2023 International Conference on Integration of Computational Intelligent Systems (ICICIS)
Pune, India. Nov 1-4, 2023

Several Classification and Recommendations Methods Used in Dengue Fever Prediction System

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2023 International Conference on Integration of Computational Intelligent System (ICICIS) | 979-8-3503-1878-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICICIS56802.2023.10430287

***Abstract*- Mosquitos influence dengue fever, and the dengue virus is a universal community health issue worldwide. An analysis and prediction are required to resolve the effects of the dengue virus in communities. The main motive of this article is to recognize the classification or recommendation methods based on machine learning (ML) and deep learning (DL) for predicting and detecting dengue fever. The classification methods such as SVM, KNN, DT, and naïve bayes are used to perform experimental results. In this article, a comparison of these methods is executed, and SVM achieves a better accuracy rate. This method is highest accurate and suitable for predicting the dengue virus. The naïve bays is an effective method for better performance with less time-consuming. This method takes 0.01 seconds and reduces the probability of errors. The techniques like DT, KNN, and naïve Bayes provide 55.5%, 96%, and 72% accuracy, respectively. The SVM, DT, and naïve bayes consumed the time of 0.16sec, 0.05sec, and 0.01sec, respectively.**

Keywords:-Dengue Fever, Classification and recommendation methods, Naïve Bayes, Support Vector Machine.

I. INTRODUCTION

DF (dengue fever) is a dangerous viral disease influenced by the Aedes mosquito during the larva state. This virus is spread by prey on human blood by mosquitos. The symptoms of this virus are not visible in the initial state and are visible when patients reach a critical situation. Various epidemiological surveys show dengue virus affects anyone and informs the immune system when it enters the human body [1]. Then, the human body grows an immune system to anti-serotype. The laboratory reports of DF patients are detected clinical symptoms, infection, etc. DF is similar to other flu diseases like normal fever, typhus, etc. [2]. The dengue virus is divided into four subparts:

- Dengue virus (DENV 1)
- Dengue virus (DENV 2)
- Dengue virus (DENV 3)
- Dengue virus (DENV 4).

Fig 1 represents the dengue virus's different subparts such as DENV-I, DENV-II, DENV-III, and DENV-IV with EDII circled in red, blue, black, and green resp. The mosquito bites the human body, then the body temperature increases, headaches, vomiting, joint pain, etc. [3] [4]. Sometimes patients face dangerous conditions due to acute symptoms of DF, such as Dengue haemorrhagic fever (DHF), Dengue

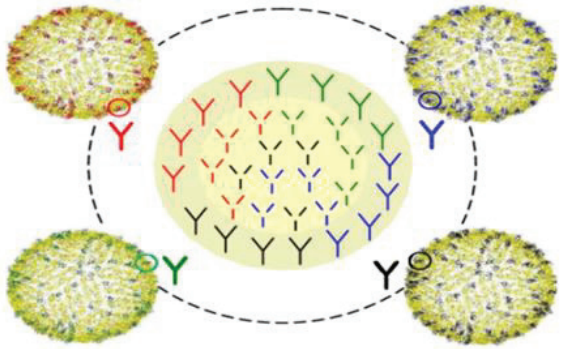

Fig. 1. Dengue Virus Different sub-parts [33]

Shock Syndrome (DSS), etc. [5]. These symptoms are primarily controlled through liquids and juices [6]. DF can be diagnosed effectively using clinical methods such as DENV isolation and NS1 antigen capturing. Using serology methods, the evaluating ratio detects various states of DF through IgM, and IgG values with serology methods [7] [8].

DF is a dangerous illness called haemorrhagic DF influenced by mosquitos and is also a cause of vector-borne diseases (VBD) such as the Zika virus, Chikungunya, yellow fever, etc. [9]. This virus is affected anyone but more widely in immune deficiency people caused due to chomp of Aedes named female mosquitos. These dengue-influenced mosquitos are bitten by the human body and enter through blood. Normal mosquitos are also infected when dengue-influenced people bite them, and they transmit the dengue virus from one person to another, which is the cause of the epidemic.

DENV is primarily found in subtropical environmental areas [10]. The dengue fever diagnosis is a challenging issue caused by non-specific clinical that is not stable due to various attributes such as the patient's age, gender, levels of Dengue, and earlier medical conditions. The early-stage detection of DF and proper take care reduced mortality rates from 10 % to 1 % [11]. To the evaluation by WHO, approximately 0.4 – 1.3 million population of outbreak cases of Dengue increased in 1996-2005 and 2010-2015. These dengue cases further reached around 2.2-3.2 million, respectively.

DENV is one of the most effective diseases in people, and around 33% population in the world, with various urban areas in India, are faced with a pitfall. The prediction of the DENV outbreak is to save human life with awareness,

appropriate treatment, and care. The forecast of the dengue virus is a critical phase, the challenging issue and different approaches to prediction are still in the early phases [12]. Rainy seasons provide more growth of mosquitos due to rainwater, and dengue disease increases during this season. To the survey of the home ministry, around 36,000 population infected with DENV, and most of the people belong to *Bangla, Orissa, Kerala, and Karnataka* [13]. Various VBDs are increased social and health issues, and economic impacts, and decrease the development of social and economic progress. It is increased by around 300 times in developed countries compared to developing regions [14]. This disease is more affected by the poor such as in poor-quality houses near the vector site. This is influenced by arthropods, which deliver pathogens to humans, such as Dengue infected through mosquitos. Other VBDs diseases, such as Lyme and leishmaniasis, are spread through ticks and sandflies [15]. Due to various aspects, such as globalization and environmental change, VBD is identified in regions where this is not endemic [16]. VBD pathogens are, by chance, located in non-endemic areas, and for the establishment of pathogen other factors are needed [17] [18]. According to WHO, VBDs are responsible for all infectious diseases 17%, malaria exists in around 97 regions, and approximately 3.4 billion population under VBDs risk. DENV influences about 40% of the population in the world. In 2006, various countries, including India, were spread through Chikungunya. Approximately 1,400,000 cases were found.

In 2013, VBD cases were reported around 51258 population in the USA. The global vector control response (GVCR) recognizes vector control as the primary method to resolve the VBDs and respond to the outbreak. Indian govt. declared a $ 9.87 billion amount for the medical health sector and also achieved the goal to enhance healthcare funds to 3% of GDP (gross domestic product) by 2022 [19].

Various machine learning (ML) techniques, methods, and models have been developed for the prediction and diagnosis of DENV, such as Sandali Raizada et al. (2020) developed efficient an algorithm for predicting VBDs called convolution neural network multi-model disease outbreak prediction (CNN-MDOP). The authors used contrasting data and forecasts of VBDs outbreaks in different areas of the country. The existing research is not focused on contrasting data in the medical data. So, the authors achieved an accuracy of 88% for predicting VBDs [19]. Caicedo-Torres et al. (2016) designed ML systems for the prediction of dengue disease using a patient's dataset accessed from a hospital to classify and evaluate the different systems. For this construction of the system 5-fold cross-validation method is used by the authors. Using this method, authors achieved better prediction of Dengue, and the SVM is deployed for experimental results with parameters of receiver operating characteristic (ROC) area [20]. Althouse et al. (2011) described the prediction of DENV in Singapore. For this purpose, the authors used negative binomial regression (NBR), gradient-boosted regression (GBR), and step-down linear regression. In the end, step-down linear regression provided better performance by using comparison with other methods [21]. Nishanthi P.H.M et al. (2014) constructed a model using the artificial neural network (ANN) technique to forecast dengue outbreaks. It works as a multi-layer perceptron (MLP), connected with initial layers for predicting dengue outbreaks. The authors analyze the correlation of each variable individually. The highest value of correlation variables is used as input to the ANN model. This model achieved an accuracy of 68.5% [22]. Rao N.K et al. (2014) constructed a method for predicting dengue disease using the decision tree (DT) technique. The authors develop an unsupervised system using dataset analysis to predict the most influenced area. The supervised classifier system is designed for disease prediction and achieved an accuracy of 97% [23]. Sharma D et al. (2020) developed an ML-based system for DF prediction system. For this purpose, the authors accessed datasets from the medical college of Dhaka and Chittagong. The pre-processing of data is done with random forest (RF) and DT, and this system achieved an accuracy of 79% over three categories of DF [4]. S.K Dey et al. (2022) used two methods such as multi-linear regression (MLR) and support vector regression (SVR), to predict the DF cases in 11 regions of Bangladesh. The authors divided the dataset into training (80%) and testing (20%) and achieved accuracy corresponding to these two methods. The authors gained 67% and 75% accuracy for MLR and SVR, respectively. Mean absolute error (MAE) for MLR and SVR achieved 4.57 and 4.95, respectively [24].

This article defines the different sections: Sect. 2 discusses related to the existing work with other classification, feature extraction, and feature selection methods. These methods were deployed by different researchers and experts for the prediction of dengue fever. Sect. 3 defines dengue fever's various signs and symptoms, such as high fever, body aches, etc. After that sect. 4 represents the different classification types and recommendation methods used to predict or detect dengue fever. Machine learning/ Deep learning techniques are discussed. This article uses naïve bayes, SVM, DT, and KNN methods to perform the desired result. From these ML and DL techniques, the SVM provides better accuracy and naïve Bayes less time-consuming method for better performance. Sect. 5 describes the conclusion and Further improvement of this topic or field.

II. RELATED WORK

Several researchers developed various techniques for dengue fever prediction in different areas. The Dengue fever prediction use different ML techniques like regression, decision tree, random forest, etc. This section describes the existing research on dengue fever with distinct ML techniques to get the best solution for the prediction of dengue fever. The prediction of dengue fever is the diagnosis and analysis using the development of an accurate system. **Dhiman Sharma et al. (2020) [4]** described Dengue viral disease caused by Aedes mosquitos. From research of a WHO report in 2019, around 100 to 400 million population was infected with high-risk dengue disease at the global level. WHO declared the dengue virus as one of the top 10 health-related critical issues at the international level. Different levels of dengue fever cause dangerous problems in the human body, like dengue shock or syndrome. An adequate system was required to control Dengue and its subtypes in its initial state with proper care and supportive treatment. In 2019, 101000 dengue cases were detected in Bangladesh. So, the authors proposed the ML technique for predicting dengue fever. The authors utilized a dataset from medical patient's symptoms reports and developed real-time data of dengue patients from Chittagong and Dhaka medical colleges in Bangladesh. This dataset was divided into 7:3

ratios for training and testing, respectively. The authors used ML techniques for the proposed system, such as DT (decision tree) and RF (random forest). The proposed method achieved 79% accuracy with DT as compared to RF. **Sandeep Kumar Rana et al. (2022) [8]** proposed Dengue viral fever is an epidemic disease influenced due to blood-feeding mosquitoes. Dengue fever was most affected in tropical and noon-tropics areas and frequently developed epidemic issues. Various health problems consist the human body due to dengue fever, such as vomits, headaches, joint pain, etc. Dengue fever was not detected in the initial phase, and then it developed critical problems in the human body, such as shock and bleeding, which was the cause of death. So, the authors developed a system to predict Dengue in the human body based on particular signs of Dengue viral. This developed DFES (Dengue Fever Expert System) ML analytics used an unbalanced dataset for training and testing. The authors used four types of methods and two types of classifiers, DT and RF, to develop and pre-process the proposed system, respectively. **Khaing Thanda Swe et al. (2020) [11]** described normal fever as not critical, but hyperthermia was increased body temperature due to heat stroke, dangerous side effects of medicine, etc. DF (dengue fever) was the most necessary form, which was more critical viral influenced by mosquitos worldwide. Around 40% of people stayed in the more affected area, and 400 million populations were infected with Dengue worldwide. Approximately 22000 people died from dengue fever, and the death rate increased due to this virus. Doctors used various solutions, such as blood and urine tests, to diagnose dengue fever. The authors proposed a model to reduce blood and urine tests for predicting Dengue in patients. This proposed model dataset accessed from Lao PDR hospital based on actual data contained numeric digits. The proposed model was used to detect the Dengue viral signs in patients and achieved better analysis and detection through SVM (support vector machine). **Naiyar Iqbal et al. (2017) [12]** described the Dengue viral disease was raised every year recorded, and according to WHO's report, from 1996-2005, dengue patients increased by around 0.4 to 1.3 million, and from 2010-2015, it grew to 2.2 to 3.2 million, respectively. So, developing a system to predict and analyze the dengue disease was required. The authors developed a system using seven ML models for dengue fever forecasting and eight parameters considered for better performance. The proposed achieved 92 % accuracy, 90% sensitivity, and 94% specificity of 92% using LogitBoost. **N. Rajathi et al. (2018) [13]** described Dengue as an epidemic viral disease discovered in India and other developing nations. To earlier research, around 390 million people were infected with Dengue every year, and observed that Dengue influences one person to another. Highly hazardous countries such as American and Asian nations were affected by mosquitos. Aedes named mosquitos caused this viral disease. It was becoming a more critical issue at the global level and shared in all countries. The authors compared different approaches and found a better approach over accuracy for dengue prediction. The authors classified dengue fever using a data mining approach, and the Weka tool was utilized for comparison and evaluation. **Sandali Raizada et al. (2021) [19]** described VBDs (vector-borne diseases) as illnesses influenced by parasites, bacteria, viruses, etc. The VBDs diseases were spread by arthropods like ticks, fleas, mosquitos, etc, through human blood-feeding. Every year, yellow fever and malaria VBDs diseases caused a high death rate, and around 700,000 people died from these diseases. These diseases had part of Dengue because both were influenced by mosquitos through blood-feeding and mostly spread in tropical areas infecting the population at high risk. AI (artificial intelligence) consisted of deep learning (DL) as a subpart used to develop a powerful system with DL layers for human neurons. The authors developed a VBDs prediction system using the composition of AI-DL and ML algorithms. They gave more profitable solutions for healthcare and diagnosis through medical data. This developed model was predicting VBDs diseases such as malaria, Dengue, chikungunya, etc. The authors also examined the 2013-17 years of data collected from India. The authors gave better ANN (artificial neural network) risk prediction techniques with contrasting data. The proposed model achieved an accuracy of 86% with ANN techniques. **T. Sajana et al. (2018) [25]** described dengue fever, as part of an infected group of viruses such as Flaviviridae, containing four serotypes raised from mosquitoes every year. Approximately 2.5 million people lived in high-risk dengue areas, and 100 million latest dengue cases occurred worldwide. Dengue fever had grown as dramatically every year due to mosquitoes. Several countries, such as South Africa and East and West Nations, were most affected by the endemic of Dengue. In 1970, nine countries were announced affected by DHF plagues, which increased 9 in 1995. Various clinical symptoms were used for the diagnosis of dengue fever. The surgeons analyzed the risk of fever by taking multiple tests on dengue patients using clinical signs. The drawback of these clinical signs to developing ML (Machine Learning) was significant for diagnosing dengue fever patients. The authors developed a tool for surgeons to predict dengue fever using the ML approach. They give direction by comparing various methods for new research to create an accurate tool for dengue virus detection and prediction. The authors compared three algorithms, CART (classification & Regression Tree), MLP (multiple layers prediction), and C4.5, evaluating accuracy better with CART than with the other two algorithms. **Rajeeb Kapoor et al. (2021) [26] described** vector-borne diseases caused dangerous issues in India. These diseases had developed high risk for communities, prediction, and analysis of these diseases were still a major issue for the Indian government. Most people are affected by these diseases, and controlling these VBDs was a difficult task due to the population's geographical area and living style in the existing system. The authors mainly focused on identifying symptoms and clinical data used for predicting VBDs using an effective prediction model. VBDs covered a huge number of diseases, and they gave direction to research on vector-borne diseases. The authors mostly focused on Dengue because from the early years this was a more challenging factor in the world and achieved a better improvement in the prediction of disease at its early stages. The authors proposed a system consisting of five main modules: transformation, pre-processing, feature scaling and normalization, division of datasets system development, and prediction. The proposed model provided the prediction of Dengue and its types at the initial stage from clinical data records of patients. The authors used five methods of ML in the development of the proposed model, these methods such as decision tree (DT), logistic regression (LG), support vector machine, random forest (RF) classifiers, GNB (gaussian naïve Bayes) classifier, etc. The proposed system achieved an accuracy of 97.5% and a mean square error (MSE) of 0% using the GNB classifier.

III. CAUSES, SIGNS, AND SYMPTOMS OF DENGUE FEVER

A. Causes of DF

Any one of the four dengue viruses [27] spread by mosquitoes living in or close to human habitations can cause dengue fever (DF). The virus that causes Dengue enters the bloodstream when a mosquito bites a person. After healing, the patient may become immune to the virus, but they are still susceptible to contracting other viruses. Eliminating and Managing the mosquitoes that spread the virus is necessary to prevent DF.

B. Symptoms and Signs

The main primary signs and symptoms of Dengue appear 3 to 15 days after the mosquito bite and include the subsequent:

- Headache
- High Fever
- Severe pain behind the eyes

Other connected signs and symptoms [27] are:

- Mild bleeding
- Rashes
- Bone Pain
- Muscle Pain
- Lower back pain
- Reduce WBC (white blood cell), and Platelets.

IV. CLASSIFICATION AND RECOMMENDATION FOR DENGUE PREDICTION

Several methods that are utilized for the recommendation and classification are as follows:

A. Support Vector Machine (SVM) Classifier

In ML (machine learning), SVMs also known as support vector networks are SL (supervised learning) models with connected learning methods which study data used for RA (regression analysis) and classification. They are gathering the dataset of Dengue. They separate the dataset into two sections such as training and testing data, then they utilized the CM (confusion matrix) then needed a 100 percent [28] accuracy rate.

B. KNN (K-Nearest Neighbors) classifier

The data value in the KNN model is a non-parametric technique utilized for classification and regression. In both scenarios, the input comprises the k-nearest training examples in the FS (feature space). The outcome is based on whether KNN is utilized for regression or classification. KNN classifier, the outcome is a class data of test. They used the CM and then developed the K value as 5 which defines 96 percent accuracy and when the k value is 21 it defines 90 percent accuracy[28].

C. Random Forest

This algorithm is a supervised learning (SL) approach that is deployed on a more significant amount of data. It can be responsible for giving solutions for problems and forecast repetition displayed in figure 2. The density of the forest grows according to a large number of trees available in the forest, which is correct for anyone individual forest. So, similar algorithms permit forest extraction over the random forest depending on data testing with information tests in the form of initial. In the end, it affects the voting model due to average searching. This method is more efficient than DT in the form of performance [29][31].

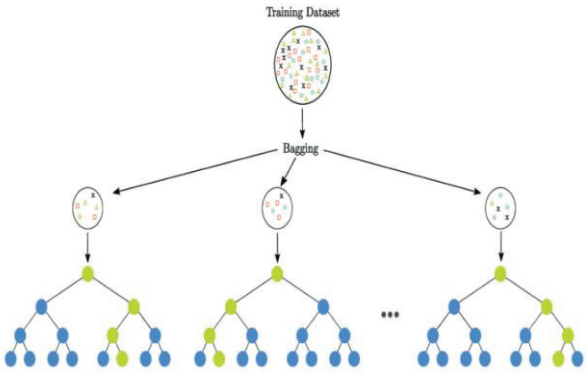

Fig. 2. Random Forest [29]

In the training phase, this algorithm produces a set of different DTs used to style decisions. The choice of the mean forecast for regression and the predictions from all hierarchies are considered attention. It means the output result as expectations are shared. It is also called the ensemble technique since it is applied to a different data point to conclude. The working process of this algorithm is described as follows.

- Choose instances in the datasets randomly with programming.
- Make a tree for every situation or encounter.
- Show the output projection of each DT.
- This predicts the votes for every outcome, which is the display.
- Select the forecast with more accuracy from the cast ballots. This algorithm deals with decline issues and uses MSE for every data node.

D. Decision Tree

DT [30] is the most preferred approach for supervised classification. It is performed by working on different conditions to design decisions in a tree hierarchy. It assembles and separates the rules to develop a DT based on convenient features. It provides various advantages to data mining, such as

- Easy to recognize over the customer.
- It is efficiently applied to a large amount of data input.
- It is responsible for mismatched composition values and incorrect data.
- It performs better using a few efforts and is utilized in implementing data extraction over the different platforms.

E. NB (Naïve Bayes)

It is one of the methods that work as a probabilistic classification of all attributes controlled in the data sample separately and then classifies data issues. Executing the methods using NB they study the classifier output to make a forecast of each occurrence of the database.

An accuracy rate and time tool to construct the classifier or recommendation are defined in Tables 1 and 2 for each method, It is explored that the SVM, KNN, DT, and NB, are the most accurate methods to classify the user misunderstanding with the accuracy of 100, and 0.01 time. Moreover, the decision tree took minimum time than SVM to classify due to the input kind being definite, and not continuous.

TABLE I. EXISTING RESULT ANALYSIS

Classifiers Models/Methods	Accuracy Values
SVM [28]	100
KNN [27]	50
DT [27]	55.6
NB [27]	72.2

TABLE II. PERFORMANCE COMPARISON OF THE RECOMMENDATION AND CLASSIFICATION METHODS

Classifiers Models/Methods	Time (sec)
Naïve Bayes [32]	0.01
SVM [32]	0.16
DT [32]	0.05

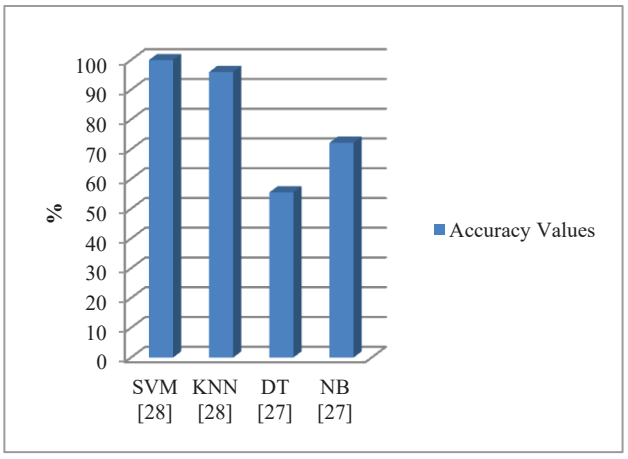

Fig. 3. Performance Analysis (Accuracy)

Fig 3 shows after executing the Naïve Bayes method, it has been considered that a classification accuracy of 72.2 percent is attained. The comparison of existing methods provided accuracy, such as the decision tree method achieved 55.5 percent and the KNN method obtained 96% percent. The SVM method achieved 100% percent accuracy. So, according to this comparison of different methods, SVM outcomes achieved more accuracy than other methods.

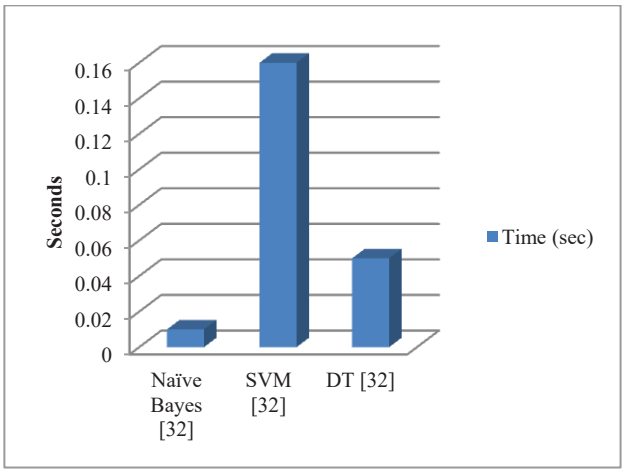

Fig. 4. Performance Analysis (time)

Figure 4 represents performance analysis with time in seconds. The SVM is takes more time as comared to naïve bayses and DT. According to this figure, naïve Bayes reduces the possibility of errors and provides better performance corresponding to SVM and DT because naïve Bayes consumes low time (0.01 sec) for an accurate result.

V. CONCLUSION AND FUTURE SCOPE

This awareness review provides better observations in predicting and detecting the dengue virus. This article focuses on different classification and recommendation techniques required for dengue prediction and compares additional machine learning and deep learning such as SVM, DT, KNN, and naïve Bayes. Several symptoms and signs of dengue fever, such as headache, body pain, etc., are described. Different features of dengue fever are considered for comparison and experimental results for dengue prediction. This article achieved better accuracy and time using SVM and naïve bayes, respectively. In this article, further improvement can be extended for dengue prediction using these ML and DL techniques. An accurate model or system for dengue prediction and detection will be developed using these ML and DL methods.

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