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A Machine Learning-Based Surveyof Cerebrovascular Disease Prediction

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Abstract – Machine Learning (ML) is a branch of Artificial Intelligence (AI) that employs software implementations to examine the highest level of accuracy. ML can be applied to predict diseases in the health sector. When the blood flow to a portion of the brain is interrupted or diminished, brain tissue is deprived of oxygen and nutrients, resulting in a stroke. Within a minute, brain cells begin to die. There are two types of brain stroke: ischemic stroke (a blocked artery in the brain) and hemorrhagic stroke (a blood vessel leaks or bursts). The goal of this research is to implement and examine the ML algorithms that are employed in stroke prediction. This review represents the ML approaches utilized for stroke predictions, using previous studies. The death rate, morbidity, and functional result are all predicted outcomes, according to the majority of the studies. The most commonly used techniques to predict the stroke are Support Vector Machines, Random Forest, Decision Trees, Logistic Regression, KNN, XGBoost, and Artificial Neural Networks. Best results are produced based on the determination of precise attributes to utilize as causes of stroke. The purpose of this survey is to predict symptoms and changes in patient's health at an early stage so that stroke can be observed later. For the prevention of major causes of stroke, the prime time of 0-90 minutes will be regarded as the prime period. Despite this, just a few oracles and classifiers produced reporting criteria for medical sector tools, none of which were useful. As a result, the goal of this analysis was to examine the accuracy of several ML algorithms for stroke prediction.

Keywords – Stroke prediction, Machine Learning Techniques, Artificial Intelligence, Ischemic Stroke, Hemorrhagic Stroke.

1. INTRODUCTION

1.1 Artificial Intelligence (AI)

Artificial Intelligence refers to the intelligence illustrated by computers. In today's Smart environment, Artificial Intelligence has become highly popular. It is the mimicking of human intelligence in computers that has been programmed to learn and replicate human activities. These computers can learn from their mistakes and do human-like jobs. Artificial intelligence (AI) will have a significant influence on human quality of life as it advances. Metadata has taken over the world, where everything around us has a connection to a data source and every aspect of human life is documented digitally. There are many types of data available in the current electronic world, including cybersecurity data, IoT data, business data, smart cities data, smartphone data, social media data, and healthcare.

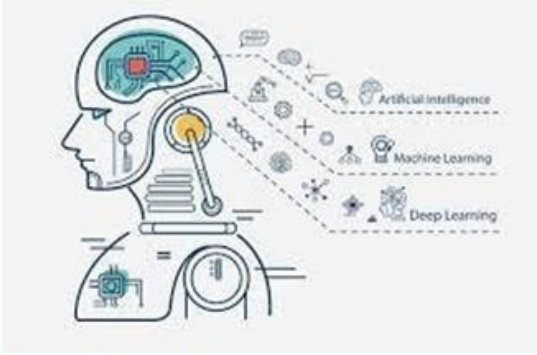

Figure 1. Brain of AI

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There are different types of data including structured, semi-structured, and unstructured. A variety of applications can be created based on insights extracted from these data without human assistance. It is therefore vitally important to develop data management tools that can help knowledge or extract insights from data in a timely and intelligent way, which supports the development of real-world applications. In today's smart world, the majority of apps are created by AI, which is nothing more than computers doing the work, which can mimic cognitive functions similar to those of the human brain, such as knowledge, prediction, and problem-solving. Since the inception of artificial intelligence (AI), particularly machine learning (ML), both technology and data analysis have grown rapidly in recent years, typically allowing the applications to operate intelligently.

1.2 Machine Learning (ML)

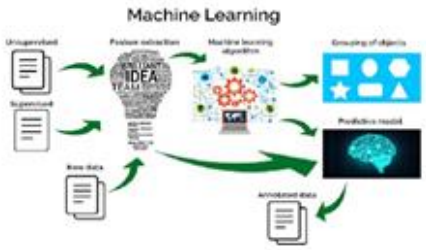

Figure 2. Process of ML

ML usually delivers systems with the ability to learn and enrich from knowledge automatically without being explicitly programmed. Figure 1 illustrates the layers of AI. The base layer was called Machine Learning in other words the Brain of AI (Fig.1). Therefore, machine learning techniques with their own algorithms are necessary to analyze these data intelligently, and to develop the applications for real-world use. In the Machine Learning process (Fig.2), there are two types of data that are generally used. One is training data (80% of the data used for training the model) the other one is testing data for the model and getting the similar output which we trained in it. During the time of training the model, we need to pre-process the datasets. There are three types of Machine Learning techniques (Fig.3) like Reinforcement Learning and Supervised, Unsupervised.

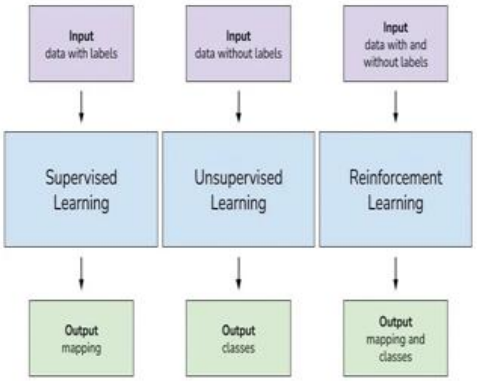

Figure 3 – ML Techniques

1.2.1 Supervised Learning

In machine learning one of the types is Supervised Learning which generally maps inputs to outputs based on samples of input-output pairs. It uses labeled training data and a collection of training examples to infer a function. The inference is performed utilizing labeled training data and examples gathered during training. Supervised learning is carried out to be accomplished from a certain set of inputs i.e., a task-driven approach when certain goals are identified. The common supervised works are "regression" that fits the data and "classification" that isolates the data. For example, predicting the class label or sentiments of a piece of text, like a product review or tweet.

1.2.2 Unsupervised Learning

Unsupervised Learning specialist for the unlabeled datasets without mortal hindrance. For example, a chatbot process. This is extensively utilized for rooting relating meaningful trends and structures, generative features, groupings in results, and experimental purposes. The most common unsupervised learning works are dimensionality reduction, viscosity estimation,

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clustering, point literacy, changing association rules, and anomaly discovery.

1.2.3 Reinforcement Learning

Reinforcement Learning enables machines and software agents to automatically estimate the optimal address in a particular environment or context to enhance its effectiveness. For instance, a climate-driven approach. This type of learning is disadvantageous or grounded on price, and its ultimate goal is to use perceptivity attained from environmental activists to take steps to increase the bonus or minimize the threat. It's an important tool for training AI models that can help to improve the robotization or optimize the functional effectiveness of refined systems similar to independent driving, robotics supply chain, and manufacturing logistics.

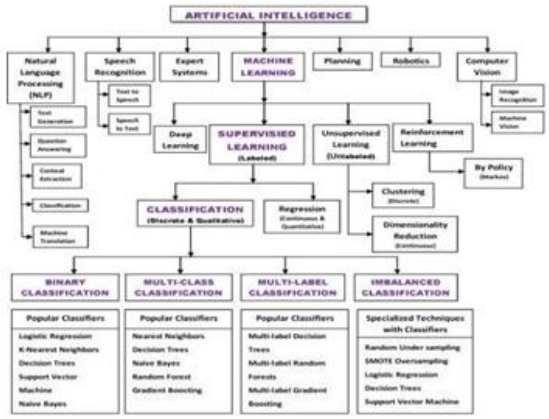

Figure 4 - AI tree

We concentrated on the Classification issue(Fig. 4), a subset of the supervised Learning Techniques. The study area of the survey is Cerebrovascular Disease (Stroke) in the Healthcare Sector.

Stroke was the second leading cause of mortality worldwide in 2013, with an estimated 6.5 million fatalities and 113 million DALYs (Disability Adjusted Life Years). Moreover, two-thirds of these deaths occurred in underdeveloped nations. Next 30 years, 80% of the predicted global burden of new strokes of 15 million will occur in low and middle-income countries [1]. The Indian Stroke Association found that the incidence of stroke in India has increased by almost 100%. The incidence of stroke in India was assumed to be between 105 and 152/1,00,000 people per year in a recent habitual evaluation [2]. Every year, almost

million Indians suffer from a stroke. Early treatment of a stroke can diminish mortality and morbidity. Fig. 5 reveals the death rate for leading diseases in the world demonstrated by WHO (World Health Organization) compared with 2009 and 2019.

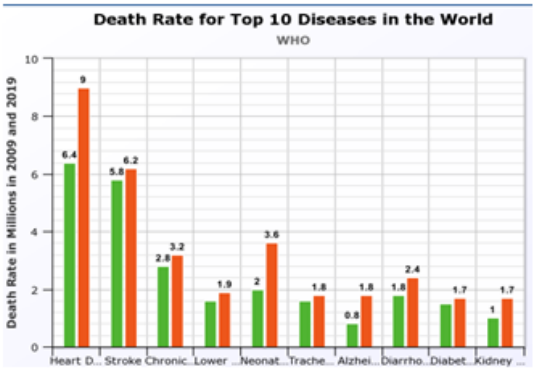

Figure 5 –Leading Disease Charted by WHO

After 2019, stroke has been linked to COVID-19 in several studies, with 0.9 percent to 23 percent [3] of COVID-19 patients developing a stroke as a result of respiratory infection [4,5]. The Covid-19 pandemic continues to have an influence on people's lives; recent research published in the Journal of the American Medical Association Neurology in July 2020 found a link between those who have COVID-19 and an increased risk of ischemic stroke. As a result, an increased risk of stroke has necessitated a greater understanding of stroke among the general population [6]. There are two common stroke types (Fig.6). One is Ischemic stroke, which is caused when a clot or other blockage affects a brain

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artery and it is the most common type of stroke across the globe. Therefore, it becomes vital to manage the time between the onset of stroke and its treatment.

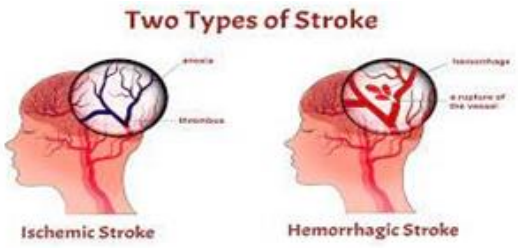

Figure 6 Common Types of Stroke

If a person has a stroke within 0-90 minutes of the commencement of the stroke, there is a better chance of recovery if the right treatment is given and the protocol is followed. A delay in seeking the proper treatment results in instances of incapacity and may typically be fatal.

One of the key issues that impede higher stroke care-associated outcomes is correct data of stroke risk factors (Table 1) and correct practices of stroke prevention. it's 2 styles of citations:

1. Stroke in hardly affected COVID-19 patients who at the start develop COVID-19 symptoms and in a while develop stroke as a multiorgan involvement.

2. Periodic studies have shown that some patients present with stroke as an initial materialization and are later on found to own COVID-19, these are young patients while not risk factors for brain stroke.

However, while this growing non-communicable unwellness [7] threatens the larger populace, stroke treatment and rehabilitation stay underdeveloped within the country. Undoubtedly, associate integrated and comprehensive approach to handle the growing burden of stroke is the want of the hour. Increasing awareness and promoting health-seeking behavior will lead to patients being known faster, remarked comprehensive centers immediately, and receiving the most effective treatment. The first designation of Stroke has been expedited by the Doctor's treatment, ensured, and incorporated with the new era of Computer Science, AI and Machine Learning (ML). Public education and spreading mass awareness are key steps to preventing a stroke. Recognizing symptoms and early diagnosis will save a lot of lives each day.

Table 1 - Common Risk Factors for Stroke

Non – Modifiable factors	Modifiable factors	Lifestyle & Social
• Age • Gender • Family History • Ethnicity • Genetic Evidence • Previous history of CVD	• Blood Pressure • Cholesterol • HDL cholesterol • Smoking • Blood sugar/diabetes • BMI • Markers chronic inflammation	• Income • Social deprivation • Environment • Diet • Stress • Exercise

2. SURVEY OF THE LITERATURE RELATING TO MACHINE LEARNING

A study and analysis are being done in this section on the preliminary papers involved in the work of predicting stroke types using different machine learning approaches.

In 2012, A.Sudha et al., [8] used Classification algorithms like Decision Tree, Naive Bayes, and Neural Networks for their models to predict Stroke disease.Principal Component Analysis (PCA) algorithm was used for dimensionality reduction. The reduction of the data was done through PCA, which determined the attributes

that contributed more to stroke prediction. They used three classifiers for the diagnosis of patients with Stroke. After the observations, Neural Network performance reveals more accuracy.

In 2015, Balar Khalid and Naji Abdelwahab,[9] developed a data mining framework that combines classification and logistic regression for predicting ischemic stroke. The authors studied the various risk factors associated with ischemic stroke. They used the implementation of WEKA

3.6. The data were preprocessed, cleaned, and analyzed using logistic regression and the C4.5 algorithm. According to their study, the logistic regression model performed well. By analyzing the data from the case study, the researchers were able to determine what factors led to ischemic strokes. XLSTAT demonstrated a very high sensitivity of 77.58% and a very high specificity of 83%. The ROC curve measures specificity as a function of sensitivity.

In 2017, M.Seetal Singh and Prakash Choudhary [10] compiled datasets from the Cardiovascular Health Study (CHS). A total of 212 strokes and non-strokes were gathered in three datasets. There are 357 attributes in total and 1824 entities with 212 stroke occurrences in the final dataset. As part of the proposed method, C4.5 decision tree algorithms are used for the feature selection method, and PCA is used to reduce the dimension. Following the reduction, an Adopted back propagation neural network (ANN) classification was used to construct an accurate classification model with an accuracy of 97.7%.

In 2018 Y.Zhang et al., [11] explained that detecting stroke risk is an extremely challenging and time-sensitive task. In this research, they studied the biomedical test and discovered six aspects associated with the most significant risk factors, and proposed a new feature selection model based on feature standard deviation, which is a hybrid of support vector machines and the glow–worm swarm optimization techniques. The proposed model produced a result of 82.58 percent. This model improved the accuracy of the referenced unique technique and will be taken into consideration in the research.

In 2019 Garcia –Terriza et al., [12] stated, the purpose of the current study was to apply machine learning-based modelling strategies to the test. They created the notion of detecting the kind of stroke, whether hemorrhagic or ischemic, and predicting future consequences of the condition in this work. When combined with monitoring technology, they can identify the kind of stroke only a few minutes after the crisis has occurred. The datasets featured seven predictors and two target variables: a) stroke diagnosis; and b) death forecasting.Seven different algorithms were used and evaluated. The Random Forest model performed the best, with average values of 0.93±0.03 and 0.97±0.01, respectively.

In 2019 Tasfia Ismail Shoily et al.,[13] employed a sufficiently big datasets of stroke-affected individuals who had been correctly diagnosed. For the screening of stroke disease, four classifiers were used:

Naive Bayes, J48, k-NN, and Random Forest. The innovation and key contribution of their study were the datasets collection and preparation for usage with WEKA. The datasets used in this approach are not entirely symmetrical, which is one of its shortcomings. The Naive Bayes method did not perform as predicted. It is feasible to expand the research in the future by utilising alternative categorization approaches with symmetrical data.

In 2019 M.Seetal Singh et al., [14] proposed and

applied five methods for predicting the stroke namely SVM, ANN, PCA+ANN, DT+ANN, DT+PCA+ANN.

Only the C4.5 method and the Decision Tree were utilised for feature selection. Dimension reduction was accomplished using the PCA tool; dimension reduction improves accuracy while decreasing run time.Classifiers such as ANN (Artificial Neural Network) and SVM (Support Vector Machine) were employed for classification. Finally, the composite approach of DT, PCA, and ANN yielded better results among the many methods used.

In 2019 Eva Tuba et al., [15] stated the most common Machine Learning job in the medical industry is to improve the accuracy and speed of data processing and diagnosis. To improve classification accuracy, select a significant feature collection and appropriate classification model parameters. For the classification of medical datasets, ancient Genetic Algorithms (GA), Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO), and others were extensively used. The author suggested the BrainStorm Optimization technique in this study for conducting feature selection and modifying parameters of the SVM utilised for Medical datasets classification. The proposed technique performed better in terms of classification accuracy.

In 2020 Khanday et al.,[16] Using classical and ensemble machine learning methods, authors categorised textual clinical reports into four categories. Term frequency/inverse document frequency (TF/IDF), Bag of words (BOW), and report length were used in feature selection engineering. Following classification, it was discovered that logistic regression and the multinomial Nave Bayesian classifier produced good results (96.2 percent). For better outcomes, more feature engineering is required. Recurrent neural networks may be utilised in the future to improve accuracy.

In 2020 L. J. Muhammad et al.,[17] indicated that early prediction of COVID-19 can help lessen the enormous strain on healthcare systems by assisting in the diagnosis of COVID-19 patients In this

study, decision tree, logistic regression, naive Bayes, SVM, and ANN models for COVID-19 infection prediction were created using an epidemiology dataset for positive and negative COVID-19 cases in Mexico. Before creating the models, the correlation coefficient analysis between multiple dependent and independent characteristics was performed to assess the strength and link between each feature of the dataset. According to the results of the model performance evaluation, the decision tree model has the greatest accuracy of 94.99 percent, the Support Vector Machine Model has the best sensitivity of 93.34 percent, and the Nave Bayes Model has the highest specificity of 94.30 percent.

In 2020 Fengxia Li et al.,[18] acknowledged Stroke patients require home-based treatment in the context of the emerging crown pandemic. Based on this, they integrate regression models and SVM utilising machine learning techniques to create a smart wearable device system and a system prediction module to forecast patient care requirements. The node collects and wirelessly transmits data on human body movements and physiological parameters. The programme is used to swiftly process and analyse the patient's numerous motion and physiological characteristics, and to preserve the analysis and processing structure in a database. The findings suggest that wearable devices can enhance patient health indicators, and that when the patient's condition improves, so does the patient's self-care abilities and mobility.

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In 2021 Darabi et al.,[19] stated to improve predictors of 30 days readmission following an ischemic stroke and create models to identify high-risk people for targeted treatments. They used data from electronic health records at the patient level (EHR). Random forest, gradient boosting machine, extremegradient boosting-XGBoost, support vector machine, and logistic regression are the five machine learning techniques. Adaptive sampling and a data-driven feature selection technique were applied. Among the algorithms studied, XGBoost with ROSE sampling had the best AUC (area under the curve) performance, while LR with ROSE sampling and feature selection had the best sensitivity..

In 2021 Vempadi Krishna et al.,[20] stated goal of the effort, early brain stroke prediction, generates a larger quantity that is beneficial for the initial time investment. Several machine learning (ML) techniques were utilised in this study, including K closest neighbour, logistic regression, random forest (RF) classifier, and SVC. Finally, the authors used KNN with Graphical User Interface to build and evolve

the model. The KNN model performed the best, with a score of 99.35 percent, compared to DT's score of 98.98 percent, RF's score of 98.57 percent, SVM's score of 94.57 percent, and LR's score of 94.32 percent. A user may use GUI to input their health report information and forecast if they are suffering from a brain stroke or not. It will forecast early identification of a brain stroke, reducing morbidity and mortality, as well as prompting the patient to contact a doctor for treatment.

In 2021 Ponmalar A et al.,[21] proposed ANN (Artificial Neural Network) as a machine learning method, with the greatest degree of accuracy of 99 percent. In contrast, when compared to current systems like Random Forest and XGBoost, the ANN produced the predicted results. It is feasible to predict whether or not someone is at risk of having a stroke by using machine learning algorithms. It aids in the identification of stroke patients. This study looked at more than a dozen indicators. Authors built a multi-layered method based on fully connected neural networks implemented in Keras with Tensorflow as a backend to address this classification challenge.

3. A RELATIVE APPRAISAL FOR PRECEDING WORK

S.No	Author Name	Advantages/Methods Used	Disadvantages	Results
1	Sudha et al.[8]	DT, Bayesian Classifier, and Neural Network were used. The PCA Algorithm is used to avoid overfitting.	Only 1000 records were taken.	Neural Network-94% Decision tree – 92% Naive Bayes classifier -91%
2	Singh & Choudhary[10]	The Decision Tree technique was employed for feature selection, while PCA was utilised for dimensionality reduction. For categorization, ANN was utilised.	-	The accuracy of the Back Propagation neural network forecasting model was 97.7 percent.
3	Y.Zhang et al.[11]	They developed a novel feature selection model that combines STD, a filter-based variable, and SVM.	Need to improve the accuracy.	SVM Classifier used and obtain 82.58% of accuracy.
4	Garcia–Terriza et al.[12]	As confirmed, They employed the sample and normalised it using Z-normalization. Following the training of their two algorithms, they established stroke subtype diagnosis and exits prediction.	Because it does not assist rural regions, their investigation highlighted computer-aided ways.	The Random Forest model performed the best, with average values of 0.93±0.03 and 0.97±0.01, respectively.
5	Tasfia Ismail Shoily et al.[13]	Authors proposed With the use of WEKA, four classifiers were employed to determine stroke disease: Nave Bayes, J48, k-NN, and Random Forest.	The data source is not symmetrical in every way. The Naive Bayes method did not perform successfully.	Random Forest provide the highest accuracy 99.8%
6	M.Seetal singh et al.[14]	For feature selection, DT with the C4.5 was employed, PCA was utilised for dimension reduction, and ANN and SVM were used for classification.	This study demonstrates a limited set of input parameters. A vast number of input parameters were required for the upgrade.	The combination of the Decision Tree, Principal Component Analysis, and Artificial Neural Network resulted in a 97.7 percent success rate.
7	Khanday et al.[16]	For feature selection engineering, Term frequency/inverse document frequency (TF/IDF) and Bag of words (BOW) were utilised. Logistic regression and Multinomial Nave Bayes	For better outcomes, more feature engineering is required. RNN(Recurrent Neural Network)	Logistic regression and Multinomial Nave Bayes both have an accuracy of 96.2 percent.

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		outperformed other ML techniques.	may be used to improve accuracy.	
8	L. J. Muhammad et al.[17]	For dependent and independent characteristics, correlation coefficient analysis was utilised. They created and compared five models, including the probable decision tree, logistic regression, naive Bayes, SVM, and ANN.	To enhance the outcomes, more feature engineering is required.	The model decision tree has the highest accuracy of 94.99 % Logistic regression 94.91% Naive Bayes 94.36 %
9	Darabi et al.[19]	Patient EHR (electronic health record) was employed, along with five ML algorithms: random forest, gradient boosting, extreme gradient boosting-XGBoost, support vector machine, and logistic regression-LR. The Rstudio package Boruta is used for data-driven feature selection. ROSE (Random Over-Sampling) Sampling is used to balance a dataset.	For a limited number of data, the model is overfitting. The vast majority of patient data comes from non-urban locations.	The best result was achieved by LR using ROSE Sampling and feature selection, with AUC (area under the curve):0.64, Sencitivity.:0.53, and Specificity:0.69..
10	Dr Vampati Krishna et al. [20]	Author created a model and applied machine learning methods such as K nearest neighbour, logistic regression, Random forest (RF), and SVM. Using the FLASK framework and the KNN model, the author utilizes a Graphical User Interface (GUI).	The GUI interface may not be supported in rural locations.	The accuracy of the KNN Classifier was 99.35 %
11	Ponmalar A et al.[21]	Kaggle dataset of 10,000 patients and hospital data was utilised. Using the Keras framework and the Tensorflow backend, the author created a multi-layered fully connected feed-forward neural network.	-	The classifier based on an Artificial Neural Network (ANN) attained the greatest accuracy of 99%

4. CONCLUSION

The COVID-19 outbreak has ushered in a new era of healthcare. It is critical to plan for the continuous development of acute operation techniques as well as the finding of implicit long-term complaint instantiations in COVID-19 survivors, including Stroke [22]. Machine learning has made significant progress in predicting stroke in a variety of settings. Choose one of the following methods: Consider situations, datasets, parameters, and other analyses before selecting a machine learning approach that matches each circumstance. At this time, a firm recommendation for usage in stroke prediction cannot be provided. Techniques differ depending on its application and Practices. It is prudent to select one of them based on the importance of the specific problem statement. To make a decision, statistical analysis and initialization must be performed.

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