2022 10th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)
Amity University, Noida, India. Oct 13-14, 2022

2022 10th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) | 978-1-6654-7433-7/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICRITO56286.2022.9964524

Classification of Migraine Disease using Supervised Machine Learning

Seema Gulati
Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab
Rajpura, India
seemag.gulati@gmail.com

Kalpna Guleria*
Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab
Rajpura, India
guleria.kalpna@gmail.com

Nitin Goyal
Computer Science and Engineering Department, Shri Vishwakarma Skill University, Palwal, Haryana
India
er.nitin29@ieee.org

Abstract: **The study by Jama Network reveals that around 10% of the world is suffering from Migraine, which is a grievous disease of the brain and causes severe disability to the health of an individual. The pain in the head is so intense that the sufferers are unable to carry out their routine tasks once the migraine triggers. Therefore, it is considered the seventh most disease which can cause severe disability. Therefore, it is not only crucial to detect it at an early stage but also to identify the type of migraine for the sufferers to be treated timely. Machine learning has various applications related to the medical domain which supports the early prediction of disease. In this paper, five supervised machine learning methods have been used to classify the disease based on the symptoms of the subjects. The best-suited algorithm is found for the classification task and the implementation of the algorithms is completed using the Weka data mining tool. The results show that the best-suited algorithm out of the chosen popular models for the classification task is the simplistic model Naive Bayes.**

Keywords: Migraine Disease, Machine Learning, Classification, Naive Bayes, SMO (SVM), Logistic Regression, J48 (Decision Tree), Random Forest.

I. INTRODUCTION:

The brain plays a pivotal role in the functioning of the human body, and in the analogy of computer sciences, it is the central controlling unit that is responsible for all the internal and external activities of the physical body. Thus, any type of headache can interfere with the normal day today life of people. A migraine is usually said to be a severe headache, yet there is more to it than it appears on the outside. This is a neural disease that gives a person grievous, depleting, and agonizing pain, leaving the patient bed-ridden for days if untreated. The pain is usually triggered by locomotion, noise, and brightness. The sufferer, along with the scintillating pain experiences different problems like nausea, irritation, temporary vision loss, dysarthria or speech difficulty, numbness, etc. The intense pain of a migraine attack, although it causes a range of symptoms, but the most noted one is the hammering and pulsating pain that is felt on one side of the head, usually near the crown area. The pain worsens on mobilizing, bright lights, different smells and sounds, which might extend to hours or in the worst case even days. According to various researches around the world Migraine is ranked seventh most disabling disease in humans [1]-[2].

A whopping 10% of the population worldwide suffers from migraines, and migraine attacks are frequent in people aged 20 to 50 years of age. Also, the disease affects women more than men and the ratio is 3:1, the disease is thrice more prevalent in females than the males. A survey conducted in the US reveals that 17.1% of the females have symptoms of migraine in contrast to only 5.6% of males who suffer from migraine symptoms [3].

A. Aura associated with migraine:

Aura is a term associated with migraine that includes a list of symptoms that appear either before the migraine attack or along with it. The aura usually is a sign of warning that a migraine attack is about to come. Though an aura is usually misunderstood to be a stroke or a seizure, it occurs before the migraine headache strikes or even after in a few cases. Approximately 15-20 percent of the people with Migraine experience auras. There are a number of issues associated with an aura which are listed below, and the good news is that these issues are reversible in nature and can be treated or healed as well [4]–[6].

1. The appearance of flashing dots, sparkles, or lights which are quite bright.
2. At times the sight is interfered with by blind spots
3. Numbness and a tingling sensation are also witnessed.
4. There are changes in the speech and the sound.
5. Tinnitus, i.e., ringing in the ears, also is witnessed in some cases.
6. Difficulty in seeing or temporary loss of vision.
7. Visibility of jagged lines, impairing vision.
8. Perception of smell and taste change.

Categories of Migraine:

This neural disorder has different types, and there can be different names given to the same type [7]–[9]. The major classification of the malady on the basis of symptoms is given below.

Migraine without Aura: It is also termed a Common Migraine, and the alarm bell or the aura is not present in this type of migraine. Thus, the attack knocks with the migraine headache directly without giving any signal. The other symptoms are the same, with just the aura phase missing.

Migraine with Aura: It is also known as Complicated Migraine, and about 15-20% of the patients suffering from the disease go through an aura along with intense headaches. In most cases, the occurrence of aura alarms the patients about the migraine attack is about to follow.

Migraine without Headache: This type of migraine is generally known by the name Silent Migraine, and technically, it is called Acephalgic Migraine. The Acephalgic Migraine is accompanied by the aura symptoms but the headache that follows does not occur after or before the aura.

Hemiplegic Migraine: This is another serious type of Migraine that cause neurological changes or sensory changes on one of the sides of the body or a short-lived paralysis, technically called Hemiplegia, again on one side. This condition may or may not include pain in the head; the common symptoms that appear are numbness, feeling excessively weak on one of the sides, tingly sensations, losing sensation, changes in vision, and giddiness.

Migraine with brainstem aura: There is another term associated with the aura in this category of migraine known as basilar type aura. It was earlier used but nowadays, it is not commonly used. The attack of migraine has a different type of aura; the symptoms include vertigo or wobbliness or shakiness is experienced along with mumbling speech or slurry speech. In addition to these, a double image formation in sight or losing balance may be preceded by a headache. The malady may usually occur all of a sudden and can be linked to a ringing sound in the ears, fumbling while speaking, or nausea.

Chronic Migraine: A migraine that occurs for more than half of a month, i.e., 15 days or more, is termed a migraine of chronic level. The intensity of the pain varies and also the sickness or the symptoms that appear keep wavering. The sufferers need to take medication for longer periods like 10 to 15 days, and in turn that causes an upsurge in the frequency of headaches.

Status Migraine: This type of migraine seldom occurs and usually the migraine persists for more than 72 hours. The primary cause of this type of migraine is withdrawal from certain medications or starting some medications. The pain and the nauseousness in this type of migraine are intense and exhausting.

Diagnosis of Migraine:

The doctor of healthcare practitioner studies the complete medical history of the sufferer. The history is mainly the type of headaches and the frequency. The family history of migraine is also taken into account as many studies suggest genetic inheritance of the disease [10]-[11]. The chance of getting a migraine is 50% if one of the parents has a migraine history and it surges to 75% in case both parents have had migraine in the background.

To ascertain the migraine history, the practitioner would pose a set of questions to the subject which the subject has to report. The quiz would definitely comprise the following points:

1. Give a description of your headaches (adjectives), and their severity.
2. When the pain is usually experienced? Any particular event or date (associated with any even like mensuration in females).
3. Where is the pain located in your head? Which side or part of the head?
4. Is there any particular event or thing that worsens the pains or if it decreases the occurrence of any?
5. What is the frequency of the pain or headaches?
6. What happens before or after the headache? (looking for aura).
7. What is felt while you experience the headache? (looking for symptoms).
8. Are you on medications currently, or were you before?
9. Anybody in the immediate family or the generation before had such headaches? Or were you ever diagnosed with migraine?

The practitioner, after discussing the subject, may order a few tests in order to establish any doubts. These tests could be blood tests or imaging tests like a CT scan or an MRI scan to be sure of the root cause of the headache.

What is Machine Learning, and how can it be used in migraine?

Machine Learning is a subset of Artificial Intelligence that aims at getting closer to the pattern of human learning on the basis of the data available. The ML algorithms learn and relearn to improve the accuracy of the decisions or predictions made. ML has four major categories of learning models. These are classified on the basis of the dataset, and the type of learning methodology employed: supervised, unsupervised, semi-supervised, and reinforcement learning.

An important utility of Machine Learning is within the prognosis of illnesses, which can be in any other case, hard to diagnose[12]–[15]. The researchers have covered many different ways to detect the disease using MRI (Magnetic Resource Imaging), DTI (Diffusion Tensor Imaging), etc. Some efficient models have been developed by different researchers in the last five to six years to detect Migraine, which is a disabling disease. Classification into different Migraine types is done by only a few, which is evidently necessary for the treatment of the malady. ML can be proved to be quite fruitful and time-saving in this case [16]-[17].

II. Related work:

Some of the important research works in the classification of Migraine have been mentioned in this section. These studies are all based on the experiments conducted on the test images obtained from the subjects and thereafter applying Machine Intelligence to detect and classify them into Migraine Types.

The authors in [18] worked on classifying Migraine via Brain MRI. The intention of the research was to identify classifiers based on the measures of the structures of the brain. These measures were obtained with the help of MRI. The classification was to be done in 3 categories, Healthy Controls/ Episodic Migraine/ Chronic Migraine. The region of interest was the cortex, and the measures utilized were cortical thickness, surface area, and volume. PCA (Principal Component Analysis) was utilized to obtain the variability in the structure of the brain, approximately 85%. The experiment was conducted on a total of 120 participants, 66 of these were Migraineurs, and 54 were healthy individuals. The dataset was divided into a ratio 0f 90:10; 90% of the data was used for the training purpose and 10% for the testing of the algorithm. The classification algorithms included in the study were SVM (Support Vector Machine), DT (Decision Tree), DLDA (Diagonal Linear Discriminate Analysis), and DQDA (Diagonal Quadratic discriminate Analysis). The outputs of the experiments showed that the accuracies of DQDA and DT were the best out of these with DQDA being 68% and DT 64.7% accurate. The overall accuracy obtained for the binary classification of healthy controls and migraineurs was 67.2% for the DQDA model and 66.5% for the DT model.

The researchers in [19] also used machine learning approaches to establish biomarkers from resting-state functional MRI (Magnetic Resource Imaging) data that classifies data into healthy individuals and migraine sufferers. In this study, a total of 108 individuals have considered as subjects after the filtration process 58 of them were migraineurs and the rest were non-migraineurs fit individuals. The functional connections of regions of interest i.e., pain-related regions. These were 33 in magnitude and were fed into the Machine Learning classification model to obtain a binary classification. The obtained accuracy levels were higher for the migraineurs who were suffering from a time period of 14 years or higher in comparison to a shorter duration that is less than 14 years. The highest was 86.1% for the binary classification. The goal was fulfilled with the help of machine learning classification and the pain circuits in the brain which were formed with migraine were studied.

The research by [20] focussed on the classification of patients suffering from migraine without an aura and the individuals who do not suffer from migraine issues. The study has 21 patients with Migraine without aura and 28 non-sufferers. Both the rs-fMRI (resting-state functional MRI) and structural MRI were used to extract features for the classification purpose. There were 116 ROIs for each of the measures. After the feature extraction, the SVM model was used for the classification purpose using the cross-validation method. The method achieved an accuracy of 83.67%. The features which proved to be the determinants in the task at hand were Anterior Cingulate Cortex, Prefrontal, and Orbitofrontal Cortex.

Researchers in [21] have worked on the classification of migraine into three categories sporadic migraine, chronic, and medication overuse. They have worked on a dataset with a total of 52 subjects. The methodology employed here is a combination of 2 phases. In the first phase, the subjects had to take magnetic resonance with tensor in order to study the white matter and they were also tested on pain and emotions. The DTI images thus obtained and also the results of the test were then subjected to a set of feature selection methods in order to reduce the dataset. The algorithms used in the feature extraction of the images were Gradient Tree Boosting, L1-based, Univariate and Random Forest. In the second phase, some pre-trained classification models were used to classify the data points into one of the three categories as already stated above. The algorithms utilized for the purpose are: Naive Bayes, Support Vector Machine, and boosting. The approach improves the accuracy of migraine diagnostics classifiers in comparison to individual feature extraction. All three classifiers yielded an accuracy level of more than 90%. Also, they have concluded with the three most useful attributes leading to an increase in the classification accuracy are: pain, analgesics, and left uncinated brain.

Another study by [22] used Deep Learning algorithms for the Classification of Migraine. The authors have used resting-state functional magnetic resonance imaging (rs-fMRI) to distinguish the subjects into sufferers of Migraine and non-sufferers. The sufferers were further bifurcated into migraine with and without aura. Here the experimental setup included a total of 64 people, from which 28 were non-sufferers and 21 were sufferers without aura, and 15 with aura. The classification accuracy of the SVM (Support Vector Machine) algorithm in Machine Learning was improved from 83.67% to 86.18% using a CNN (Convolutional Neural Network) algorithm of Deep Learning. The improvement is significant. In conclusion, the deep learning methods were found to be better in terms of performance and thus more such models can be built in the future to help in making decisions regarding Migraine Sufferers for an early diagnosis and treatment.

The study by [23] also adopted some popular state-of-the-art Machine Learning models to categorize subjects into migraineurs (in the ictal and interictal states) and normal. According to their study, significant changes in the somatosensory evoked potentials occur in the cortex of the brain due to migraine. Therefore, somatosensory evoked potentials were gathered from all the patients. A total of 57 patients were taken out of which only 15 were normal and the rest migraineurs (29 interictal and 13 ictal). The dataset thus formed was cleansed and the useful attributes were extracted using Fourier Transformations. The output from this step was taken as input for the Machine Learning algorithms: Extreme Gradient Boosting Trees, KNN (K-Nearest Neighbours), Logistic Regression, Random Forest, Linear Discriminant Analysis, Support Vector Machines, and Multilayer Perceptron; for the purpose of solving the classification task. The classification task was a multiclass classification into three classes of ictal migraineurs, interictal migraineurs, and non-migraineurs with the highest accuracy of 72.4%.

III. MATERIALS AND METHODS:

Dataset

In this paper, the dataset used is procured from Kaggle - an online community platform for Machine Learning evangelists. The dataset contains 400 instances of patients' data with 24 attributes. The attributes selected for the classification purpose were 16 in number. They are described in Table 1.

TABLE I. DESCRIPTION OF THE ATTRIBUTES OF THE DATASET.

S.No.	Attribute Name	Particulars
1	duration	refers to the duration of headache in hours and lies in the range 1-3
2	frequency	refers to the frequency of headaches per week lie between 1-8 per week
3	intensity	measures the intensity on a scale of 4 points, lies between 0-3
4	nausea	Refers to the discomfort before vomiting, 0 stands for the absence of nausea, and 1 for the presence
5	vomit	0 stands for absence and 1 for the presence
6	phonophobia	fear of sound, 0 stands for the absence of the fear, and 1 for the presence
7	photophobia	irritation from bright light, 0 stands for no irritation, and 1 for the presence of the symptom
8	visual	represents the number of visual symptoms out of the 4: Blind Spots/Shimmering Spots, slurred lines, vision loss, flashes of light
9	dysphasia	refers to the language disorder where it becomes difficult to frame sentences; 0 stands for absence and 1 for the presence
10	dysarthria	refers to the problem in speaking, often mumbling is heard in this condition; 0 stands for absence and 1 for the presence
11	vertigo	Refers to the problem of feeling physical dis-balance; 0 stands for the absence of the symptoms and 1 is for the presence

12	tinnitus	A strange ringing sound from inside the ears; 0 stands for the absence of the symptoms and 1 is for the presence
13	hyperacusis	A partial loss of hearing ability, 0 stands for the absence of the symptoms, and 1 is for the presence
14	diplopia	This refers to a vision malady, where 2 images of the same object are visible; 0 stands for the absence of the symptoms, and 1 is for the presence
15	conscience	The state of being confused and not-oriented accompanied by a temporary loss of consciousness, the value is set to 1 if this symptom appears and reset to 0 in case this symptom is not experienced.
16	paresthesia	Refers to the tingling sensation and at times pricking like that of a sharp needle; 0 stands for the absence of the symptoms and 1 is for the presence
17	type	The categorical variable is determined by the model. There are 7 types of migraine: 1. Typical aura with migraine, 2. Migraine without aura, 3. Basilar type aura (Migraine with brainstem aura), 4. Sporadic hemiplegic migraine, 5. Familial hemiplegic migraine, 6. Typical aura without Migraine, 7. Other.

Methods

In this paper, the task of classification is done on the basis of symptoms recorded from the patients of different types of Migraine. The supervised algorithms used for this task are discussed in the subsequent paragraphs.

Naive Bayes: This classification algorithm is based on the Bayes Theorem which considers the probability of occurrence of events, which is also termed a Probabilistic Classifier. The Naive Bayes assumes independence of events, thus their probability of occurrence is also independent of each other. It is relatively a simpler method for building classifiers. For instance, a fruit could be a mango if it is oval in shape, yellow in colour, and sweet in taste. The Naive Bayes classification method assumes that all three factors the shape, the colourr, and taste contribute independently to classifying the fruit like a mango. The assumption disregards any correlation between features of the fruit i.e., its shape, its taste, and its colour[24]. With plenty of real-life applications, the estimation of parameters for these classifiers employs the maximum likelihood method. Therefore, the Bayes Model could be used in the applications without adopting the Bayesian Probability. The algorithm is relatively simple to use and though the presumed propositions are quite simplistic in nature yet it is capable of outperforming the other algorithms in many real-world applications. Apart from being simple, another benefit of Naive Bayes is that it can be trained on a small dataset.

SMO (Sequential Minimal Optimization): The SMO is a simplistic algorithm and the purpose is to train SVM (Support Vector Machines). The training of an SVM requires solving large quadratic problems (QP) which are time-consuming in nature. Here, the relatively easier approach is followed by the SMO by dividing the big QP into smaller ones. For this purpose, Osuna's Theorem is used, so that the convergence of the problem is certain. The smaller problems are then solved using an analytical method which saves a lot of clock time in contrast to the numerical method of solving the QP problems. Also, SMO is capable of handling large datasets for training since the memory utilized while training is linear. In addition, the SMO is better scalable from linear to the square in the training dataset size due to the avoidance of matrix multiplication in contrast to the chunking algorithm which can go to cubic sizes. In performance, SMO's execution time is better when using Sparse Datasets and linear SVMs[25]-[26].

Multinomial Logistic Regression: Logistic Regression is a supervised learning model also called logit. It is usually employed for classification tasks but is also used in regression. The prediction is done with help of independent variables and is applied to categorical and dependent variables. The algorithm will output values in the range 0 to 1. Therefore, Logit is applied to only binary classification. An expansion of Logistic Regression is adopted in the form of Multinomial Logistic Regression to approach multiclass classification. This variant can be implemented by dividing the multiclass into many binary classes and then applying the Binomial version to it, thereby solving the multiclass classification problem. The other approach that can be followed is to alter the model itself to adapt multiclass classification. Here, the probabilities are calculated for each class and then the highest magnitude is the output class to which the input belongs. The probability distribution function is termed a multinomial probability distribution [27]-[28].

J48 algorithm for Decision Tree: Decision Tree algorithm C4.5 is applied using the J48 Java implementation of the model. It serves as an expansion of the ID3 (Iterative Dichotomiser) which keeps dividing the features into subgroups iteratively to form a decision tree. The decisions in c4.5 are based on Entropy and Information Gain (or Gain). Entropy is basically the measure of disorder or the occurrence of odds. Gain is the reduction in entropy and thus they both are inversely related to each other. During the building of the decision tree, the decisions or branches that do not contribute to the decision are removed known as pruning. The advantage of using J48 is that it accounts for missing values [29].

Random Forest: The algorithm is capable of solving both classification and regression tasks and falls under the umbrella of Supervised Learner. This is a classifier with a forest of many decision trees and the one which is voted by the majority wins or is established as the decision tree. Random forests handle both categorical data and continuous data. This is the reason both classification problems and regression problems can be solved using this algorithm. The ensemble technique of Bagging is used to solve random forests also called majority voting [30].

The tool used for the implementation of the Machine Learning algorithms for multi-class classification is Weka [31]. Weka is a reputed and reliable tool for implementing Machine Learning algorithms. It is an open-source and free-to-use software developed for the researchers' community at the University of Waikato, New Zealand. The expansion of the term weka is "Waikato Environment for Knowledge Analysis". Coincidentally, Weka is the name of a bird species found on the islands of New Zealand. Thus, the logo bears the picture of the flightless bird.

Weka is a simple and easy-to-learn data mining tool with a graphical user interface and a good user experience. It is licensed under GNU General Public License. Earlier it was C-based but now the tool is completely Java-based with a set of visualization tools and a large number of Machine learning algorithms. Weka also has filters for pre-processing of data and the datasets in weka have an arff extension called the Attribute-Relational File Format. Weka has support for many file formats like CSV and json. In addition to this, weka also provides access to other toolboxes such as sci-kit learn, Deeplearning4j, and R. The tasks supported by weka are data pre-processing, feature selection, clustering, regression, classification, and visualization.

IV. RESULTS AND DISCUSSIONS:

As mentioned above, in the dataset description the Migraine dataset is taken from the Kaggle online platform for learners. Five selected classifiers are applied to this dataset to find the classifier best-suited classification of migraine into different types. The dataset is split in a ratio of 7:3, 70% of the data is used to train the models and the remainder 30% is used to test. Therefore, out of 400, 120 records are used for the testing of the trained model and the remainder of 280 records are for the training purpose. The table below shows the values of the evaluation metrics; obtained from applying the models on the Weka tool.

TABLE I. THE TABLE SHOWS THE OUTPUT VALUES OBTAINED FROM THE WEKA TOOL ON APPLYING THE MODELS.

	Typical aura with migraine	Migraine without aura	Basilar-type aura	Sporadic hemiplegic migraine	Familial hemiplegic migraine	Other	Typical aura without migraine	Average Weighted
Naive Bayes	97.3	100	83.3	80	57.1	100	100	94.2
SMO	98.6	95.2	100	40	28.6	100	100	91.7
Logistic Regression	97.3	100	20	66.7	42.9	100	100	90
J48	98.6	100	33.3	20	42.9	66.7	100	88.3
Random Forest	98.6	100	16.7	0	57.1	66.7	100	87.5

The chart (Fig 1) shown below compares the classification accuracies of the 7 classes of Migraine and the 8th one is the average accuracy of all the 5 classifiers; i.e., Naive Bayes, SMO, Logistic Regression, J48 and Random Forest. The parameters used for comparing the models trained on the migraine dataset are: Accuracy, Precision, Recall, F-measure, and ROC Area. The comparative charts of these parameters for the 5 classifiers are shown below in Fig 2 – Fig 6.

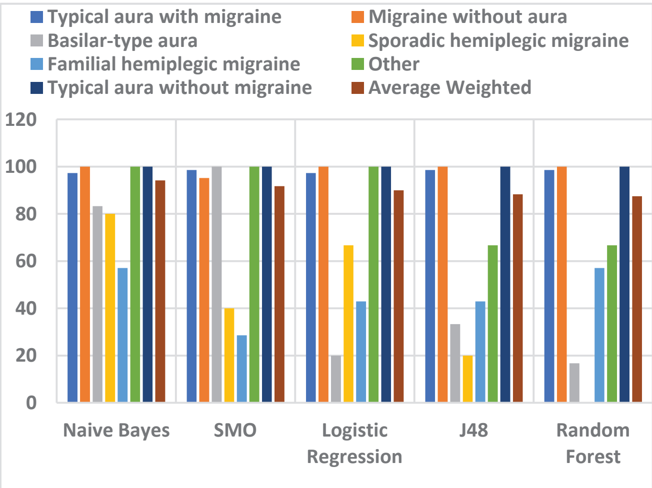

Fig. 1. Category-wise comparison of accuracies of the various classifiers.

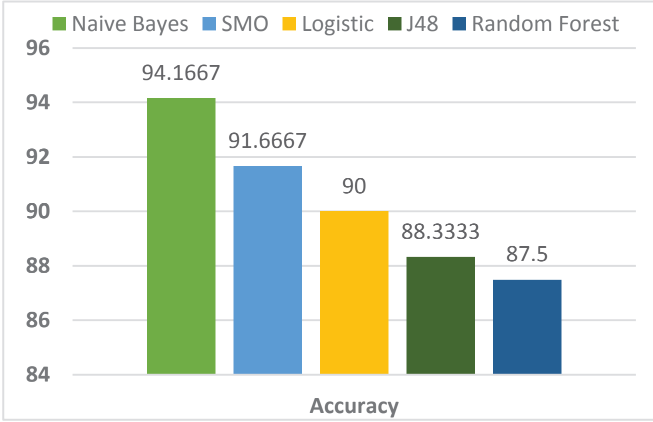

Fig. 2. Comparison of obtained Accuracy.

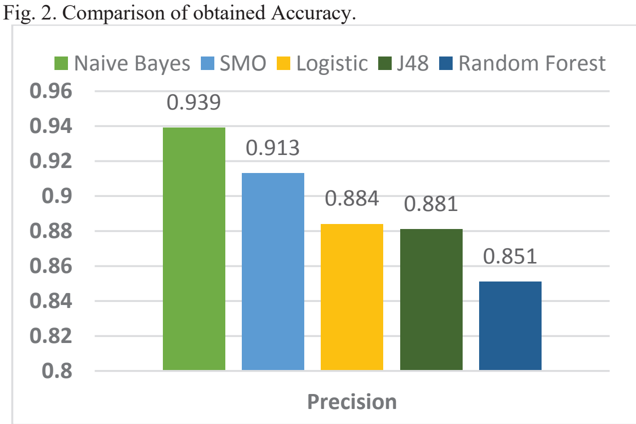

Fig. 3. Comparing the Precision of the algorithms.

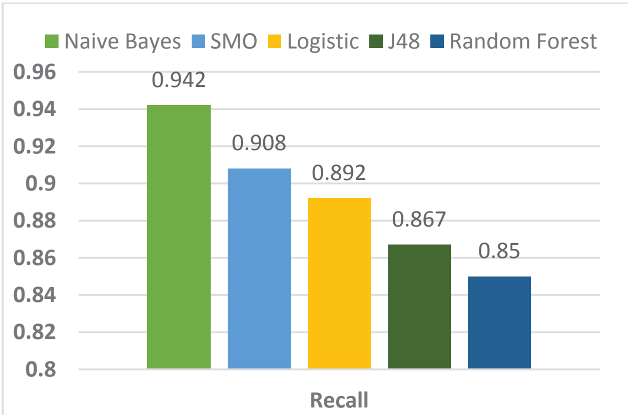

Fig. 4. Curve to compare the value of Recall obtained.

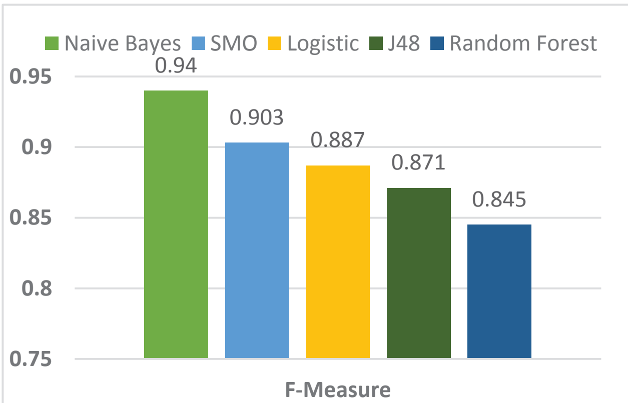

Fig. 5. F-measure comparison of various classification algorithms.

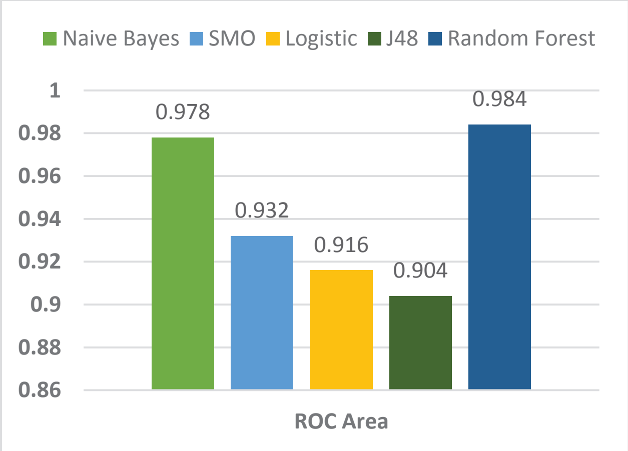

Fig. 6. ROC-Area under the curve, comparison of values obtained

V. Conclusion

The multi-class classification accuracy as shown in the comparison chart above (Fig 1) clearly unveils that, the Naive Bayes classifier is the best as its average weighted accuracy is the highest and it even has achieved 100% accuracy for the classes: Migraine without Aura and Typical Aura without Migraine, as well as for others category. Although, the average weighted accuracy of SMO(SVM) is at power with the Naive Bayes but it shows a lot of variation and is not as consistent. In the same context, the worst performance is shown by Random Forest algorithm which has an average of 87.5% accuracy and it becomes zero in case of Sporadic hemiplegic migraine. It is also observed that the accuracy for Sporadic hemiplegic migraine is the least for all the classifiers, the simple reason is that it has least number of instances (14 out of 400). Therefore, the classifiers are not sufficiently trained for this category.

In general, the highest accuracy is achieved by the Naive Bayes model, followed by the SMO (SVM), Logistic Regression, J48 (Decision Tree), and Random Forest models. The accuracy levels of the algorithms vary significantly from 94.2% to 87.5%. The same trend is followed in the precision, recall and F-measure. The ROC Area shows a bit of variation, with the highest score of Random Forest (lowest accuracy) at the lead and followed by Naïve Bayes, SMO, Logistic and J48.

Therefore, after comparing all metrics it can be concluded that the model best suited for the classification of Migraine data is the Naive Bayes with the best accuracy, precision, recall, and F-measure. Although, the ROC Area of Random Forest has a greater magnitude than the Naïve Bayes yet the difference is not quite significant.

References

[1] W. Z. Yeh, L. Blizzard, and B. v. Taylor, "What is the actual prevalence of migraine?," Brain and Behavior, vol. 8, no. 6, p. e00950, Jun. 2018, doi: 10.1002/BRB3.950.

[2] T. J. Steiner, L. J. Stovner, and G. L. Birbeck, "Migraine: The seventh disabler," Cephalalgia, vol. 33, no. 5, pp. 289–290, Apr. 2013, doi: 10.1177/0333102412473843

[3] A. Medical Association, "What Is Migraine?," 2022, doi: 10.1001/jama.2021.1640.

[4] A. Charles, "The pathophysiology of migraine: implications for clinical management," The Lancet Neurology, vol. 17, no. 2, pp. 174–182, 2018.

[5] D. Pietrobon, "Pathophysiology of Migraine," Article in Annual Review of Physiology, 2012, doi: 10.1146/annurev-physiol-030212-183717.

[6] D. I. Friedman and T. de Ver Dye, "Migraine and the environment," Headache, vol. 49, no. 6, pp. 941–952, Jun. 2009, doi: 10.1111/J.1526-4610.2009.01443.

[7] A. P. Andreou and L. Edvinsson, "Mechanisms of migraine as a chronic evolutive condition," J Headache Pain, vol. 20, no. 1, pp. 1–17, 2019.

[8] B. K. Rasmussen and J. Olesen, "Migraine with aura and migraine without aura: An epidemiological study," Cephalalgia, vol. 12, no. 4, pp. 221–228, Nov. 1992, doi: 10.1046/j.1468-2982.1992.1204221.

[9] D. Pietrobon and J. Striessnig, "Neurobiology of migraine," Nature Reviews Neuroscience 2003 4:5, vol. 4, no. 5, pp. 386–398, 2003, doi: 10.1038/nrn1102.

[10] A. K. Eigenbrodt et al., "Diagnosis and management of migraine in ten steps," Nature Reviews Neurology, vol. 17, no. 8, pp. 501–514, 2021.

[11] A. Negro and P. Martelletti, "Gepants for the treatment of migraine," Expert Opinion on Investigational Drugs, vol. 28, no. 6, pp. 555–567, 2019, doi: 10.1080/13543784.2019.1618830.

[12] S. Sharma, R. Mittal, and N. Goyal, "An Assessment of Machine Learning and Deep Learning Techniques with Applications," SPAST Abstracts, vol. 1, no. 01, 2021.

[13] S. Gulati, K. Guleria, and N. Goyal, "Classification and Detection of Coronary Heart Disease using Machine Learning," 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), pp. 1728–1732, Apr. 2022, doi: 10.1109/ICACITE53722.2022.9823547.

[14] A. Sharma, K. Guleria, and N. Goyal, "Prediction of Diabetes Disease Using Machine Learning Model," in International Conference on Communication, Computing and Electronics Systems, 2021, pp. 683–692.

[15] P. K. Sarangi, K. Guleria, D. Prasad, and D. K. Verma, "Stock movement prediction using neuro genetic hybrid approach and impact on growth trend due to COVID-19," International Journal of Networking and Virtual Organisations, vol. 25, no. 3–4, pp. 333–352, 2021, doi: 10.1504/IJNVO.2021.120172.

[16] M. A. Rocca, J. U. Harrer, and M. Filippi, "Are machine learning approaches the future to study migraine patients?," Neurology, p. 10.1212/WNL.0000000000008956, Jan. 2020, doi: 10.1212/WNL.0000000000008956.

[17] Y. W. Woldeamanuel and R. P. Cowan, "Computerized migraine diagnostic tools: a systematic review.," Ther Adv Chronic Dis, vol. 13, p. 20406223211065236, Jan. 2022, doi: 10.1177/20406223211065235.

[18] T. J. Schwedt, C. D. Chong, T. Wu, N. Gaw, Y. Fu, and J. Li, "Accurate Classification of Chronic Migraine via Brain Magnetic Resonance Imaging," Headache: The Journal of Head and Face Pain, vol. 55, no. 6, pp. 762–777, Jun. 2015, doi: 10.1111/HEAD.12584.

[19] C. D. Chong, N. Gaw, Y. Fu, J. Li, T. Wu, and T. J. Schwedt, "Migraine classification using magnetic resonance imaging resting-state functional connectivity data," Cephalalgia, vol. 37, no. 9, pp. 828–844, Aug. 2017, doi: 10.1177/0333102416652091.

[20] Q. Zhang et al., "Discriminative Analysis of Migraine without Aura: Using Functional and Structural MRI with a Multi-Feature Classification Approach," PLOS ONE, vol. 11, no. 9, p. e0163875, Sep. 2016, doi: 10.1371/JOURNAL.PONE.0163875.

[21] Y. Garcia-Chimeno, B. Garcia-Zapirain, M. Gomez-Beldarrain, B. Fernandez-Ruanova, and J. C. Garcia-Monco, "Automatic migraine classification via feature selection committee and machine learning techniques over imaging and questionnaire data," BMC Medical Informatics and Decision Making, vol. 17, no. 1, pp. 1–10, Apr. 2017, doi: 10.1186/S12911-017-0434-4/TABLES/6.

[22] H. Yang, J. Zhang, Q. Liu, and Y. Wang, "Multimodal MRI-based classification of migraine: Using deep learning convolutional neural network 08 Information and Computing Sciences 0801 Artificial Intelligence and Image Processing," BioMedical Engineering Online, vol. 17, no. 1, pp. 1–14, Oct. 2018, doi: 10.1186/S12938-018-0587-0/FIGURES/5.

[23] B. Zhu, G. Coppola, and M. Shoaran, "Migraine classification using somatosensory evoked potentials," Cephalalgia, vol. 39, no. 9, pp. 1143–1155, Aug. 2019, doi: 10.1177/0333102419839975.

[24] F. Harahap, A. Y. N. Harahap, E. Ekadiansyah, R. N. Sari, R. Adawiyah, and C. B. Harahap, "Implementation of Naïve Bayes Classification Method for Predicting Purchase," 2018 6th International Conference on Cyber and IT Service Management, CITSM 2018, Dec. 2019, doi: 10.1109/CITSM.2018.8674324.

[25] A. Torres-Barrán, C. M. Alaíz, and J. R. Dorronsoro, "Faster SVM training via conjugate SMO," Pattern Recognition, vol. 111, p. 107644, Mar. 2021, doi: 10.1016/J.PATCOG.2020.107644.

[26] S. K. Shevade, S. S. Keerthi, C. Bhattacharyya, and K. R. K. Murthy, "Improvements to the SMO algorithm for SVM regression," IEEE Transactions on Neural Networks, vol. 11, no. 5, pp. 1188–1193, Sep. 2000, doi: 10.1109/72.870050.

[27] D. Böhning, "Multinomial logistic regression algorithm," Annals of the Institute of Statistical Mathematics 1992 44:1, vol. 44, no. 1, pp. 197–200, Mar. 1992, doi: 10.1007/BF00048682.

[28] "Multinomial Logistic Regression : Nursing Research." https://journals.lww.com/nursingresearchonline/Abstract/2002/11000/Multinomial_Logistic_Regression.9.aspx.

[29] M. Mathuria et al., "Decision Tree Analysis on J48 Algorithm for Data Mining," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 3, no. 6, p. 2277, 2013. [Online]. Available: http://www.cs.waikato.ac.nz/ml/weka.

[30] G. Biau and E. Scornet, "A random forest guided tour," TEST 2016 25:2, vol. 25, no. 2, pp. 197–227, Apr. 2016, doi: 10.1007/S11749-016-0481-7.

[31] "Weka 3 - Data Mining with Open Source Machine Learning Software in Java." https://www.cs.waikato.ac.nz/ml/weka/ (accessed Jun. 30, 2022).