre, E.; Grande, I.; Carvalho, A. F.; Fernandes, B. S.; Berk, M.; Birmaher, B.; Tohen, M.; Suppes, T., (2018), "Early Intervention in Bipolar Disorder," Am. J. Psychiatry, 175 (5), 411–426. https://doi.org/10.1176/appi.ajp.2017.17090972.

[6] O'Donovan, C.; Alda, M., (2020), "Depression Preceding Diagnosis of Bipolar Disorder", Front. Psychiatry, 11, 500. https://doi.org/10.3389/fpsyt.2020.00500.

[7] Geetha, G.; Dr, K., (2020), "Prediction of Diabetics Using Machine Learning" International Journal of Recent Technology and Engineering (IJRTE), No. 5.

[8] Mateo-Sotos, J.; Torres, A. M.; Santos, J. L.; Quevedo, O.; Basar, C., (2020), "A Machine Learning-Based Method to Identify Bipolar Disorder People," Circuits Systems Signal Process, 41 (4), 2244–2265. https://doi.org/10.1007/s00034-021-01889-1.

[9] Alonso, J. F.; Romero, S.; Ballester, M. R.; Antonijoan, R. M.; Mañanas, M. A., (2015), "Stress Assessment Based on EEG Univariate Features and Functional Connectivity Measures," Physiol. Meas, 36 (7), 1351–1365. https://doi.org/10.1088/0967-3334/36/7/1351.

[10] Espinós, U.; Fernández-Abascal, E. G.; Ovejero, M., (2019), "Theory of Mind in Remitted Bipolar Disorder: InterPeopleal Accuracy in Recognition of Dynamic Nonverbal Signals," PLoS One, 14 (9), e0222112. https://doi.org/10.1371/journal.pone.0222112.

[11] Thieme, A.; Belgrave, D.; Doherty, G., (2020), "Machine Learning in Mental Health: A Systematic Review of the HCI Literature to Support the Development of Effective and

Implementable ML Systems," ACM Trans. Comput. Hum. Interact, 27 (5), 1–53. https://doi.org/10.1145/3398069.

[12] Beaufort, I. N.; De Weert-Van Oene, G. H.; Buwalda, V. A. J.; de Leeuw, J. R. J.; Goudriaan, A. E., (2017), "The Depression, Anxiety and Stress Scale (DASS-21) as a Screener for Depression in Substance Use Disorder InPeople: A Pilot Study," Eur. Addict. Res, 23 (5), 260–268. https://doi.org/10.1159/000485182.

[13] Vuppalapati, C.; Khan, M. S.; Raghu, N.; Veluru, P.; Khursheed, S., (2018), "A System to Detect Mental Stress Using Machine Learning and Mobile Development," In 2018 International Conference on Machine Learning and Cybernetics (ICMLC); IEEE.

[14] Priya, A.; Garg, S.; Tigga, N. P., (2020), "Predicting Anxiety, Depression and Stress in Modern Life Using Machine Learning Algorithms," Procedia Comput. Sci, 167, 1258–1267. https://doi.org/10.1016/j.procs.2020.03.442.

[15] Chen, M.; Hao, Y.; Hwang, K.; Wang, L.; Wang, L., (2017), "Disease Prediction by Machine Learning over Big Data from Healthcare Communities," IEEE Access, 5, 8869–8879. https://doi.org/10.1109/access.2017.2694446.

[16] Leal, J., (2018), "Application of Machine Learning Algorithms for Bipolar Disorder Crisis Prediction," ApplicationOM.

[17] Sau, A.; Bhakta, I., (2017), "Predicting Anxiety and Depression in Elderly People Using Machine Learning Technology" Healthc. Technol. Lett., 4 (6), 238–243. https://doi.org/10.1049/htl.2016.0096.

[18] Kumarasinghe, K.; Kasabov, N.; Taylor, D., (2020), "Deep Learning and Deep Knowledge Representation in Spiking Neural Networks for Brain-Computer Interfaces," Neural Netw., 121, 169–185. https://doi.org/10.1016/j.neunet.2019.08.029.

[19] Doryab, A.; Frost, M.; Faurholt-Jepsen, M.; Kessing, L. V.; Bardram, J. E., (2015), "Impact Factor Analysis: Combining Prediction with Parameter Ranking to Reveal the Impact of Behavior on Health Outcome," Pers. Ubiquitous Comput, 19 (2), 355–365. https://doi.org/10.1007/s00779-014-0826-8.

[20] Grünerbl, A.; Muaremi, A.; Osmani, V.; Bahle, G.; Ohler, S.; Tröster, G.; Mayora, O.; Haring, C.; Lukowicz, P., (2015), "Smartphone-Based Recognition of States and State Changes in Bipolar Disorder People," IEEE J. Biomed. Health Inform, 19 (1), 140–148. https://doi.org/10.1109/JBHI.2014.2343154.

[21] Faurholt-Jepsen, M.; Bauer, M.; Kessing, L., (2018), "V. Smartphone-Based Objective Monitoring in Bipolar Disorder: Status and Considerations," Int. J. Bipolar Disord., 6 (1), 6. https://doi.org/10.1186/s40345-017-0110-8.

[22] Bauer, M.; Grof, P.; Rasgon, N.; Glenn, T.; Alda, M.; Priebe, S.; Ricken, R.; Whybrow,

P., (2006), “Mood Charting and Technology: New Approach to Monitoring People with Mood Disorders,” Curr. Psychiatry Rev., 2 (4), 423–429. https://doi.org/10.2174/157340006778699747.

[23] Kumar, A.; Sharma, A.; Arora, A., (2019), “Anxious Depression Prediction in Real-Time Social Data,” SSRN Electron. J., https://doi.org/10.2139/ssrn.3383359.

[24] Liu, D.; Feng, X. L.; Ahmed, F.; Shahid, M.; Guo, J., (2021), “Detecting and Measuring Depression on Social Media Using a Machine Learning Approach: Systematic Review (Preprint),” JMIR Preprints, https://doi.org/10.2196/preprints.27244.

[25] Muhammad, A.; Ashjan, B.; Ghufran, M.; Taghreed, S.; Nada, A.; Nada, A.; Maryam, A., (2020), “Classification of Anxiety Disorders Using Machine Learning Methods: A Literature Review,” Insights Biomed Res, 4 (1). https://doi.org/10.36959/584/455.

[26] Islam, M. R.; Kabir, M. A.; Ahmed, A.; Kamal, A. R. M.; Wang, H.; Ulhaq, A., (2018), “Depression Detection from Social Network Data Using Machine Learning Techniques,” Health Inf. Sci. Syst., 6 (1), 8. https://doi.org/10.1007/s13755-018-0046-0.

[27] Shatte, A. B. R.; Hutchinson, D. M.; Teague, S. J., (2019), “Machine Learning in Mental Health: A Scoping Review of Methods and Applications,” Psychol. Med., 49 (9), 1426–1448. https://doi.org/10.1017/S0033291719000151.

[28] Portugal, L. C. L.; Schrouff, J.; Stiffler, R.; Bertocci, M.; Bebko, G.; Chase, H.; Lockovitch, J.; Aslam, H.; Graur, S.; Greenberg, T.; Pereira, M.; Oliveira, L.; Phillips, M.; Mourão-Miranda, J., (2019), “Predicting Anxiety from Wholebrain Activity Patterns to Emotional Faces in Young Adults: A Machine Learning Approach,” NeuroImage Clin., 23 (101813), 101813. https://doi.org/10.1016/j.nicl.2019.101813.

[29] Martínez, A.; Benítez, R.; Estrada, H.; Hernández, Y., (2018), “Predictive Model for Detection of Depression Based on Uncertainty Analysis Methods,” Proc. (MPDI), 2 (19), 551. https://doi.org/10.3390/proceedings2190551.

[30] Santosh, A.; Shinde, M.; Raja Rajeswari, P., (2018), “Intelligent Health Risk Prediction Systems Using Machine Learning: A Review,” International Journal of Engineering & Technology, 7 (3).

[31] Librenza-Garcia, D.; Kotzian, B. J.; Yang, J.; Mwangi, B.; Cao, B.; Pereira Lima, L. N.; Bermudez, M. B.; Boeira, M. V.; Kapczinski, F.; Passos, I. C., (2017), “The Impact of Machine Learning Techniques in the Study of Bipolar Disorder: A Systematic Review,” Neurosci. Biobehav. Rev., 80, 538–554. https://doi.org/10.1016/j.neubiorev.2017.07.004.

[32] Lee, H.-J., (2019), “Addendum to the Acknowledgements: Mood Prediction of People with Mood Disorder by Machine Learning Using Passive Digital Phenotypes Based on Circadian Rhythm: A Prospective Observational Cohort Study (Preprint),” JMIR Preprints, https://doi.org/10.2196/preprints.15966.

[33] Sun, Q.; Yue, Q.; Zhu, F.; Shu, K., (2019), "The Identification Research of Bipolar Disorder Based on CNN," J. Phys. Conf. Ser., 1168, 032125. https://doi.org/10.1088/1742-6596/1168/3/032125.

[34] Saylan, C.; Yilancioglu, K., (2016), "Classification of Schizophrenia and Bipolar Disorder by Using Machine Learning Algorithms," J. Neurobehav. Sci., 3 (3), 92. https://doi.org/10.5455/jnbs.1471026038.

[35] Rahman, R. A.; Omar, K.; Mohd Noah, S. A.; Danuri, M. S. N. M.; Al-Garadi, M. A., (2020), "Application of Machine Learning Methods in Mental Health Detection: A Systematic Review," IEEE Access,8, 183952–183964. https://doi.org/10.1109/access.2020.3029154.

[36] Mehta, M.; Julaiti, J.; Griffin, P.; Kumara, S., (2020), "Early Stage Machine Learning-Based Prediction of US County Vulnerability to the COVID-19 Pandemic: Machine Learning Approach," JMIR Public Health Surveill., 6 (3), e19446. https://doi.org/10.2196/19446.

[37] Gupta, M.; Vaikole, S., (2020), "Recognition of Human Mental Stress Using Machine Learning Paradigms," SSRN Electron. J., https://doi.org/10.2139/ssrn.3571754.

[38] Priya, A.; Garg, S.; Tigga, N. P., (2020), "Predicting Anxiety, Depression and Stress in Modern Life Using Machine Learning Algorithms," Procedia Comput. Sci., 167, 1258–1267. https://doi.org/10.1016/j.procs.2020.03.442.

[39] Goli, H.; Aparna, C., (2019), "Performance Research on Different Machine Learning Algorithms for Detection of Sleepy Spindles from EEG Signals," International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8 (9S2), 203–208.

[40] Saral, B.; Priya., (2019), "Screen Time Addiction and Psychological Metric Analysis among Teens Using Machine Learning Techniques," J. Adv. Res. Dyn. Control Syst., 11 (10-SPECIAL), 119–124. https://doi.org/10.5373/jardcs/v11sp10/20192782.

[41] Shrestha, A.; Dang, J.; Nakajima, K.; Wang, X., (2019), "Image Processing-Based Real-Time Displacement Monitoring Methods Using Smart Devices," Structural Control and Health Monitoring.

[42] Kiranashree, B.; Ambika, V.; Radhika, A., (2021) "Analysis on Machine Learning Techniques for Stress Detection among Employees," Asian Journal of Computer Science and Technology, 10 (1), 35–37.

[43] Vikhrov, I.; Ashirbaev, S., (2021), "Covid-19 Monitoring and Tracking System Using Information Technologies and Artificial Intelligence," Health Problems of Civilization.

[44] Kouris, I. N.; Makris, C. H.; Tsakalidis, A. K., (2005), "Using Information Retrieval Techniques for Supporting Data Mining," Data Knowl. Eng., 52 (3), 353–383. https://doi.org/10.1016/j.datak.2004.07.004.

[45] Gitlin, M.; Malhi, G. S., (2020), "The Existential Crisis of Bipolar II Disorder," Int. J. Bipolar Disord., 8 (1), 5. https://doi.org/10.1186/s40345-019-0175-7.

[46] Chien, I.; Enrique, A.; Palacios, J.; Regan, T.; Keegan, D.; Carter, D.; Tschiatschek, S.; Nori, A.; Thieme, A.; Richards, D.; Doherty, G.; Belgrave, D., (2020), "A Machine Learning Approach to Understanding Patterns of Engagement with Internet-Delivered Mental Health Interventions," JAMA Netw. Open, 3 (7), e2010791. https://doi.org/10.1001/jamanetworkopen.2020.10791.

[47] Mateo-Sotos, J.; Torres, A.; Santos, J.; Quevedo, O.; Basar, C., (2021) "A Machine Learning- Based Method to Identify Bipolar Disorder People," Circuits, Systems, and Signal Processing.

[48] Vinodh., (2020), "Perspective Analysis of Dyslexia Detection among Children's Using Paradigms of Machine Learning and Artificial Intelligence," J. Adv. Res. Dyn. Control Syst., 12 (7), 582–589. https://doi.org/10.5373/jardcs/v12i7/20202041.

[49] Agnihotri, N.; Prasad, S. K., (2022), "Review on Machine Learning Techniques to Predict Bipolar Disorder," Turk. J. Comput. Math. Educ. (TURCOMAT), 13 (2), 195–206.

[50] Agnihotri, N.; Prasad, S. K., (2021), "Predicting the Symptoms of Bipolar Disorder in People Using Machine Learning," In 2021 10th International Conference on System Modeling & Advancement in Research Trends (SMART); IEEE; pp 697–702.

[51] Agnihotri, N.; Prasad, S. K., (2022), "Bipolar Disorder: Early Prediction and Risk Analysis using Machine Learning," YMER; 21(8); pp 958-980.

[52] Stahl, S.M., (2018), "Depression and Bipolar Disorder," Cambridge University Press.

[53] Rawat, S. S.; Alghamdi, S.; Kumar, G.; Alotaibi, Y.; Khalaf, O. I.; Verma, L. P.; (2022), "Infrared Small Target Detection Based on Partial Sum Minimization and Total Variation," MDPI; 10(4); pp 671

[54] Dia, I.; Ahvar, E.; Lee, G. M.; (2022), "Performance Evaluation of Machine Learning and Neural Network-Based Algorithms for Predicting Segment Availability in AIoT-Based Smart Parking,"Network; 2(2); 225–238. https://doi.org/10.3390/network2020015.

[55] Cooper, A.; Horrocks, J.; Goodday, S.; Keown-Stoneman, C.; Duffy, A., (2021), "Predicting the risk and timing of major mood disorder in offspring of bipolar parents: exploring the utility of a neural network approach," International Journal of Bipolar Disorders; 9(1). https://doi.org/10.1186/s40345-021-00228-2

[56] Wessa, M.; Kanske, P.; Linke, J., (2014), "Bipolar disorder: a neural network perspective on a disorder of emotion and motivation," Restorative neurology and neuroscience; 32(1); 51–62. https://doi.org/10.3233/RNN-139007.

[57] Ortiz, A.; Bradler, K.; Mowete, M.; MacLean, S.; Garnham, J.; Slaney, C.; Mulsant, B. H.; Alda, M., (2021), "The futility of long-term predictions in bipolar disorder: mood fluctuations are the result of deterministic chaotic processes," International journal of bipolar disorders; 9(1); 30. https://doi.org/10.1186/s40345-021-00235-3.

[58] Benacek, J.; Martin-Key, N. A.; Spadaro, B.; Tomasik, J.; Bahn, S., (2022), "Using decision-analysis modelling to estimate the economic impact of the identification of unrecognised bipolar disorder in primary care: the untapped potential of screening," International journal of bipolar disorders; 10(1); 15. https://doi.org/10.1186/s40345-022-00261-9

[59] de Oliveira, L.; Portugal, L. C.; Pereira, M.; Chase, H. W.; Bertocci, M.; Stiffler, R., Greenberg, T.; Bebko, G.; Lockovich, J.; Aslam, H.; Mourao-Miranda, J.; & Phillips, M. L., (2019), "Predicting Bipolar Disorder Risk Factors in Distressed Young Adults From Patterns of Brain Activation to Reward: A Machine Learning Approach," Biological Psychiatry: Cognitive Neuroscience and Neuroimaging; 4(8); 726–733. https://doi.org/10.1016/j.bpsc.2019.04.005

[60] A. R. Subhani.; W. Mumtaz.; M. N. B. M. Saad.; N. Kamel.; A. S. Malik., "Machine Learning Framework for the Detection of Mental Stress at Multiple Levels," IEEE Access; vol. 5; pp. 13545-13556; 2017; doi: 10.1109/ACCESS.2017.2723622.

[61] Rios, A. C.; Noto, M. N.; Rizzo, L. B.; Mansur, R.; Martins, F. E.; Jr, Grassi-Oliveira, R.; Correll, C. U.; Brietzke, E., (2015), "Early stages of bipolar disorder: characterization and strategies for early intervention," Revista brasileira de psiquiatria (Sao Paulo, Brazil : 1999); 37(4); 343–349; https://doi.org/10.1590/1516-4446-2014-1620.

[62] Valenza, G.; Nardelli, M.; Lanata', A.; Gentili, C.; Bertschy, G.; Kosel, M.; Scilingo, E. P.; (2016), "Predicting Mood Changes in Bipolar Disorder through Heartbeat Nonlinear Dynamics," IEEE journal of biomedical and health informatics; 20(4); 1034–1043; https://doi.org/10.1109/JBHI.2016.2554546.

[63] Hanssen, I.; van Dord, M. I.; Compen, F. R.; Geurts, D. E. M.; Schellekens, M. P. J.; Speckens, A. E. M., (2019), "Exploring the clinical outcome of Mindfulness-Based Cognitive Therapy for bipolar and unipolar depressive People in routine clinical practice: a pilot study," International journal of bipolar disorders; 7(1);18;https://doi.org/10.1186/s40345-019-0153-0.

[64] Ortelbach, N.; Rote, J.; Dingelstadt, A. M. L.; Stolzenburg, A.; Koenig, C.; O'Malley, G.; Quinlivan, E.; Fiebig, J.; Pfeiffer, S.; König, B.; Simhandl, C.; Bauer, M.; Pfennig, A.; Stamm, T. J., (2022), "The big five model in bipolar disorder: a latent profile analysis and its impact on longterm illness severity," International journal of bipolar disorders; 10(1); 1. https://doi.org/10.1186/s40345-021-00248-y.

[65] Lee, C. Y.; Zeng, J. H.; Lee, S. Y.; Lu, R. B.; Kuo, P. H., (2021), "SNP Data Science for Classification of Bipolar Disorder I and Bipolar Disorder II," IEEE/ACM transactions on

computational biology and bioinformatics; 18(6); 2862–2869; https://doi.org/10.1109/TCBB.2020.2988024.

[66] Anand Thoutam, V.; Srivastava, A.; Badal, T.; Kumar Mishra, V.; Sinha, G. R.; Sakalle, A.; Bhardwaj, H.; Raj, M., (2022), "Yoga Pose Estimation and Feedback Generation Using Deep Learning," Computational intelligence and neuroscience; 4311350; https://doi.org/10.1155/2022/4311350.

[67] Ceccarelli, F.; and Mahmoud, M., (2021), "Multimodal temporal machine learning for bipolar disorder and depression recognition," Pattern Analysis and Applications; 25(3); 493-504; doi: 10.1007/s10044-021-01001-y.

[68] Vieta, E.; Salagre, E.; Grande, I.; Carvalho, A.F.; Fernandes, B.S.; Berk, M.; Birmaher, B.; Tohen, M.; Suppes, T., (2018), "Early Intervention in Bipolar Disorder," Am J Psychiatry; 175(5); 411-426. doi:10.1176/appi.ajp.2017.17090972.

[69] Fast, J. A.; Preston, J., (2006), "Take Charge of Bipolar Disorder. In A 4-Step Plan for You and Your Loved Ones to Manage the Illness and Create Lasting Stability," https://doi.org/10.1604/9780446697613

[70] Yildiz, A.; Ruiz, P.; Nemeroff, C., (2015), "The Bipolar Book: History, Neurobiology, and Treatment"

[71] Fountoulakis, K. N., (2014), "Bipolar Disorder. In An Evidence-Based Guide to Manic Depression"

[72] Yatham, L.N., (2010), " Bipolar Disorder: Clinical and Neurobiological Foundations"

[73] Miklowitz, D. J., (2019), "The Bipolar Disorder Survival Guide. In What You and Your Family Need to Know," The Guilford Press.

[74] Bauer, M.; Kilbourne, A.; Greenwald, D., (2009), "Overcoming Bipolar Disorder: In A Comprehensive Workbook for Managing Your Symptoms and Achieving Your Life Goals," https://doi.org/10.1604/9781572245648

[75] Mondimore, F. M., (2014), "Bipolar Disorder. In A Guide for People and Families"

[76] Theobald, O., (2018), "Machine Learning for Absolute Beginners," In A Plain English Introduction.

[77] Goodfellow, I.; Bengio, Y.; Courville, A., (2016), "Deep Learning"

[78] Hack, S., (2019), "Machine Learning. In 4 Books in 1: A Complete Overview for Beginners to Master the Basics of Python Programming and Understand How to Build Artificial Intelligence Through Data Science"

[79] Deisenroth, M. P.; Faisal, A. A.; Ong, C. S., (2020), "Mathematics for Machine Learning"

[80] Bonaccorso, G., (2018), "Machine Learning Algorithms. In Popular Algorithms for Data Science and Machine Learning, 2nd Edition"

[81] Jo, T., (2021), "Machine Learning Foundations. In Supervised, Unsupervised, and Advanced Learning. Springer" https://doi.org/10.1007/978-3-030-65900-4

[82] B. Saha, T. Nguyen, D. Phung, and S. Venkatesh, "A framework for classifying online mental health-related communities with an interest in depression," IEEE Journal of Biomedical and Health Informatics, vol. 20, no. 4, pp. 1008–1015, 2016. doi:10.1109/jbhi.2016.2543741

[83] L. Sivagnanam and N. Karthikeyani Visalakshi, "Multimodal Machine Learning Framework to detect the bipolardisorder," Advances in Parallel Computing Algorithms, Tools and Paradigms, 2022. doi:10.3233/apc220019

[84] R. Saranya and S. Niraimathi, "BD-MDL: BIPOLAR DISORDER DETECTION USING MACHINE LEANRING AND DEEP LEARNING," Journal of Pharmaceutical Negative Results, pp. 5892–5905, 2022. doi:10.47750/pnr.2022.13.S07.715

[85] J. Chung and J. Teo, "Mental health prediction using machine learning: Taxonomy, applications, and challenges,"Applied Computational Intelligence and Soft Computing, vol. 2022, pp. 1–19, 2022.doi:10.1155/2022/9970363

[86] F. Ceccarelli and M. Mahmoud, "Multimodal Temporal Machine Learning for bipolar disorder and depression recognition," Pattern Analysis and Applications, vol. 25, no. 3, pp. 493–504, 2021. doi:10.1007/s10044-021- 01001-y

[87] J. Tomasik et al., "A machine learning algorithm to differentiate bipolar disorder from major depressive disorder using an online mental health questionnaire and Blood Biomarker Data," Translational Psychiatry, vol. 11, no.1, 2021. doi:10.1038/s41398-020-01181-x

[88] Y. K. A and A. K. Saxena, “A novel predictive scheme for confirming state of bipolar disorder using recurrent decision tree,” International Journal of Advanced Computer Science and Applications, vol. 13, no. 2, 2022. doi:10.14569/ijacsa.2022.0130262

[89] M. Á. Luján, A. M. Torres, A. L. Borja, J. L. Santos, and J. M. Sotos, “High-precise bipolar disorder detection by using radial basis functions based neural network,” Electronics, vol. 11, no. 3, p. 343, 2022. doi:10.3390/electronics11030343

[90] D. Y. Mahmood and M. A. Hussein, “AnalyzingNB, DT and NBTree intrusion detection algorithms,” Journal of Zankoy Sulaimani - Part A, vol. 16, no. 1, pp. 69–76, 2014. doi:10.17656/jzs.10285

[91] H. Bhagwat and U. Gogate, “Reviewing Machine Learning Algorithms in the Domain of Healthcare,” International Journal of Engineering Research & Technology, vol. 10, no. 4, Apr. 2021. doi:10.17577/IJERTV10IS040014

[92] S. Uddin, A. Khan, M. E. Hossain, and M. A. Moni, “Comparing different supervised machine learning algorithms for disease prediction,” BMC Medical Informatics and Decision Making, vol. 19, no. 1, 2019. doi:10.1186/s12911-019-1004-8

[93] V. Rupapara et al., “Blood cancer prediction using leukemia microarray gene data and hybrid logistic vector trees model,” Scientific Reports, vol. 12, no. 1, 2022. doi:10.1038/s41598-022-04835-6

[94] R. Ahuja and A. Banga, “Mental stress detection in university students using machine learning algorithms,”Procedia Computer Science, vol. 152, pp. 349–353, 2019. doi:10.1016/j.procs.2019.05.007

[95] J. Bektaş and T. Ibrikci, “Hybrid classification procedure using SVM with LR on two distinctive datasets,” Proceedings of the 6th International Conference on Software and Computer Applications, 2017.doi:10.1145/3056662.3056717

[96] Vandana, N. Marriwala, and D. Chaudhary, “A hybrid model for depression detection using Deep Learning,” Measurement: Sensors, vol. 25, p. 100587, 2023. doi: 10.1016/j.measen.2022.100587

[97] P. J. Moore, M. A. Little, P. E. McSharry, J. R. Geddes, and G. M. Goodwin, “Forecasting depression in bipolar disorder,” IEEE Transactions on Biomedical Engineering, vol. 59, no. 10, pp. 2801–2807, 2012. doi:10.1109/tbme.2012.2210715

[98] H. Kour and M. K. Gupta, “An hybrid deep learning approach for depression prediction from user tweets using feature-rich CNN and bi-directional LSTM,” Multimedia Tools and Applications, vol. 81, no. 17, pp. 23649– 23685, 2022. doi:10.1007/s11042-022-12648-y

[99] S. K. Prasad and N. Agnihotri, “Implementing machine learning techniques to predict bipolar disorder,” International Journal of Medical Engineering and Informatics, vol. 1, no. 1, p. 1, 2022. doi:10.1504/ijmei.2022.10052205

[100] A. Cooper, J. Horrocks, S. Goodday, C. Keown-Stoneman, and A. Duffy, “Predicting the risk and timing of majormood disorder in offspring of bipolar parents: Exploring the utility of a neural network approach,” International Journal of Bipolar Disorders, vol. 9, no. 1, 2021. doi:10.1186/s40345-021-00228-2

[101] V. Bellandi et al., “A methodology to engineering continuous monitoring of intrinsic capacity for elderly people,”Complex & Intelligent Systems, vol. 8, no. 5, pp. 3953–3971, 2022. doi:10.1007/s40747-022-00775-w

[102] R. Rone Sarra, A. Musa Dinar, and M. Abed Mohammed, “Enhanced accuracy for heart disease prediction using Artificial Neural Network,” Indonesian Journal of Electrical Engineering and Computer Science, vol. 29, no. 1, p. 375, 2022. doi:10.11591/ijeecs. v29.i1. pp375-383

[103] M. B. Fonseca, R. S. Andrades, S. de Bach, C. D. Wiener, and J. P. Oses, “Bipolar and schizophrenia disorders diagnosis using artificial neural network,” Neuroscience

and Medicine, vol. 09, no. 04, pp. 209–220, 2018. doi:10.4236/nm.2018.94021

[104] M. Wessa, P. Kanske, and J. Linke, “Bipolar disorder: A Neural Network perspective on a disorder of emotion and motivation,” Restorative Neurology and Neuroscience, vol. 32, no. 1, pp. 51–62, 2014. doi:10.3233/rnn- 139007

[105] A. A. Rawi, M. K. Elbashir, and A. M. Ahmed, “Classification of 27 heart abnormalities using 12-lead ECG signals with combined deep learning techniques,” Bulletin of Electrical Engineering and Informatics, vol. 12, no. 4, pp. 2220–2235, 2023. doi:10.11591/eei.v12i4.4668

[106] Y. Ramdhani, C. M. Putra, and D. P. Alamsyah, “Heart failure prediction based on random forest algorithm using genetic algorithm for feature selectio,” International Journal of Reconfigurable and Embedded Systems (IJRES), vol. 12, no. 2, p. 205, 2023. doi:10.11591/ijres.v12.i2.pp205-214

[107] S. Gouraguine, M. Riad, M. Qbadou, and K. Mansouri, “Dysgraphia detection based on convolutional neural networks and child-robot interaction,” International Journal of Electrical and Computer Engineering (IJECE), vol. 13, no. 3, p. 2999, 2023. doi:10.11591/ijece.v13i3.pp2999-3009

[108] A. P. Begum and P. Selvaraj, “Alzheimer’s disease classification and detection by using AD-3D DCNN model,” Bulletin of Electrical Engineering and Informatics, vol. 12, no. 2, pp. 882–890, 2022. doi:10.11591/eei.v12i2.4446

[109] A.-A. Nayan et al., “A deep learning approach for brain tumor detection using magnetic resonance imaging,” International Journal of Electrical and Computer Engineering (IJECE), vol. 13, no. 1, p. 1039, 2023. doi:10.11591/ijece.v13i1.pp1039-1047

[110] H. S. Hamid, B. AlKindy, A. H. Abbas, and W. B. Al-Kendi, “An intelligent strabismus detection method based on Convolution Neural Network,” TELKOMNIKA (Telecommunication Computing Electronics and Control), vol. 20, no. 6, p. 1288, 2022.

doi:10.12928/telkomnika.v20i6.24232

[111] N. Nagesh, P. Patil, S. Patil, and M. Kokatanur, “An architectural framework for automatic detection of autism using deep convolution networks and genetic algorithm,” International Journal of Electrical and Computer Engineering (IJECE), vol. 12, no. 2, p. 1768, 2022. doi:10.11591/ijece.v12i2.pp1768-1775

[112] H. A. Aal, S. A. Taie, and N. El-Bendary, “An optimized RNN-LSTM approach for parkinson’s disease early detection using speech features,” Bulletin of Electrical Engineering and Informatics, vol. 10, no. 5, pp. 2503–2512, 2021. doi:10.11591/eei.v10i5.3128

[113]A. Darmawahyuni, S. Nurmaini, M. N. Rachmatullah, F. Firdaus, and B. Tutuko, “Unidirectional-bidirectional recurrent networks for cardiac disorders classification,” TELKOMNIKA (Telecommunication Computing Electronics and Control), vol. 19, no. 3, p. 902, 2021. doi:10.12928/telkomnika.v19i3.18876

[114] A. Kifouche and A. Guessoum, “Tracking times in temporal patterns embodied in intra-cortical data for controling neural prosthesis an animal simulation study,” International Journal of Electrical and Computer Engineering (IJECE), vol. 10, no. 5, p. 4721, 2020. doi:10.11591/ijece.v10i5.pp4721-4737

[115] M. S. AL-Huseiny, N. K. Abbas, and A. S. Sajit, “Diagnosis of arrhythmia based on ECG analysis using CNN,” Bulletin of Electrical Engineering and Informatics, vol. 9, no. 3, pp. 988–995, 2020. doi:10.11591/eei.v9i3.2172.

[116] N. Azman, M. K. Ghani, S. R. Wicaksono, B. Kurniawan, and V. Repi, “Insomnia analysis based on internet of things using electrocardiography and electromyography,” TELKOMNIKA (Telecommunication Computing Electronics and Control), vol. 18, no. 3, p. 1406, 2020. doi:10.12928/telkomnika.v18i3.14897.

[117] Devastator, T. (2022) Global trends in mental health disorder, Kaggle. Available at: https://www.kaggle.com/datasets/thedevastator/uncover-global-trends-in-mental-

health-disorder (Accessed: 22 December 2023).

[118] Bruna, M.O. (2019) Theory of mind in remitted bipolar disorder, Kaggle. Available at: https://www.kaggle.com/datasets/mercheovejero/theory-of-mind-in-remitted-bipolar-disorder (Accessed: 22 December 2023).

[119] Moitra M;Owens S;Hailemariam M;Wilson KS;Mensa-Kwao A;Gonese G;Kamamia CK;White B;Young DM;Collins PY; (no date) Global Mental Health: Where we are and where we are going, Current psychiatry reports. Available at: https://pubmed.ncbi.nlm.nih.gov/37256471/ (Accessed: 22 December 2023)