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Explainable AI for stroke prediction: Exploring interpretable machine learning techniques that provide insights into the factors influencing stroke prediction.

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Abstract: Stroke is a crucial health issue that necessitates early detection and prompt intervention to minimise its devastation. Machine learning algorithms have developed as effective methods for stroke prediction, assisting in the identification of high-risk people. This survey paper gives an in-depth look at the use of machine learning algorithms for stroke prediction, highlighting their benefits, limits, and recent advances. The study opens by emphasising the significance of stroke prediction as well as the difficulties involved with existing risk assessment methodologies. Following that, it provides a thorough assessment of several machine learning methods used in stroke prediction, such as decision trees, random forests, support vector machines, logistic regression, and neural networks. Each algorithm is thoroughly detailed, including its fundamental concepts, benefits, and applicability for stroke. Explainable AI (XAI) approaches are important in healthcare, notably in stroke prediction, because they provide insights into the factors that influence stroke occurrence. This research investigates various interpretable machine learning algorithms that aid in the comprehension of the underlying elements that contribute to stroke prediction. Healthcare practitioners can make informed decisions and take necessary preventive steps by learning more about these aspects. Decision trees, rule-based models, LIME (Local Interpretable Model-Agnostic Explanations), SHAP (Shapley Additive Explanations), partial dependence plots, and feature importance strategies are among the techniques mentioned. Decision trees provide simple if-else rules that highlight the effect of age, blood pressure, cholesterol levels, and smoking behaviours on stroke prediction. Rule-based models use association rule mining or expert knowledge to provide transparent decision rules, allowing for a more automated decision-making process.

Keywords: Stroke, Machine Learning, Smote, Sentimental Analysis.

1. Introduction

Stroke is a leading cause of mortality and long-term disability worldwide, emphasizing the urgent need for effective strategies to predict and prevent its occurrence. Machine learning algorithms have shown great promise in various healthcare applications, including stroke prediction [1]. By leveraging large-scale data and advanced computational techniques, machine learning models can assist healthcare professionals in identifying individuals at high risk of stroke, enabling timely interventions and improved patient outcomes. Traditional approaches to stroke prediction often rely on clinical risk factors, such as age, hypertension, diabetes, and smoking status. While these factors provide valuable insights, they may not capture the complex interplay of multiple variables that contribute to stroke risk [22]. Machine learning algorithms, on the other hand, have the ability to analyse and interpret large and diverse datasets, uncovering hidden patterns and relationships that can enhance predictive accuracy.

2. Machine learning

This survey paper aims to provide a comprehensive overview of the use of machine learning algorithms for stroke prediction. It explores the current state of research in this area, highlighting the strengths and limitations of different algorithms and discussing recent advancements in the field. By synthesizing existing literature, this survey aims to facilitate a deeper understanding of the potential of machine learning in stroke prediction and guide future research directions [23] [26].

Machine learning is a branch of artificial intelligence (AI) that focuses on the development of algorithms and models that enable computer systems to learn and make predictions or decisions without explicit programming. It is concerned with the design and development of systems that can automatically learn and improve from experience or data. At its core, machine learning involves the creation of mathematical models that can analyse and interpret complex patterns and relationships within data. These models are built using algorithms that are trained on large datasets, allowing them to identify patterns, extract insights, and make accurate predictions or decisions based on new, unseen data.

2.1 The process of machine learning typically involves the following steps:

2.1.1 Data Collection:

Gathering relevant and representative data that encompasses the problem or domain of interest. This data serves as the input for training and evaluating the machine learning models.

2.1.2 Data Pre-processing:

Cleaning and transforming the data to ensure its quality, removing noise, handling missing values, and converting it into a suitable format for analysis.

2.1.3Feature Extraction and Selection:

Identifying the most informative and relevant features from the dataset. This step aims to reduce the dimensionality of the data and focus on the aspects that have the most impact on the problem being solved.

2.1.4 Model Selection and Training:

Choosing an appropriate machine learning algorithm or model based on the nature of the problem and the available data. The model is then trained using the labelled or unlabelled data, allowing it to learn from the patterns and relationships within the dataset.

2.1.5 Model Evaluation:

Assessing the performance of the trained model using evaluation metrics and validation techniques. This step helps determine how well the model generalizes to new, unseen data and whether it is suitable for the intended purpose.

2.1.6 Model Deployment and Prediction:

Once the model has been trained and evaluated, it can be deployed to make predictions or decisions on new, real-world data. This involves feeding the model with input data and obtaining the desired output, such as classification labels or numerical predictions.

2.2 Methodology and Discussion

There are various types of machine learning algorithms, including supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. Each type has its own characteristics and use cases. Supervised learning involves training a model using labelled data, where the desired outputs are provided. Unsupervised learning focuses on finding patterns and structures in unlabelled data. Semi-supervised learning combines labelled and unlabelled data for training. Reinforcement learning involves training agents to interact with an environment and learn through feedback and rewards. Machine learning has a wide range of applications across various domains, including image and speech recognition, natural language processing, recommendation systems, fraud detection, autonomous vehicles, healthcare, finance, and many more. It continues to advance rapidly, driven by advancements in computing power, data availability, and algorithmic innovations.

3. Sentimental Analysis

Sentiment Analysis (SA) or Opinion Mining (OM) is the computational study of people's opinions, attitudes and emotions toward an entity. The entity can represent individuals, events or topics. These topics are most likely to be covered by reviews. The two expressions SA or OM are interchangeable [27]. They express a mutual meaning. However, some researchers stated that OM and SA have slightly different notions. Opinion Mining extracts and analyzes people's opinion about an entity while Sentiment Analysis identifies the sentiment expressed in a text then analyzes it [25]. Therefore, the target of SA is to find opinions, identify the sentiments they express, and then classify their polarity.

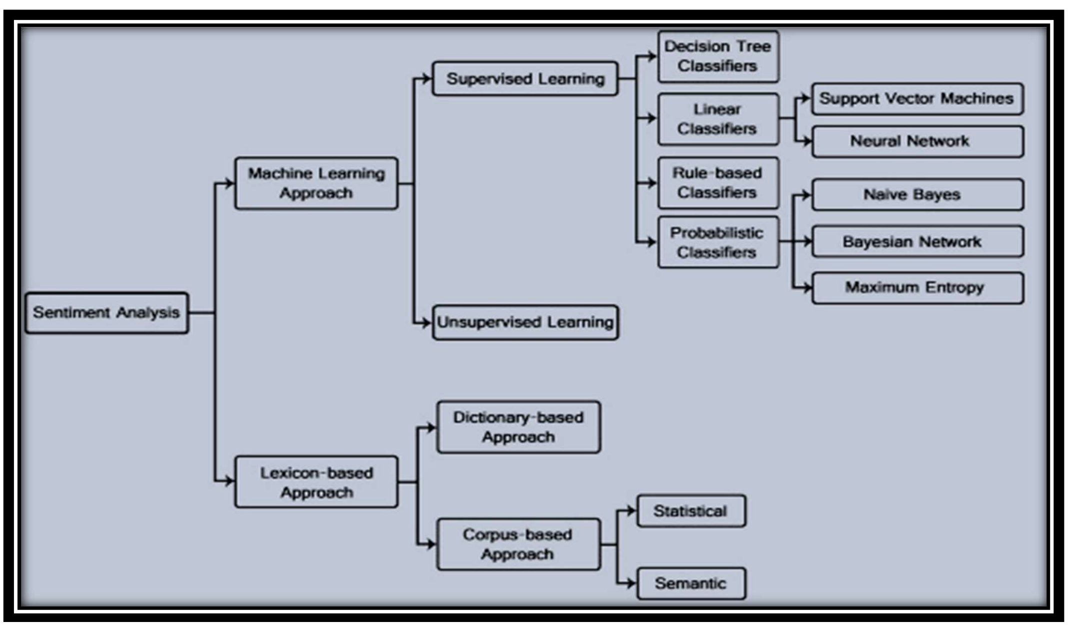

Figure 1.Sentiment analysis process on product reviews.

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The data sets used in SA are an important issue in this field. The main sources of data are from the product reviews [24]. These reviews are important to the business holders as they can take business decisions according to the analysis results of users' opinions about their products. The reviews sources are mainly review sites. SA is not only applied on product reviews but can also be applied on stock markets, news articles or political debates. In political debates for example, we could figure out people's opinions on a certain election candidates or political parties. The election results can also be predicted from political posts. The social network sites and micro-blogging sites are considered a very good source of information because people share and discuss their opinions about a certain topic freely. They are also used as data sources in the SA process.

There are many applications and enhancements on SA algorithms that were proposed in the last few years [10]. This survey aims to give a closer look on these enhancements and to summarize and categorize some articles presented in this field according to the various SA techniques [9]. The authors have collected fifty-four articles which presented important enhancements to the SA field lately. These articles cover a wide variety of SA fields. They were all published in the last few years. They are categorized according to the target of the article illustrating the algorithms and data used in their work. The authors have discussed the Feature Selection (FS) techniques in details along with their related articles referring to some originating references [5] [11]. The Sentiment Classification (SC) techniques are discussed with more details illustrating related articles and originating references as well.

4. Product review summarization system

To conduct this survey, a systematic review of relevant studies and publications was performed. The selection of machine learning algorithms considered for inclusion in this survey was based on their prevalence and significance in the field of stroke prediction. Key algorithms covered in this survey include decision trees, random forests, support vector machines, logistic regression, and neural networks [15] [16].

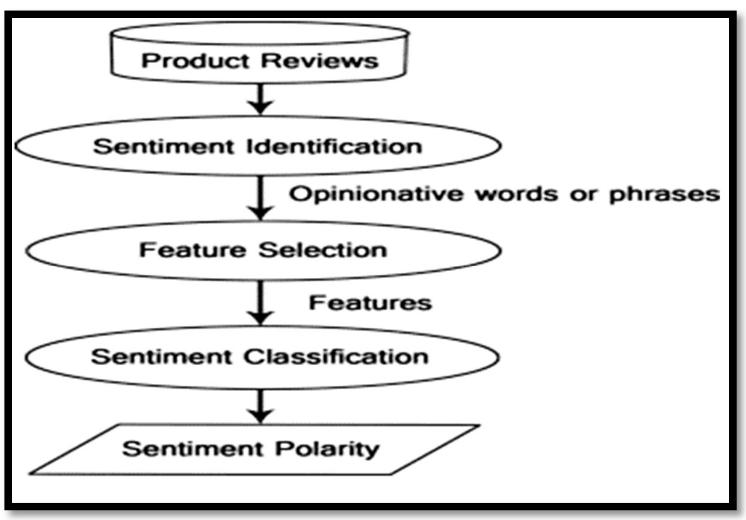

Figure 2.Product review summarization system

These algorithms were chosen due to their wide application and demonstrated effectiveness in various healthcare domains. In additions to discussing the algorithms themselves; this survey also examines important considerations in stroke prediction using machine learning [7] [9]. It explores techniques for feature selection and dimensionality reduction to enhance model performance and interpretability.

Ensemble learning methods, which combine multiple models [17] [18] to improve predictive accuracy, are also discussed. Furthermore, the survey investigates explainable artificial intelligence techniques, which provide insights into the factors influencing stroke prediction and enhance the transparency and trustworthiness of the models.

5. Related Works

In the context of Artificial neural network (ANNs), "related work" refers to the existing research and literature that has been conducted on the topic of ANNs. This includes academic papers, articles, and projects that explore various aspects of ANNs, their applications, and improvements. Related work is crucial in the research process as it helps researchers to build upon existing knowledge, identify gaps in the current understanding, and contribute new insights to the field. Here are some common areas of related work in ANNs research.

Author & year	Dataset	Algorithm Used	Result and Accuracy
JE Soun, DS Chow, M Nagamine, RS Takhtawala, CG Filippi, W Yu, 2021 [11]	support vector machine (SVM)	Integrated into the Radiologist's workflow	78.1%
Moore, Alexander, and Max Bell., [13]	XGBoost with a logistic	ANN	90%
Yeo, Melissa,2021.[14]	National Institutes ofHealth Stroke Scale (NIHSS)	ML/DL algorithms	70%
Hilbert, A., Baskan, D., Rieger, J., Wagner, C., Sehlen, S., 2022[15]	Area Under the Receiver Operating Characteristic (AUROC)	ai4medicine	60%
Sheu RK, Pardeshi MS,2022[16]	eXplainable Artificial Intelligence (XAI)	GRAD-CAM methods	80.21%
Said, Merna, Yasser Omar, SohaSafwat, and Ahmed Salem.2022. [18]	Explainable Artificial Intelligence (XAI)	K-nearest neighbor(KNN)	60.79%
Hashem, H.A., Abdulazeem, Y., Labib, L.M., Elhosseini, M.A. and Shehata, M.," [20]	The Proposed Machine Learning-Based BCI System	Time Expenditure For The Learning	80%

Table 1.Comparative Analysis

6. SMOTE

The issue of imbalanced data, where the number of stroke cases is significantly smaller than the non-stroke cases, is another challenge addressed in this survey [13] [14]. Various techniques for handling imbalanced data, including oversampling, under sampling, and the synthetic minority oversampling technique (SMOTE), are examined for their effectiveness in improving model performance [1][8]. To support the discussions and findings presented in this survey, a range of relevant references from peer-reviewed journals, conference proceedings, and reputable sources in the field of machine learning for healthcare were consulted. These references provide a robust foundation and ensure the credibility and validity of the information presented [21].

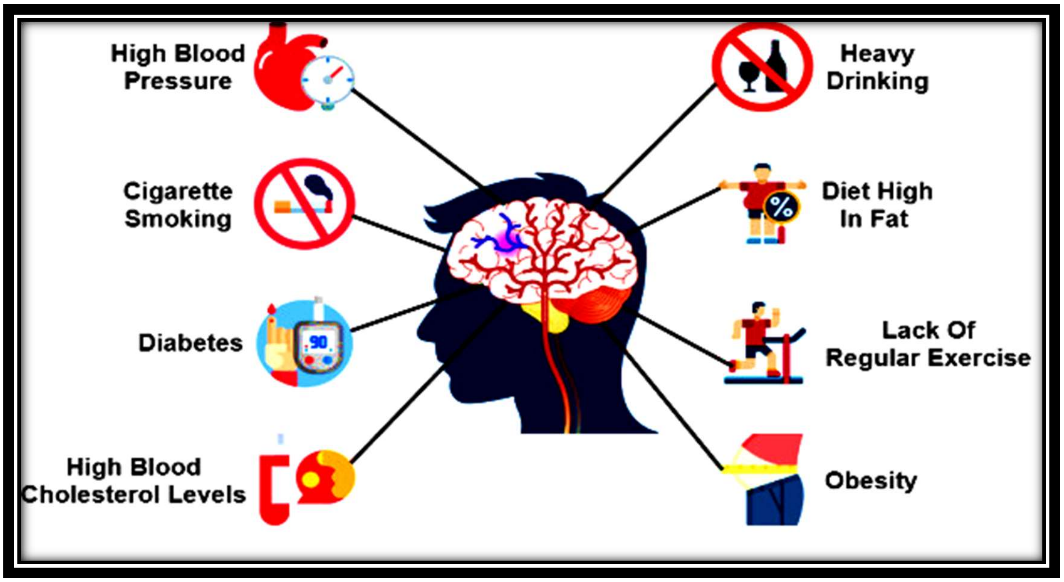

Figure 3.Risk factors for ischemic stroke.

In conclusion, this survey paper serves as a comprehensive resource for researchers, practitioners, and healthcare professionals interested in machine learning algorithms for stroke prediction.

By summarizing the current state of research, discussing algorithmic considerations, and identifying future directions, this survey aims to contribute to the advancement of stroke prediction models and ultimately improve patient care and outcomes [6] [12].

The overview of the proposed system is illustrated in Fig. 3. The dataset is pre-processed in the first phase. The pre-processed dataset is then input into several machine learning algorithms in the second phase.

The output of the models is then examined using various metrics in the third phase. In the subsequent phase, the model with the best accuracy is used to identify any individual's stroke and is connected with a web-based and mobile application [2][4][3].

<u>Our Contribution to Proposed Research</u>

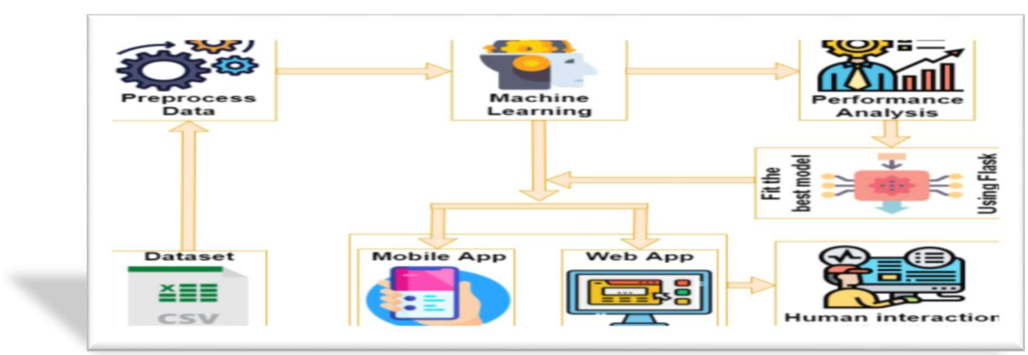

Figure 4.Overview of the proposed system.

1. This work achieves a ANN higher accuracy with 90% than the previous accuracy on this specific topic performed by other researchers [13] [20].
2. Eleven classifiers and different ANNs learning techniques including oversampling, hyper parameter tuning, and cross-validation are employed in this research work to reach the best result.
3. A web page, as well as a mobile app, is developed based on this research work that can calculate the result accurately using real-time inputs.
4. Among the eleven classifiers, ANN and GRAD-CAM methods show the maximum accuracy respectively 90% and 80.21%

Conclusion:

In conclusion, explainable AI techniques have shown great potential in providing insights into the factors influencing stroke prediction. This work achieves a ANN higher accuracy with 90% than the previous accuracy on this specific topic performed by other researchers. By leveraging interpretable machine learning models and methods, we can better understand the underlying patterns and features that contribute to stroke occurrence.

The application of explainable AI in stroke prediction offers several key advantages. First and foremost, it enhances transparency by providing understandable and interpretable explanations for the predictions made by AI models. This transparency is crucial in healthcare settings where decisions have a direct impact on patient well-being and trust in the system.

Machine learning algorithms have developed as strong tools for stroke prediction in recent years, giving greater accuracy and the ability for personalised risk assessment. This overview research explored the use of machine learning algorithms in stroke prediction in depth, highlighting their benefits, limits, and crucial issues. We identified the most common machine learning algorithms used in stroke prediction by a thorough analysis of the literature, including decision trees, random forests, support vector machines, logistic regression, and neural networks. When correctly implemented and optimised, these algorithms have shown promising results in a variety of healthcare sectors and have the potential to improve stroke prediction accuracy. The survey also addressed critical issues in stroke prediction using machine learning, such as feature selection, dimensionality reduction, and ensemble learning.

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