Detection of Bipolar Disorder Using Machine Learning with MRI

R Sujatha, K Tejesh, H Krithi and H Rasiga Shri

School of Information Technology and Engineering, Vellore Institute of Technology, Vellore, Tamilnadu, India

Abstract

Bipolar disorder is a mental ailment caused by maximal mood swings with emotional highs and lows. Nowadays, this has become the most common abnormality related to mental health and furthermore it is ignored by people of all age groups. Bipolar disease is generally heritable but not all siblings of the family will be having it though, and will be having same genetics and the factors which can be risky. Here we use random forest algorithm, along with the Mag- netic Resonance Imaging (MRI) information. The utility of these irregularities in recognizing individual bipolar disorder patients from state of mind issue or health controls define patients dependent on their illness. Here we use machine learning algorithms like Random forest algorithm and CNN-mdrp(multimodal disease risk prediction) for the accuracy .We give the risk factor and stage of the healthy patient with the attributes we collected from the MRI. We use a trained dataset and machine learning algorithms mentioned above to get the output. Voxel-Based Morphometry (VBM) will be used to dividing and pre-processing the MRI infor- mation obtained. To see the changes in Gray Matter (GM) and White Matter (WM) of the different data groups individually, a simple equation is use and also the Principle Component Analysis will be used and The project gives you the output showing that CNN MDRP with random forest has high accuracy than other algorithms in bipolar disease prediction.

Keywords

Magnetic Resonance Imaging, Random forest algorithm, Gray mat- ter, White matter, Voxel based morphometry, CNN-mdrp (multimodal disease risk prediction)

1. Introduction

Mental sickness is one of the most dangerous and life-threatening ailments. One must always take good care of their mental state of mind. There are various proposed system to identify the mental conditions of an individual. These systems were developed using some combination of machine learning algorithms working with collected data sets to train and test the model.[2]

However, this existing system has some defects that are to be rectified. The collected samples for the data set is insufficient. The attributes that are used in the data sets cannot be a fixed one, it changes with person and the disease they suffer from. [12]

Detection of Bipolar disease at an early stage enables patients to have a much higher chances of recovery and healthy survival. Therefore, even though we can't prevent it from affecting us, we can certainly detect this at an early stage so as to provide the appropriate medical help at the right time to the right people. [5]

The main motive of this paper is to develop a system that detects Bipolar diseases with more accuracy and less cost using CNN-MDRP algorithm and random forest classification which is proven to be giving more accurate results.

There is no accuracy in the present algorithms. Improvising the algorithms to include more productivity of the framework subsequently improving its working isn't finished. There is no appropriate online bipolar determination framework that are utilized in clinics and hospitals as of now. [8]

The proposed random forest Machine Learning Algorithm for classifying the data not only will predict the diseases but also its sub diseases, predicting sub diseases increases the accuracy of the system and the Deep learning algorithm CNN-mdrp is used for the accuracy prediction and from the results it shows that CNN-mdrp has high ac- curacy in fact better than CNN-udrp algorithm.

2. Existing System

The current system for Bipolar disorder disease prediction system uses random forest algorithm which actually determines the features present in the data set and makes it a decision factor at the level of dec. [17] Now the obtained testing samples are deliberately compared with the decision attributes at each level to test if a patient is screened positive or negative. Machine could predict only the disease but cannot predict sub types and risk stage of the diseases. It fails to anticipate and predict all potential states of the people. In the past, System

International Semantic Intelligence Conference (ISIC), February 25-27,2021 New Delhi, India

r.sujath@vit.ac.in (R. Sujatha); k.tejesh2017@vitstudent.ac.in (K. Tejesh); krithi.h2017@vitstudent.ac.in (H. Krithi); hrasiga.shri2017@vitstudent.ac.in (H. Rasiga Shri)
https://github.com/TEJESH-K (K. Tejesh);
https://github.com/krithi0506 (H. Krithi);
https://github.com/Rasiga-Shri (H. Rasiga Shri)

took care of just organized information. The standing associations arrange a blend of ML algorithms which are reasonably good at predicting illnesses or the disease. [13] But the limitations with the common framework exists. A machine can predict and explain a disease yet can't speak about the sub kinds of the diseases caused by the already existing disease. [18]

3. Literature Survey

This paper solves many problems related to Bipolar disorder detection. Many a times the doctors and patients mistake Major Depressive Disorder as Bipolar Disorder, this paper shows up many solutions for the doctors and patients to get diagnosed and treated with the disease.

In another system, the patients with neuroanatomical abnormalities were classified using Three- Dimensional magnetic resonance imaging (3DMRI). This system also focuses on the unaffected individuals who are blood- related to the patients suffering from Bipolar disorder.[6]

This paper uses machine learning algorithm to screen bipolar disorder by using Mood Disorder Questionnaire (MDQ), with decision tree algorithm. the data set is fed into the decision tree classifier which determines the significant features in dataset and make it decision factor at that level of decision tree.[14]

In this paper, early detection of bipolar disorder is done by using screening question- naire data for around 300 respondents and it served as a knowledge base to be processed using back propagation algorithm, which was the drawback in the previous research paper.[9]

In this paper, the patients suffering from BD were analyzed and the change in their mental states was identified. A dataset was created by monitoring their characteristics and the features was gathered to this disorder. [10]

In this paper ,1 dimensional time domain data of the fNIRS, is acquired while preparing tasks, which is used to train a set of neural networks for the diagnosis of common mood disorder, the Bipolar Disorder. With this the healthy individuals and the affected ones were classified and deep learning algorithms were employed in the detection of the disorder.[7]

In this paper, 65 individuals were isolated and examined. Their activities were rec- orded. Here, Voxel-based morphometry was used to investigate the brain anatomy from the patient's MRI. The study included 26 Bipolar patients and 38 Healthy individuals. The t-test based statistical method was also employed to group the affected individuals.[3]

In the following paper, a complete system is been developed for the Therapeutic Drug Monitoring (TDM). Here, the disease is diagnosed from the lithium present in the sweat of people affected by this disorder. This platform incorporates paper fluidics and the stable Reference Electrode (RE). The detection of Lithium is based on presence of potentiometric Ion-Selective Electrode (ISE) accompanied by a nanostructured solid contact. [4]

In this paper, they raised a SVM model using the NumPy library in python. They considered the structural and functional attributes taken from the MRI report of the patients. They also used many unique features collected from the MRI report of the affected individuals. This new invention of combining the structural and the functionals attributes of the brain anatomy improved the overall efficiency of the system. It also increased the accuracy of the system.[11]

In this paper, they examined the neurotrophic factors of the individuals, and analysed if these factors will influence in the timely detection of the Bipolar disorder. They employed the model-based algorithm for the identification. As a result of this paper neurotrophic factors were successfully found to assess the disorder.[26]

In this paper, they have used a sensitized T-shirt that records the patient's Neurotrophic factors. Here, decision tree algorithm is employed to classify the patients suffering from Bipolar disorder and the healthy ones. This T-shirt accurately predicted the Neurotrophic factors of the affected individuals and predicted the border value range of the factors.[16]

In this paper, the bipolar state relapse disorder is identified among the patients using certain attributes collected from patient's smartphones. Nowadays, smartphones are capable of monitoring the individual's heart rate, blood pressure rate etc. This disorder was successfully detected.[21]

The other paper, introduced an approach to study the mood disorder with respect to the patterns present in the emotions of the affected people. They introduced LASM - Latent Effective model to locate the connections in the emotions of people. They used six videos for the detection of the disorder. These videos were the recorded emotional videos. The study concluded that this method gave more accuracy than the existing one.[15]

In this paper, this system detects the mood disorder. The system works with LSTM- based approach for modeling the long-range speech of people, it analyses the mood of the person from their speech. The database contained of recorded speeches of different people mixed with different kinds of emotions. The SVM algorithm is also employed for the detection patients suffering mood disorder.[23]

This paper identifies the periods of depression of the patients suffering from bipolar disorder using the movements recorded from mobile location. They have used the quadratic linear regression model to monitor the characteristics of the affected individuals. This also facilitates the doctors to identify those people who are in the need of critical care.[20]

In this paper they monitored the patients of BD and

concluded that the report generated from the smartphone data matched up with the depressive states. This paper resulted that high methodological rigor along with large sample of patients affected with

bipolar disorder having manic symptom addressing doze factors before being implemented using monitoring tool.[19]

4. Methodology

4.1. DICOM

Expanded as Digital imaging and communications in medicine, is used as a standard for taking medical data as input .For example when we try to integrate medical imaging appliances , we use the DICOM standard. And here for taking the inputs from the MRI scans, we use this standard for getting the data and using it for next step. It is an international standard to send , save and print the medical imaging data, and The National Electrical Manufacturers Association(NEMA) holds the all the copyrights of the above standard After the process of getting the data from the MRI scanning , we are going to covert into NIFTI and segment the data obtained into white matter(WM) and grey matter(GM) which is later be undergoing normalization process and then the obtained output will be going through smoothing will generate a 3D Mask finally, which is used in the next process.

4.2. Voxel based Morphometry

Voxel based Morphometry technique is used to process the identified defects in the brain and prepossess them. The Voxel-based morphometry computes the changes that occurs in the structure of the brain that is obtained from the magnetic resonance imaging (MRI) . This is used to identify the structural changes that occurs in brain of the affected individuals. The brain of the affected patients, consist of greater gray matter volume in the left temporal lobe and central gray matter structures bilaterally.[1] So, Voxel Based Morphometry is used to identify structural changes in voxel-based comparison of multiple brain MRI images.

4.3. Principle Component Analysis

The Figure 1 represents the principal components of bipolar that contains differenti- ated voxels got by using certain methods are represented as Voxel of Interests. PCA is used to decrement the proportions of the Voxel that are obtained from Interests data. Here PCA is a dimensionality reduction method used in large datasets to reduce dimen- sions by transforming large set of variables into smaller set which contains almost every information in the large sets. We are doing this because smaller datasets

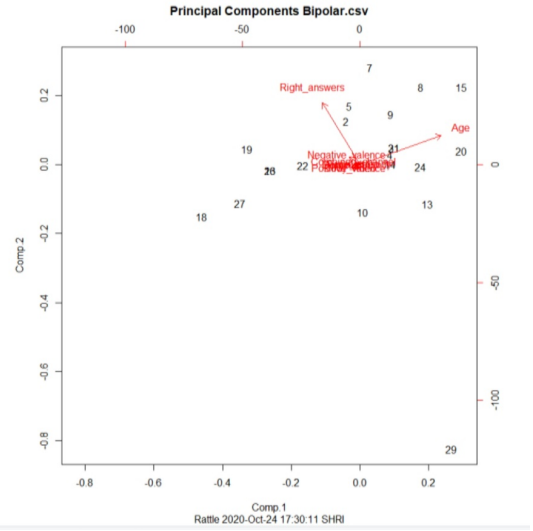

Figure 1: Principal component analysis of Bipolar dataset

makes the analysis process of data much easier and it makes it faster for machine learning algo- rithms as there is no extra variables to process. [22]

4.4. Correlation of Matrix of the Dataset

The Figure 2 represents the correlation matrix which gives us the information about the correlation coefficients between the values taken, above colorful matrix represents all the values of the considered dataset and each cell in the image shows the correlation between the values of the dataset. It is mainly used to congregate the data which is taken as the input and analyze how it going to process and work, this matrix is mainly used in the advanced analysis or as the basic fundamental structure for the advanced analysis.

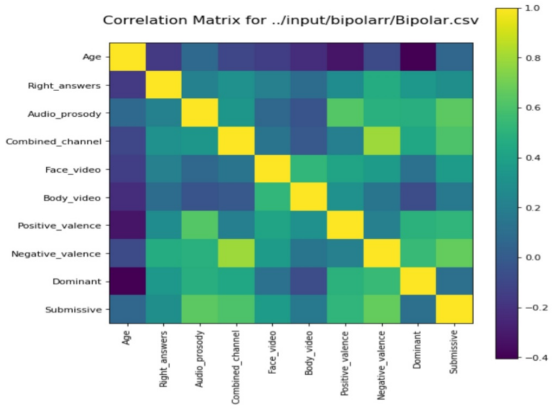

Figure 2: Correlation Matrix of the Dataset

4.5. Scatter and Density plot

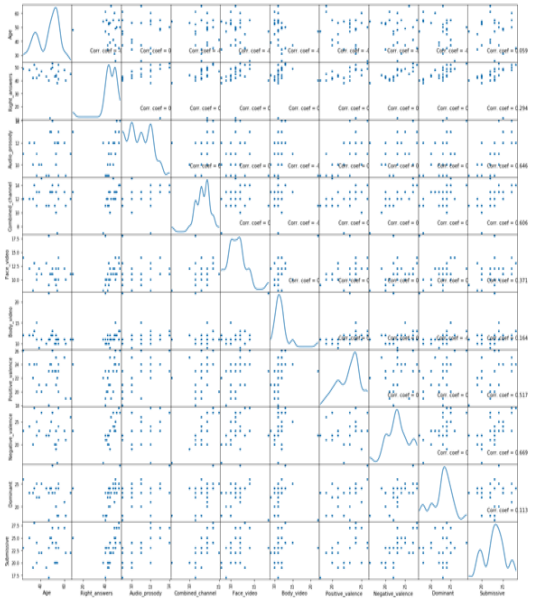

Figure 3: Scatter and Density plot

The above Figure 3 The scatter and density plot represents above gives the details of the values distributed in the data set we have taken , and it is very useful in comparing and plotting the scatter plot and it also shows us how many dots or the values are being concentrated on a single d plane or the area considered, by this we can assess the characteristics of the data and also we can predict the behavior up to an extent.

5. Proposed System

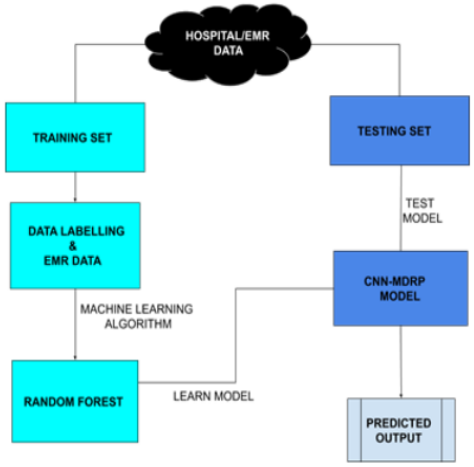

Figure 4: Architecture diagram of our system

The Figure 4 represents the architecture of our system and the application is been developed both in front- end and back-end. SQLite is used for storing all the patient and doctor information as well as reports. The Random forest Machine Learning Algorithm not only will predict the diseases but also its sub diseases. Map Reduce Algorithm which increases the efficiency of the operation and also it reduces the retrieval time of the query. [25] The proposed system is different from the ancestor's thought of execution It uses random forest machine learning procedure for calculating diseases and its respective sub diseases. which in turn increase the efficiency and performance and query response time is reduced too. Along with that, it gives separate patterns to each patient which gives the patient personalized experience. In addition to that, it provides definite rations for specific patients to pattern his/her condition. Thus, making our system broadly open by all at moderate cost. The prediction accuracy of the CNN-MDRP algorithm reaches 94% compared to other prediction algorithms.

All the data obtained about the patients from the hospital management is stored in this particular module like the MRI scans and the other types of data, mainly here we will be using both the structured and unstructured values of the attributes of brain anatomy, structured data refers to the data which is obtained from the reports of the patient and the unstructured data is something which we get from the patient's medical history and the informal conversations with the doctor and etc.

Training set and Testing data, for producing sophisticated results we perform training set where initial data help program how technologies like neural networks are

per- formed. In testing data, the obtained data will be checking for the execution of test case and verify the expected output in any of the software applications. DATA Labelling preparation, in this module we will be identifying raw data and further adding meaning and informative to provide the context so that we can prepare the data that could be enriched further. In this section we try to append or enrich the obtained data with relevant context gathered from other additional sources. Further this data is sent to the random forest classifier for classification of data ,Will also quantify the values of a out- come by providing a framework, CNN MDRP, uses both the structured and unstructured data for the prediction process, we collect the data form the medical clinics or hospitals and use CNN-MDRP to process the data and predict the risk of the disease, whereas CNN-UDRP which is in the existing system used only the structured data gives less accuracy than the proposed one.

6. CNN MDRP

Collection CNN-MDRP is performed to foresee who is influenced with the illness in an effective manner by utilizing convolutional neural network that utilizes structured and unstructured information from the hospital. To begin with, here we use the potential segment model to discover lacking data from the clinical records, from the dataset which we consider it as repository. Besides, with the assistance of factual information, we could manage the fundamental degenerative illness which is available in the past. Furthermore, dealing with the structured data by talking with clinic or the hospital specialists to get the reusable information and properties. For unorganized area, properties can be precisely abused through the CNN rule. In this way, we infer that the CNN- MDRP works the best for this specific problem.

For the assessment in the examination. To start with, we indicate TP (the number of occurrences accurately anticipated as required), FP, TN and FN as evident positive false positive (the quantity of cases erroneously anticipated as required), True negative (the quantity of examples accurately anticipated as not needed) and False negative (the number of examples mistakenly anticipated as not needed), separately. At that point, we can get four estimations:

accuracy, precision, recall and F1-measure as follows:

1. Accuracy = (TruePos + TrueNeg)/(TruePos + FalsePos + TrueNeg + FalseNeg)
2. Precision = TruePos/(TruePos + FalsePos)
3. Sensitivity = TruePos/(TruePos + FalseNeg)
4. Specificity = TrueNeg/(TrueNeg + FalsePos)

The process could be divided into in to 5 different parts:

6.1. Creating textual data

All the data collected from the clinic or the hospital, we use the word and insert into the first layer to remove the false wording, the text will be represented as a vector, we can also call it as the preprocessing. Here, each word will be outlined as Rd dimensional variable, where dia as 50, thus, a text that incorporates n words can be depicted as Tx = (tx1, tx2, ⋯, txn), Tx ∈ Rd × n.

6.2. CNN text transforming level

In each case we assess words. In some words, we incline towards 2 words from frontal and back of every factor of words in this issue.

6.3. CNN text pool layer

Taking the convolution layer output or the data as the grouping or gathering level information, we utilize a large gathering activity as possible (1-max gathering). The motivation behind why you pick the maximum or the greatest gathering system is the part of each expression is n't absolutely equivalent; from this we can decide the content or the matter which is useful to the system to proceed to the next step.

6.4. Fully connected layer of text CNN

This particular layer is related to the neural network which is fully connected, we have a process of calculating it in this layer, we have a formula which is Hf3=Wa3 Hf2=Bv3,where we say Hf3 is considered as the total connection level, and we can be considered as the artifact and Be can be considered as the deviations part

7. Result and discussions

Experimental results of this system indicate that among the existing algorithms CNN-mdrp gives us the best results with higher accuracy. In this system we used CNN-mdrp algorithm and made use of the structured and the unstructured data of the patients gathered from the clinical records of the hospital. No other system worked on both structured and unstructured data. Our proposed algorithm gives an accuracy of 94.3%. Thus, the introduced combination of the algorithms gave better results when compared to the existing systems. So this proposed system reduces the error rate and simultaneously increases the percentage of accuracy. And below we show the comparison and the explanation of the existing algorithms.

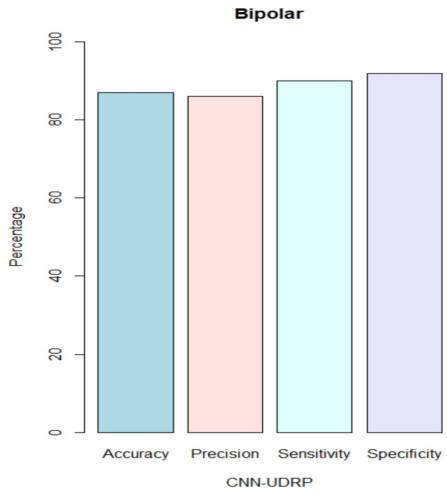

Figure 5: CNN-UDRP Using only Structured Data

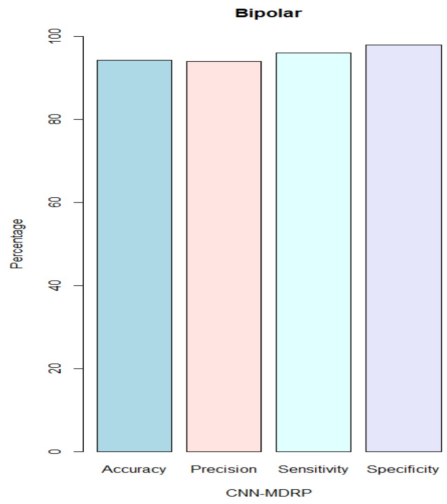

Figure 6: CNN-MDRP Using both Structured and Unstructured Data

7.1. LINEAR

The existing algorithms which have used previously are linear regression, SVM, Decision tree and the proposed one is random forest algorithm. Here what linear model means is it works completely based on supervised learning which is a part of machine learning. Prediction of value is done on independent variables by using regression models. The obtained accuracy for this algorithm is 63.3

7.2. SVM

Support vector machine algorithm (SVM)also works based on supervised learning for classification of problems. Here the optimal solution is obtained by transforming data by using techniques like kernel trick. The obtained accuracy for this algorithm is 88.9

7.3. DECISION TREE

The next algorithm used in the existing system is decision tree part of supervised learning used for classification of problem. Works by following a set of if-else condition to represent the data and categorize them. The obtained accuracy for this algorithm is 91.3

7.4. RANDOM FOREST

The proposed system uses random forest algorithm since it consists many decision trees within them, they use feature randomness while building each single tree to create the uncorrelated forest containing trees so that accuracy produced by this system automatically increases. The obtained accuracy for this algorithm is 94.3%.

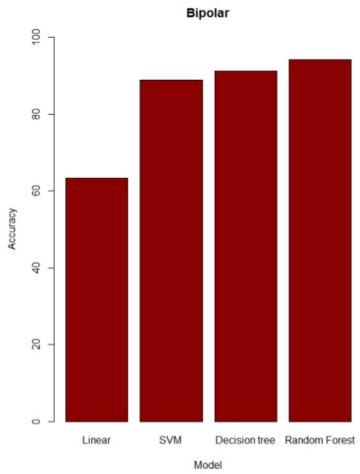

Figure 7: Graphical representation of Algorithms

Table 1
Comparison of Algorithms

Algorithm	Accuracy	Precision	Sensitivity	Specificity
Linear	63.3 %	0.6	0.7	0.58
SVM	88.9 %	0.88	0.8	0.86
Decision Tree	91.3 %	0.93	0.90	0.97
Proposed Model	94.3 %	0.94	0.96	0.98

8. Conclusion and Future work

The proposed system is completely based on the GUI where it focuses on reliability, scalability and how well it is adaptable to the user and this system can be easily expanded for any future requirements. This model could help many people by ultimately decreasing the cost required for treatment. Also this proposed system would help in satisfying the need for preparing the required instruments for clinical studies which is made available to doctors also for others who need to know the mental status of the patient. General doctors can use this instrument for initial diagnostics of mental condition of the patient.

9. References

[1] Sarıçiçek, A., Yalın, N., Hıdıroğlu, C., Çavuşoğlu, B., Taş, C., Ceylan, D., ... Özerdem, A. (2015). Neuroanatomical correlates of genetic risk for bipolar disorder: a voxel-based morphometry study in bipolar type I patients and healthy first-degree relatives. Journal of affective disorders, 186, 110-118.

[2] Vita, A., De Peri, L., Sacchetti, E. (2009). Gray matter, white matter, brain, and intracranial volumes in first-episode bipolar disorder: a meta-analysis of magnetic resonance imaging studies. Bipolar disorders, 11(8), 807-814.

[3] Cigdem, O., Beheshti, I., Demirel, H. (2018). Effects of different covari- ates and contrasts on classification of Parkinson's disease using structural MRI. Computers in biology and medicine, 99, 173-181.

[4] Occhiuzzi, C., Parrella, S., Camera, F., Nappi, S., Marrocco, G. (2020). RFID-based Dual-Chip Epidermal Sensing Platform for Human Skin Monitor- ing. IEEE Sensors Journal.

[5] Eker, C., Simsek, F., Yılmazer, E. E., Kitis, O., Cinar, C., Eker, O. D., ... Gonul, A. S. (2014). Brain regions associated with risk and resistance for

bipolar I disorder: a voxel-based MRI study of patients with bipolar disorder and their healthy siblings. Bipolar disorders, 16(3), 249-261.

[6] Cigdem, O., Soyak, R., Aydeniz, B., Oguz, K., Demirel, H., Kitis, O., ... Unay, D. (2019, October). Classification of healthy siblings of bipolar disorder patients from healthy controls using MRI. In 2019 Medical Technologies Congress (TIPTEKNO) (pp. 1-4). IEEE.

[7] Evgin, H. B., Babacan, O., Ulusoy, İ., Hoşgören, Y., Kuşman, A., Sayar, D., ... Özgüven, H. D. (2019, April). Classification of fNIRS Data Using Deep Learning for Bipolar Disorder Detection. In 2019 27th Signal Processing and Communications Applications Conference (SIU) (pp. 1-4). IEEE.

[8] Isometsä, E., Suominen, K., Mantere, O., Valtonen, H., Leppämäki, S., Pippingsköld, M., Arvilommi, P. (2003). The mood disorder questionnaire im- proves recognition of bipolar disorder in psychiatric care. BMC psychiatry, 3(1), 8.

[9] Fitriati, D., Maspiyanti, F., Devianty, F. A. (2019, September). Early Detection Application of Bipolar Disorders Using Backpropagation Algorithm. In 2019 6th International Conference on Electrical Engineering, Computer Sci- ence and Informatics (EECSI) (pp. 40-44). IEEE.

[10] Grünerbl, A., Muaremi, A., Osmani, V., Bahle, G., Oehler, S., Tröster, G., ... Lukowicz, P. (2014). Smartphone-based recognition of states and state changes in bipolar disorder patients. IEEE Journal of Biomedical and Health Informatics, 19(1), 140-148.

[11] Li, H., Cui, L., Cao, L., Zhang, Y., Liu, Y., Deng, W., Zhou, W. (2020). Identification of bipolar disorder using a combination of multimodality magnetic resonance imaging and machine learning techniques.

[12] Hirschfeld, R. M. (2002). The Mood Disorder Questionnaire: a simple, patient-rated screening instrument for bipolar disorder. Primary care compan- ion to the Journal of Clinical Psychiatry, 4(1), 9.

[13] Van Zaane, J., van den Berg, B., Draisma, S., Nolen, W. A., van den Brink, W. (2012). Screening for bipolar disorders in patients with alcohol or sub- stance use disorders: performance of the mood disorder questionnaire. Drug and Alcohol Dependence, 124(3), 235-241.

[14] Jadhav, R., Chellwani, V., Deshmukh, S., Sachdev, H. (2019, Janu- ary). Mental Disorder Detection: Bipolar Disorder Scrutinization Using Machine Learning. In 2019 9th International Conference on Cloud Computing, Data Sci- ence Engineering (Confluence) (pp. 304-308). IEEE.

[15] Huang, K. Y., Wu, C. H., Su, M. H., Kuo, Y. T. (2018). Detecting uni- polar and bipolar depressive disorders from elicited speech responses using latent affective structure model. IEEE Transactions on Affective Computing.

[16] Migliorini, M., Mariani, S., Bianchi, A. M. (2013, July). Decision tree for smart feature extraction from sleep HR in bipolar patients. In 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology So- ciety (EMBC) (pp. 5033-5036). IEEE.

[17] Castelo, M. S., Carvalho, E. R., Gerhard, E. S., Costa, C. M. C., Ferreira, E. D., Carvalho, A. F. (2010). Validity of the Mood Disorder Questionnaire in a Brazilian psychiatric population. Brazilian Journal of Psychiatry, 32(4), 424- 428.

[18Nederlof, M., Heerdink, E. R., Egberts, A. C. G., Wilting, I., Stoker, L. J., Hoekstra, R., Kupka, R. W. (2018). Monitoring of patients treated with lithium for bipolar disorder: an international survey. International journal of bipolar dis- orders, 6(1), 12.

[19] Faurholt-Jepsen, M., Bauer, M., Kessing, L. V. (2018). Smartphone- based objective monitoring in bipolar disorder: status and considerations. Inter- national journal of bipolar disorders, 6(1), 1-7.

[20] Palmius, N., Tsanas, A., Saunders, K. E. A., Bilderbeck, A. C., Geddes, J. R., Goodwin, G. M., De Vos, M. (2016). Detecting bipolar depression from geographic location data. IEEE Transactions on Biomedical Engineering, 64(8), 1761-1771.

[21] Schleusing, O., Renevey, P., Bertschi, M., Koller, J. M., Paradiso, R. (2011, March). Monitoring physiological and behavioral signals to detect mood changes of bipolar patients. In 2011 5th International Symposium on Medical Information and Communication Technology (pp. 130-134). IEEE.

[22] Conus, P., Macneil, C., McGorry, P. D. (2014). Public health signifi- cance of bipolar disorder: implications for early intervention and prevention. Bi- polar disorders, 16(5), 548-556.

[23] Yang, T. H., Wu, C. H., Huang, K. Y., Su, M. H. (2016, October). De- tection of mood disorder using speech emotion profiles and LSTM. In 2016 10th International Symposium on Chinese Spoken Language Processing (ISCSLP) (pp. 1-5). IEEE.

[24] McCormick, U., Murray, B., McNew, B. (2015). Diagnosis and treat- ment of patients with bipolar disorder: A review for advanced practice

nurses. Journal of the American Association of Nurse Practitioners, 27(9), 530- 542.

[25] Rocha-Rego, V., Jogia, J., Marquand, A. F., Mourao-Miranda, J., Sim- mons, A., Frangou, S. (2014). Examination of the predictive value of structural magnetic resonance scans in bipolar disorder: a pattern classification ap- proach. Psychological medicine, 44(3), 519-532.

[26] Zheng, Y., He, S., Zhang, T., Lin, Z., Shi, S., Fang, Y., ... Liu, X. (2019). Detection Study of Bipolar Depression Through the Application of a Model- Based Algorithm in Terms of Clinical Feature and Peripheral Biomarkers. Fron- tiers in psychiatry, 10, 266.