Revolutionizing Stroke Prevention: A Machine Learning Approach to Early Identification of Brain Stroke and Risk Factors

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Abstract— **A brain stroke is a serious medical condition that results from either internal bleeding or blockage of blood vessels within the brain. To prevent strokes and mitigate associated risks, early prediction of stroke likelihood is necessary. This study proposes the use of machine learning algorithms, along with a stroke dataset, for early stroke prediction. The algorithms used in this study include the Random Forest Classifier, Logistic Regression Classifier, Decision Tree Classifier and KNN Classifier. After evaluation using various metrics, the algorithm with the highest accuracy and performance was selected for brain stroke prediction. In addition, this study also highlights the risk factors that can contribute to the development of brain stroke. Understanding these factors can help individuals take preventive measures, such as lifestyle changes, managing blood pressure and cholesterol levels, and controlling diabetes. In some cases, medical interventions may also be necessary. With an accuracy rating of 94.71%, the Random Forest Classifier was discovered to be the most efficient algorithm.**

Keywords—Stroke, Machine learning, Random Forest Classifier, Logistic Regression Classifier, Decision Tree Classifier, KNN Classifier

INTRODUCTION

Strokes have been a major cause of mortality and disability worldwide for many years, impacting the central nervous system. Ischemic and hemorrhagic strokes, among other types, can have a temporary or permanent negative effect on the central nervous system, with varying degrees of harm. Cerebral hemorrhage is a rare bleeding event that can cause blood vessel rupture. The most frequent type of stroke, an ischemic stroke, happens when blood supply to a portion of the brain is reduced as a result of an artery becoming clogged or restricted. It is crucial to identify a stroke and address it quickly to prevent irreversible damage or death.

The World Health Organisation estimates that strokes affect about 15 million individuals yearly and cause about 5 million fatalities. This highlights the importance of early detection and treatment of strokes.

Machine learning (ML) is a powerful tool in healthcare settings that provides quick and accurate prediction results, allowing for the personalization of therapy for stroke patients. The algorithms used in ML enable precise prediction and appropriate analysis, making it an essential tool in the process of stroke diagnosis and treatment.

The main goal of this study is to assess how well four machine learning (ML) classification techniques—Random Forest Classifier, Logistic Regression Classifier, Decision Tree Classifier and KNN Classifier—perform. The most accurate model is determined by evaluating each algorithm's performance using performance assessment metrics. Results show that for predicting strokes, the Random Forest Classifier algorithm has the greatest accuracy rate of 94.71%.

Early prediction of a person's likelihood of having a stroke is critical in avoiding the stroke and reducing the associated risks. This study can help identify potential risk factors for strokes and develop preventive strategies. Additionally, this study can also assess the effectiveness of existing therapies and guide the development of new treatment strategies for stroke patients.

In conclusion, machine learning algorithms can revolutionize stroke diagnosis and treatment by providing quick and accurate predictions to identify patients at risk of stroke and tailor treatment plans to their individual needs. To increase the precision and effectiveness of stroke diagnosis and treatment, more study and development in this area is required. The brain types like ischemic stroke and hemorrhagic stroke are shown in Fig1.

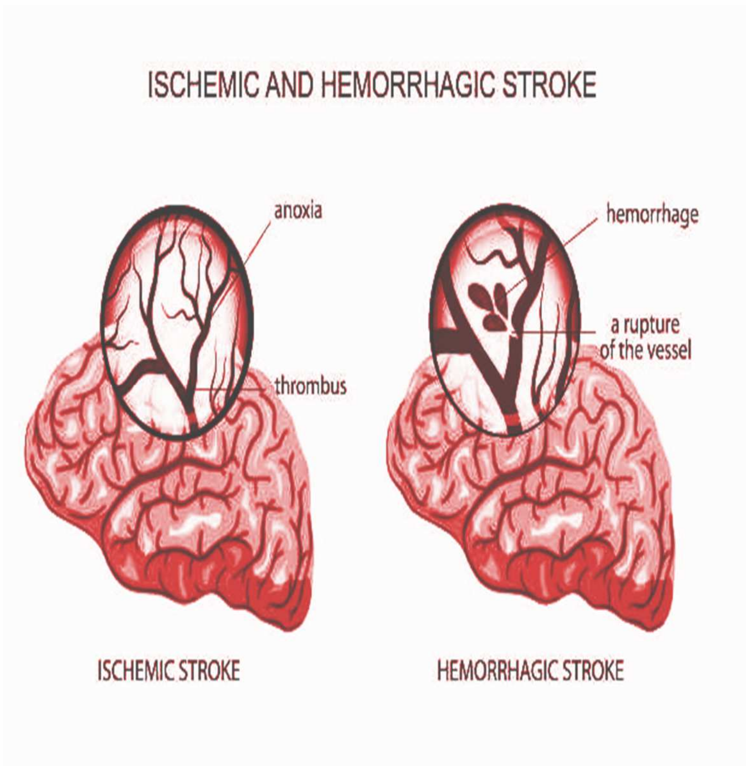

Fig:1 Types of Brain Stroke

LITERATURE REVIEW

In [1], five models are trained for precise prediction using a variety of physiological parameters and approaches for machine learning. Logistic Regression, Decision Tree Classification, Random Forest Classification, K-Nearest Neighbors, and Naive Bayes Classification are the classification techniques employed in this model. They are able to precisely forecast how different physiological aspects will affect how well a task will be performed by utilizing these models. Naive Bayes, with an accuracy of about 82%, was the algorithm that excelled at this challenge.

In [2], four leveraging machine learning techniques were developed in this research for identifying the type of stroke a person may have had or may be experiencing based on their physical condition and medical report data. The classification findings showed that all of the algorithms were successful in gathering a substantial amount of hospital entries, and the outcomes were adequate. Real-time medical choices could be aided by the utilization of this information. There are several ways to identify stroke illness, with Naive Bayes doing the best. According to the performance study, Naive Bayes is the most accurate approach.

In [3], this work provided a way for predicting early stroke disease using a variety of strategies for machine learning. Ten separate classifiers have each been instructed to classify individuals according to the presence of hypertension, body mass index, heart illness, normal blood sugar, smoking status, previous stroke, and age. In order to attain the best accuracy, the basic classifiers' output was then combined using the weighted voting method. Additionally, the proposed study's accuracy rate is 97%. The stroke prediction accuracy of this model is the greatest. The weighted voting classifier's area under the curve value is similarly high. The weighted voting classifier had the lowest rates of false positive and false negative results when compared to the other classifiers. Weighted voting was therefore practically the perfect classifier for predicting strokes, enabling medical professionals and patients to suggest therapies and spot impending strokes early.

In [4], machine learning was used to extract, categorize, and forecast several forms of stroke using medical data. Existing studies had little predictive power for risk factors associated with various types of strokes. The Stroke Prediction (SPN) algorithm, which uses an improvised random forest to analyze the degrees of risks associated with strokes, was developed to solve this shortcoming. This study used machine learning techniques to enhance the Stroke Predictor (SPR) model. It was possible to increase prediction accuracy from the prior models to 96.97%.

In [5], supervised learning techniques were used to create a novel machine learning algorithm that could predict a person's likelihood of experiencing a stroke based on medical inputs like their smoking status, heart condition, blood glucose level, and blood pressure. Random forest, KNN algorithms, and the Support Vector Machine (SVM) and other cutting-edge machine learning techniques are compared in this paper. The simulation outcomes show that the suggested method considerably raises accuracy (94.6%) and system efficiency.

In [6], with the use of a collection of stroke data, this provides a general algorithm for classifying strokes using various machine learning algorithms. Algorithms for machine learning are applicable in a multitude of domains, comprising security, medicine and transportation. In the suggested proposal, we must gather information from various patient situations and arrange it in a data set. We must train the computer using the dataset and support vector machines, XGBoost, SGD, decision trees, and random forests are just a few illustrations of the diverse approaches to machine learning accessible. Random Forest achieves good accuracy in these algorithms.

In [7], utilizing free text-based ML using NLP data from brain MRI imaging, DL algorithms outperformed additional ML techniques for forecasting future clinical outcomes. For instance, using multi-CNN and CNN techniques instead of RNN-based ones increased the prediction of unfavorable outcomes in document-level NLP DL. This NLP-based DL method, it is possible to extract and predict significant clinical outcomes from subsequent, unstructured EHR content.

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In [8], brain stroke pictures were used in this study for classification and segmentation. Le Net and auto encoder decoder are two distinct deep learning models that are used for classification and segmentation, respectively. The model is tested on 406 photos from the NIFTI format dataset used in this study. Classification model accuracy is 96%, and segmentation model accuracy is 85%. The outcomes of the experiment demonstrate how important these deep neural networks are for diagnosing brain strokes. As a result, the proposed method's accuracy is higher than that of earlier ones. Despite its numerous difficulties, deep learning is a technique that shows promise imaging techniques used in medicine. The primary issue is caused by the scarcity of medical photographs. The model will be enhanced in the future using a sizable medical dataset.

In [9], the study concentrated on improvements in stroke lesion segmentation and detection. The study examines 113 research papers that have been published in various databases for scholarly study. The research articles were selected based on a set of criteria in order to find the most significant findings regarding identification and segmentation of stroke lesions. The study's conclusion examines the obstacles researchers encounter, both technical and non-technical and makes projections about how they might impact stroke detection in the future.

In [10], microwave imaging-based stroke detection and identification. The benefit from the hemorrhage's physical characteristics, which include a 10% increase in permittivity on both real and fictitious sections. This method is based on the binary accumulative method, which independently applies to the real and fictitious components of the complex permittivity. Through thresholding and pixel-wise multiplication, the final binary image is produced. In all of the investigated situations, the hemorrhage is correctly recognised, but ischemic strokes do not experience false detections. Identification takes less than five minutes, including image reconstruction and automatic detection.

PROPOSED SYSTEM

Various datasets from Kaggle were looked into in order to continue on with the implementation. Out of all the available datasets, a suitable dataset was chosen to develop the suggested model for prediction.

The dataset collected for building the proposed model has to be preprocessed, i.e., cleaned up, in order to make it more machine-readable and understandable. In this step, missing values are dealt with, unbalanced data are corrected, and label encoding particular to this dataset is carried out. Data is cleaned, transformed and reduced into a format that machines can comprehend and analyze.

The machine undergoes training using this data. To perform this task, the dataset is broken up into two parts for training and testing, maintaining an 80% to 20% training data to testing data ratio.

Pre-processed training data and machine learning techniques like Logistic Regression Classifier, Decision Tree Classifier, Random Forest Classifier and KNN are used to train the model. And it is tested using the test dataset. When the models are compared, the model with the highest accuracy metrics is selected, and the deployment phase can be started.The suggested system's technique is shown as its workflow Diagram in Fig2.

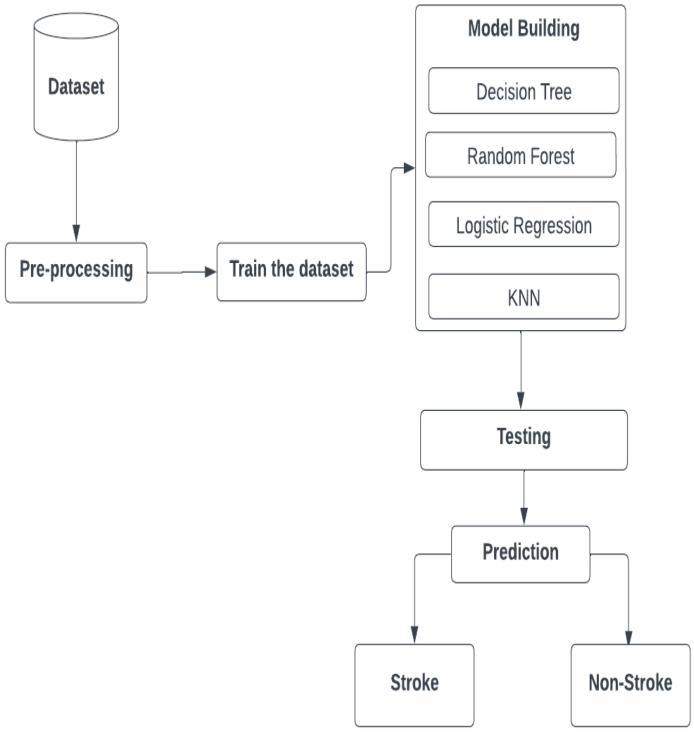
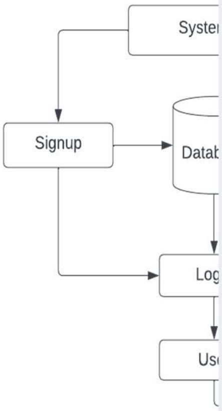


Fig:2 Workflow Diagram

The person who uses our website will be someone who is interested in learning if they are at danger of having a brain stroke or not. In order to access the Web page, the user will have to provide certain information. An HTML website is built for the model deployment to make it simple for the user to enter the input parameters and receive the outcome. The user-entered parameters are sent to the model. The output of the model, a prediction of a brain stroke is generated using the input parameters. The Data Flow diagram shown in Fig 3.



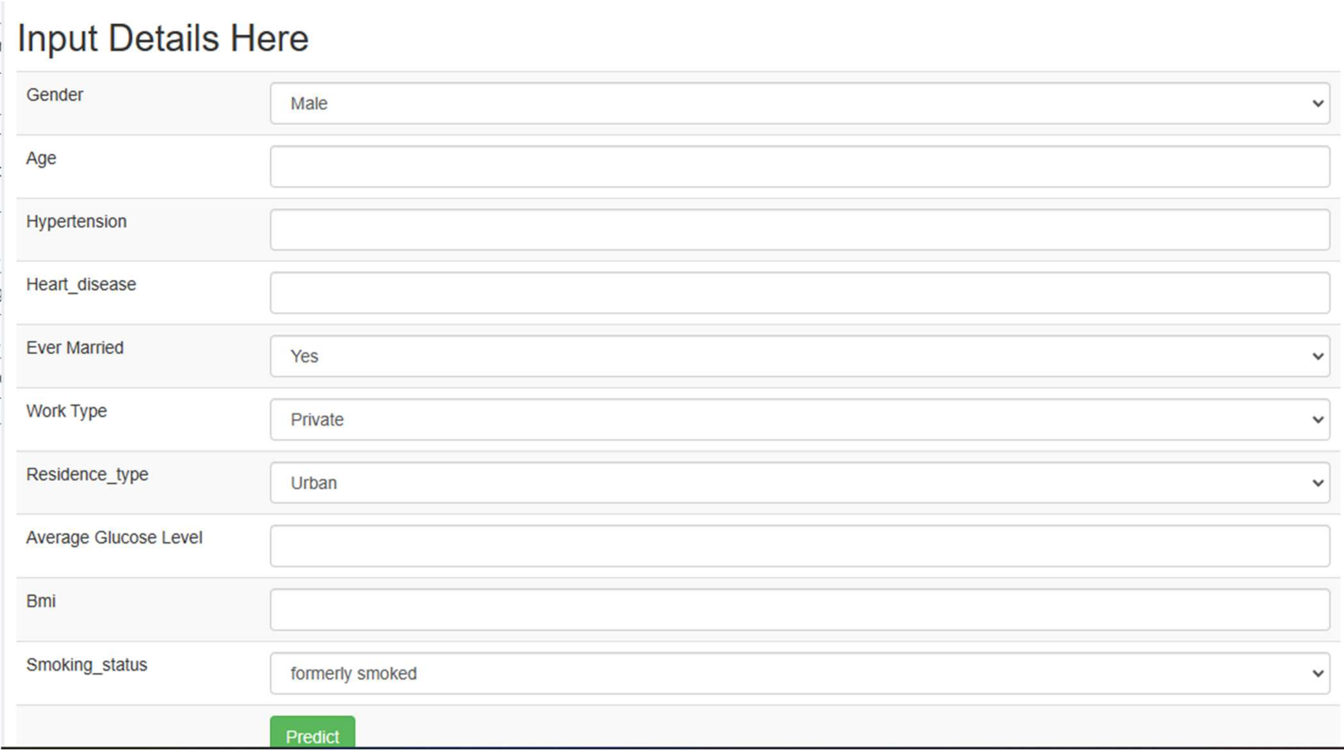


Fig:3 Data Flow Diagram

Fig:4 Input Form

HTML code was used to generate the web page. This programme has an input form that gathers user input data and employs them to project the probability of having a stroke. The user hits the "Predict" button, which sends the input parameters to the flask programme. Web page and machine learning models are connected by Flask, which provides input to the model for prediction and updates the page with the outcome. In Fig. 4, a section of the HTML page is displayed.

Once the stroke is predicted, displaying the percentage contribution of each attribute associated with stroke. Thus, the user becomes aware of the attributes that play a bigger role in causing the stroke. The overall architecture shown in Fig:5.

An interface allows the user to view all information about the brain stroke. The proposed model also identifies the factor that significantly contributes to brain stroke and thus facilitates its prevention through the adoption of necessary precautions

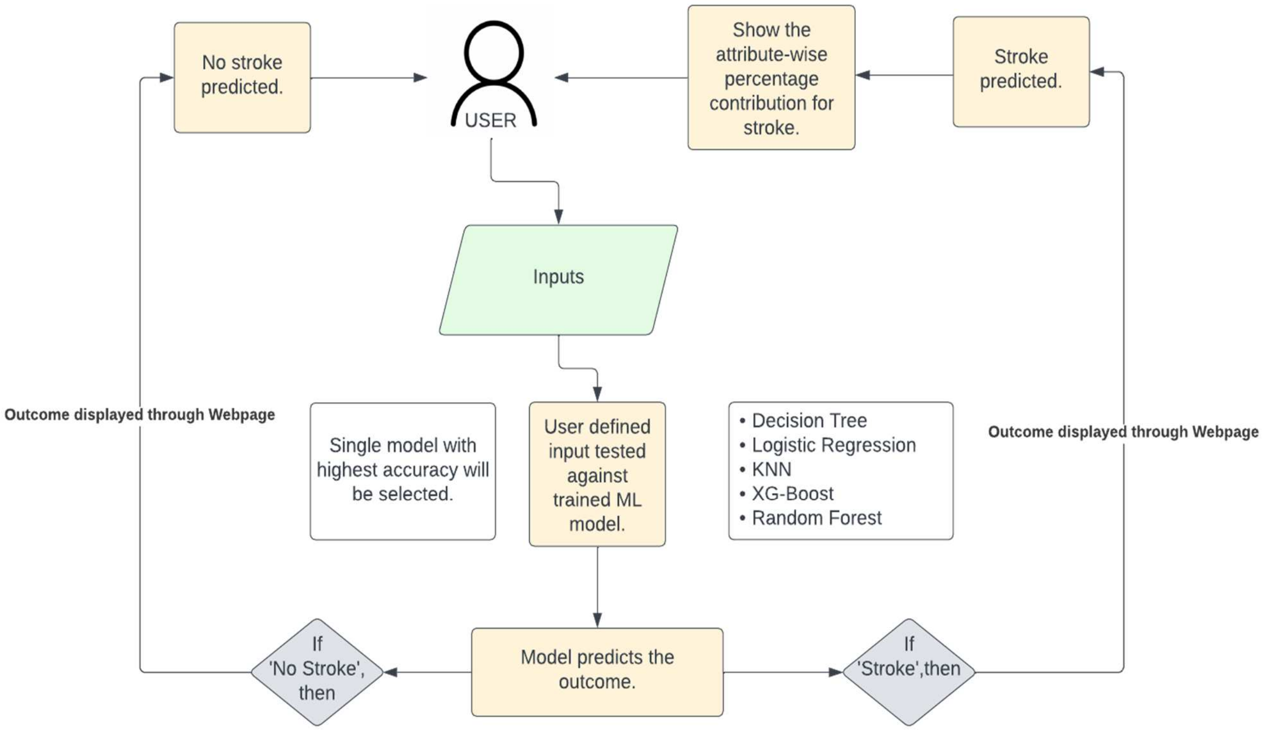


Fig:5 System Architecture

ALGORITHMS

Machine learning algorithms are an essential tool in the healthcare industry for stroke prediction and diagnosis. These algorithms, such as Random Forest, Logistic Regression, Decision Tree, and K-Nearest Neighbors, aid healthcare professionals in identifying stroke risk factors, predicting the likelihood of a stroke, and providing suitable treatment options.

a) *Data Collection*:

Gather relevant data from electronic health records, medical imaging reports, and other sources. This may include demographic information, medical history, lifestyle factors, and imaging data.

b) *Data Preprocessing*:

To remove outliers, missing values, safety precautions, and other discrepancies, clean and preprocess the data. Feature selection and transformation, such as the transformation of categorical variables into numerical values, may also be involved.

c) *Feature Engineering*:

Identify and extract features that are most relevant to brain stroke prediction, such as age, blood pressure, cholesterol levels, smoking status, and diabetes status.

d) *Model Selection:*

Depending on the nature of the data and the specifications of the problem, select a suitable machine learning algorithm. Support vector machines, decision trees, random forests, and logistic regression are a few popular algorithms used for classification tasks.

e) *Model Training:*

Divide the data into training and validation sets, then use the proper optimisation techniques to train the model on the training set. To fine-tune hyperparameters and assess the model's effectiveness, use the validation set.

f) *Model Evaluation:*

Use a variety of metrics to assess the trained model's performance, including accuracy, precision, recall, F1 score, and area under the curve (AUC). Cross-validation methods should be used to make sure the model generalizes successfully to fresh data.

g) Model *Deployment:*

Once the model is trained and validated, deploy it in a clinical setting and integrate it with electronic health records or other decision support systems. This can help healthcare professionals make more informed decisions about patient care and preventive measures.

IMPLEMENTATION

The project will be carried out as follows:

A. Dataset

Attribute Name	**Type (Values)**	**Description**
Id	Integer	Patient’s identification number.
Gender	String literal (Male,Female, Other)	Describes gender of the patient.
Age	Integer	The patient's age.
Hypertension	Integer(0,1)	Determines whether the patient has high blood pressure or not.
Heart_disease	Integer(0,1)	Determines whether or not the patient has heart disease.
Ever_married	String literal (Yes, No)	It indicates whether or not the patient is married.
Work_type	String literal (children,Govt_job,Never_worked,Private,Selfemployed)	It provides various work categories.
Residence_type	String literal (Urban, Rural)	The type of patient's residence is kept on file.
Avg_glucose_level	Floating point number	Provides the value for the blood's average glucose level.
Bmi	Floating point number	Reveals the patient's body mass index value.
Smoking_status	String literal (formerly smoked, never smoked,smokes, unknown)	It discloses the patient's smoking history.
Stroke status	Integer (1, 0)	The stroke status is provided..

Table 1. Stroke Dataset

Researchers frequently use the Kaggle dataset to forecast patients' risk of stroke. With 12 columns and 5110 rows of patient data, this dataset is especially helpful for gaining understanding of the risk factors for stroke. Patient id, gender, age, hypertension, heart disease, having been married before, type of job, type of home, average blood sugar level, BMI, smoking status, and stroke are among the characteristics of the dataset.

With a value of either 1 or 0, the stroke column is the most important attribute in this dataset. A "0" number implies that there is no stroke risk, while a "1" value indicates that there may be a stroke risk. Data preparation is essential with such a big dataset to balance the data for improved accuracy.

To better understand the dataset, a summary is provided in Table 1, which lists the features and their corresponding values. The data preprocessing step involves cleaning and transforming the data into a format that can be easily analyzed by machine learning algorithms. The balanced dataset can then be used to train and test various machine learning models to predict stroke risks accurately.

B. Data Preprocessing

In order to prevent the model from training wrongly, it is necessary to remove the unwanted noise and outliers from the dataset. Any problems that prevent the model from operating more effectively are fixed at this phase. The process of cleaning the data and making sure it is ready for model creation starts once the appropriate dataset has been selected. The dataset that was used comprises 12 attributes, as shown in Table 1. The dataset is first verified for null values, then the 'bmi' property is located, and its median value is used to fill in the blanks. Label encoding is the following task.

C. Label Encoding

Label encoding is a crucial step in machine learning, particularly when dealing with datasets that contain non-numeric data types like strings. The machine learning algorithms work best with numeric data types, and converting string literals into integers is one way to represent the data in a way that the machine can understand.

In the collected dataset, there are five columns that have string data types: gender, ever_married, work_type, residence_type, and smoking_status. In order to make use of this data in a machine learning algorithm, the string literals in these columns must be converted into integer values using label encoding.

The label encoding process assigns a unique numerical value to each unique string value in a given column. For example, if the "gender" column contains "Male" and "Female" as the only two possible string values, they could be assigned the numerical values of 0 and 1, respectively. The same process is applied to the other columns with string values.

After label encoding is applied, the entire dataset is transformed into a collection of integers that can be used by machine learning algorithms. This process is crucial in achieving accurate and meaningful predictions from the dataset, particularly when dealing with complex machine learning models that require high-quality data inputs.

D. Splitting the Data

When the numerical columns of the dataset and data preprocessing are complete, this model will begin to take shape. In order to improve accuracy and efficiency for this task, the data is divided into training and testing data, with the ratio continuing at 80% training data and 20% testing data. After splitting, a number of classification algorithms are used to train the model. The classification techniques used for this include KNN, XG-Boost, Decision Tree Classifier, Logistic Regression Classifier, Random Forest Classifier, and Logistic Regression Classifier.

E. Classification Algorithms

1) Random Forest Classifier:

The main part of a random forest classifier is a decision tree. By comparing and averaging all of the decision trees, the most effective and accurate solutions are discovered. The decision trees in Random Forest were all individually trained using an assortment of data (RF). As part of the training process, decision trees are constructed, and the outcomes are compiled. The ultimate prediction made by this algorithm is determined by a vote. In this method, each DT is required to choose one of the two output classes by a majority vote. The class with the greatest votes is selected as the final forecast using the RF method. In this situation, the stroke prediction accuracy using the random forest classification method was 94.71%, which is less accurate than using logistic regression.

2) Logistic Regression:

The main goal of logistic regression is to get outcomes that are Boolean in nature. The output in this case is of the yes/no or 0/1 type. In the supervised learning approach (LR), one of the most widely used machine learning (ML) algorithms is logistic regression. It is a forecasting method that forecasts a categorical dependent variable using a number of independent factors. Logistic regression is a technique used to forecast the outcome of a categorical dependent variable. The result is, the output has to have a discrete or categorical nature. In this case of stroke prediction, the logistic regression method's accuracy was 93.71%. Finally, utilizing this logistic regression algorithm, we must forecast the outcomes.

3) Decision Tree Classifier:

Decision tree classification addresses both regression and classification problems. The supervised learning strategy of this algorithm already has a matching output variable for the input variables. Its structure is similar to a tree. With this method, a particular parameter is used to continuously divide the data. A decision node and a leaf node are the components of the decision tree. The first node divides the data, and the second node gives the result. The accuracy of the decision tree classification technique in this case of stroke prediction was 91.48%, which was lower than the accuracy of logistic regression.

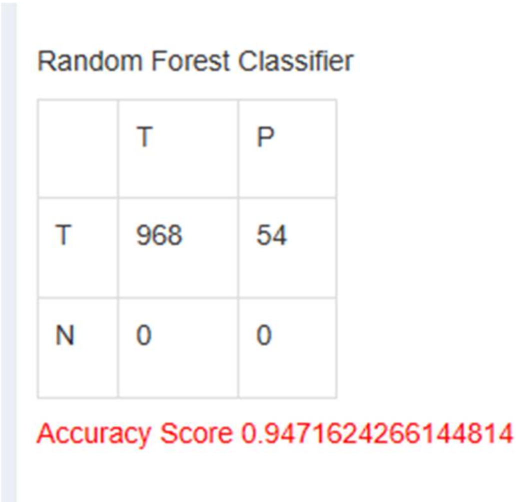
4) KNN Classifier:

In both regression and classification problems, non-parametric techniques like the K-Nearest Neighbours (KNN) classification algorithm are used. To calculate its classification, it employs the k nearest data points to a new data point. In other words, it determines the class of the new data point by determining the dominant class among its k-nearest neighbors. The dataset and the current challenge can be taken into account while choosing the value of k. The KNN classifier's accuracy for predicting strokes was 93.34%.

RESULT

The system will finally produce the anticipated result after implementing the proposed model. The homepage will assist users in entering the information needed for the linked stroke prediction system, and the GUI portion is designed to be user-friendly for regular people. In order to get the highest accuracy with our dataset, the system has been built using five different ML algorithms, as stated in the Implementation. The system scores features according to how important they are for predicting strokes. The most important features displayed at the top of the chart. This makes it easier to comprehend which characteristics are crucial for predicting brain stroke. It can direct additional investigation and feature choice.

Each algorithm's confusion matrix is displayed in Fig 6, 7, 8 and 9.


Random Forest Classifier

	T	P
T	968	54
N	0	0

Accuracy Score 0.9471624266144814

Fig:6 Random Forest Classifier

Logistic Regression

	T	P
T	968	54
N	0	0

Accuracy Score 0.9471624266144814

Fig:7 Logistic Regression

Decision Tree Classifier

	T	P
T	927	46
N	41	8

Accuracy Score 0.9148727984344422

Fig:8 Decision Tree Classifier

KNN

	T	P
T	949	49
N	19	5

Accuracy Score 0.9334637964774951

Fig:9 KNN Classifier

The accuracy results from various approaches are shown in Table 2.

ALGORITHMS	ACCURACY (%)
Random Forest	94.71%
Logistic Regression	93.75%
Decision Tree	91.48%
KNN	93.34%

Table 2. Accuracy Table

CONCLUSION

The main conclusion of this paper is, it decreases the death rate of the population due to the cause of the Brain stroke. By using this system, we can predict the brain stroke earlier and take the required measures to reduce the impact of the stroke if necessary. So that it saves the lives of the patients without going to death. To help in early prediction of stroke, building a machine learning model is a valuable tool. Numerous machine learning algorithms have been developed and proven effective in predicting stroke based on multiple physiological attributes. This information can help doctors make more informed decisions about how to treat stroke patients.

With an accuracy of 94.71%, Random Forest Classifier outperforms all other methods.

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