Application of Artificial Intelligence in Stroke Prediction: Latest Advancements and Future Prospects

Boxiang He[a]
Computer Science, Wenzhou Kean University, Wenzhou, China

Keywords: Artificial Intelligence, Brain Stroke, Machine Learning, Deep Learning.

Abstract: Some scientific and technological methods are more and more applied in medical treatment, and great achievements have been made in the prediction of stroke, but there are still great challenges. This paper explores the intersection of stroke management and Artificial Intelligence (AI), focusing on recent advancements, methodologies, limitations, and future prospects. Stroke, characterized by disrupted blood flow to the brain, necessitates swift diagnosis and intervention to mitigate potential cell damage or death. Traditional machine learning algorithms such as Support Vector Machine (SVM) and Random Forest, along with deep learning algorithms like Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN), have been employed to construct predictive models for stroke diagnosis and prognosis. However, challenges including interpretability, privacy concerns, and applicability across diverse healthcare settings persist. Solutions such as Shapley Additive Explanations (SHAP), federated learning, and transfer learning have been proposed to address these challenges and enhance the trustworthiness and generalizability of AI-driven approaches in stroke management. Continued research efforts are necessary to overcome limitations, expand sample sizes, and enhance the accuracy and efficiency of AI models in predicting and analyzing strokes, ultimately improving patient outcomes in stroke management.

1 INTRODUCTION

A stroke, also known as a brain stroke, happens when blood flow to part of the brain is disrupted, causing deprivation of oxygen and nutrients, leading to potential cell damage or death within minutes. Strokes manifest in various symptoms, such as weakness, numbness, difficulty speaking, vision problems, severe headache, and loss of balance. Recent advancements in deep learning technology have significantly influenced stroke diagnosis and treatment in the medical field. Deep learning algorithms excel in accurately analyzing medical images to identify stroke lesions, aiding in faster diagnosis and treatment planning. Additionally, deep learning can utilize large-scale clinical data to predict stroke occurrence, enabling early intervention and prevention (Lee, 2017). Pre-trained models further enhance medical image analysis, improving diagnostic accuracy and efficiency. In summary, the integration of deep learning technology offers promising prospects for precise and effective stroke diagnosis, treatment, and prevention, potentially improving patient outcomes.

Recent advancements in the intersection of brain strokes and Artificial Intelligence (AI) showcase a promising frontier in healthcare (Qiu, 2022). AI technologies are being increasingly employed across various facets of stroke management, catalyzing significant improvements in patient care. Initially, AI algorithms are revolutionizing stroke diagnosis by swiftly and accurately analyzing medical imaging scans, including Magnetic Resonance Imaging (MRIs) and Computed Tomography (CT) scans. This capability enables clinicians to promptly identify stroke symptoms and initiate timely interventions, thereby potentially minimizing long-term damage. Moreover, machine learning models harness vast datasets of patient records to predict individual stroke risks, facilitating proactive measures for prevention and intervention (Soun, 2021). Additionally, AI systems leverage real-time patient data and medical literature to generate personalized treatment plans tailored to each patient's unique needs. By optimizing

[a] https://orcid.org/0009-0001-9327-5761

He, B.
Application of Artificial Intelligence in Stroke Prediction: Latest Advancements and Future Prospects.
DOI: 10.5220/0012960700004508

In *Proceedings of the 1st International Conference on Engineering Management, Information Technology and Intelligence (EMITI 2024)*, pages 617-621
ISBN: 978-989-758-713-9

treatment strategies, AI contributes to enhancing patient outcomes and reducing healthcare costs (Haris, 2018). According to a 2017 study, machine learning has been widely used in stroke imaging, including the two main methods of Artificial Neural Network (ANN) and Convolutional Neural Network (CNN). In addition, according to a 2018 study, artificial intelligence is also used to analyze data on various brain diseases. great effect, but still has limitations Furthermore, AI-driven rehabilitation tools are aiding stroke survivors in regaining motor function and improving overall recovery trajectories. These tools, which incorporate robotics, virtual reality, and personalized exercise regimens, offer tailored support to each patient's rehabilitation journey. Lastly, AI-enabled telemedicine platforms are facilitating remote monitoring of stroke patients, allowing healthcare providers to deliver timely interventions and support, even in underserved areas. This remote monitoring capability minimizes the need for in-person visits, thereby increasing accessibility to quality stroke care. In summary, the integration of AI into stroke management holds immense promise for revolutionizing diagnosis, treatment, rehabilitation, and remote monitoring, ultimately leading to better patient outcomes and healthcare delivery (Dritsas, 2022).

The remainder of this article will delve into the method, discussion, results, and conclusion. Firstly, the method section will meticulously review and encapsulate the research methodologies employed in studying the intersection of stroke and AI in recent years. The forthcoming investigation will undertake a meticulous examination of diverse methodologies employed within the realms of stroke detection, prediction, treatment optimization, rehabilitation, and telemedicine. This scrutiny will encompass an analysis of the datasets utilized, the algorithms deployed, and the evaluation criteria employed across these studies. Subsequently, the ensuing discussion segment will undertake a critical evaluation of these methodologies, delineating their respective strengths and weaknesses. Particular emphasis will be placed on elucidating the encountered limitations, identifying potential areas for enhancement, and envisioning future prospects for furthering technological advancements. This discourse will encompass a comprehensive exploration of the challenges inherent in the integration of artificial intelligence into stroke management practices, whilst offering insights into strategies to mitigate these challenges and augment the efficacy of AI-driven approaches. Lastly, the concluding remarks will consolidate and synthesize the key findings and insights derived from the preceding sections. This will involve furnishing a comprehensive overview of the paper's contributions to the academic domain, delineating avenues for prospective research endeavors, and underscoring the imperative nature of ongoing innovation in harnessing AI to ameliorate stroke care practices.

2 METHOD

2.1 Traditional Machine Learning Algorithms

In recent years, machine learning has rapidly developed and developed in a variety of applications in various healthcare systems (Bi, 2019). Machine learning is a branch of artificial intelligence that focuses on giving computer systems the ability to learn and improve automatically without explicit programming instructions. It can extract patterns and regularities from large amounts of data to autonomously infer, generalize, and predict future behavior. Its goal is to improve task performance by letting machines learn from experience. Machine learning is of great help in the treatment and research of stroke. It helps analyze data and build models to facilitate doctors to treat faster and more accurately. Early detection of stroke is a critical step in effective treatment, and machine learning can be of huge value in this process, which is the ultimate technology that can help medical professionals make clinical decisions and predictions (Sirsat, 2020).

2.1.1 Random Forest

Random forest is an integrated learning method that integrates the prediction results of each tree to improve the accuracy and robustness of the model by constructing multiple decision trees and using random sampling and random feature selection. It is suitable for classification and regression tasks. And it has the characteristics of high parallelism and resistance to overfitting. The application of random forest in stroke research mainly includes two aspects: prediction and diagnosis of stroke, and rehabilitation and prognosis assessment after stroke. In terms of prediction and diagnosis, random forests can use patients' clinical data, imaging characteristics, etc. to predict stroke risk and diagnose conditions, improving the accuracy and timeliness of diagnosis (Steven, 2017). In addition, it can also be used to guide the formulation and evaluation of rehabilitation treatment plans, thereby improving the rehabilitation effect and prognosis quality. These applications provide important support and guidance for early intervention, personalized treatment and rehabilitation of stroke (Carlos, 2021).

2.1.2 Support Vector Machine (SVM)

Support Vector Machine (SVM) is a machine learning method commonly used for classification and regression analysis. The main idea is to find an optimal hyperplane that separates sample points of different categories.

In classification problems, the goal of SVM is to find a decision boundary that can move samples of different categories as far away from the hyperplane as possible, which can increase the robustness of classification. In order to achieve this goal, SVM defines the decision boundary through support vectors (support samples), which are the sample points closest to the hyperplane. SVM determines the optimal decision boundary by maximizing the distance (i.e., margin) between the support vector and the hyperplane. This distance is also called margin maximization. In a 2017 study, there were examples of SVM applied to brain imaging, which is also a possibility that SVM can be applied to stroke (Cuingnet, 2010).

2.2 Deep Learning Algorithms

Moreover, in recent years, deep learning algorithms have also been of great help in the study of stroke. Deep learning algorithm is an artificial intelligence technology that learns the characteristics and patterns of data through a multi-level neural network structure. These neural networks are composed of a large number of neurons, each of which is connected to the neurons of the previous layer. Through an iterative process, the connection weights between neurons are constantly adjusted to maximize the accuracy of predicting or classifying the input data. Through deep learning algorithms, the system can automatically discover complex patterns in data and perform efficient feature extraction and abstraction to achieve various intelligent tasks such as image recognition, speech recognition, and natural language processing. Wang et al. have applied deep learning algorithms in pathological image analysis in 2019 (Wang, 2019). These algorithms not only have high accuracy, but also have high computational efficiency. These methods can also be applied to analyze images of strokes.

2.2.1 ANN

In the treatment and research of stroke, ANN has also played a certain role. It represents a computing model that imitates the structure and function of biological neural networks. Artificial neural networks are composed of a large number of artificial neurons (or nodes) that are connected to each other through connections (or edges) to form a network. Each neuron receives input signals from other neurons, performs a weighted summation of these signals by weights, and then passes the result to an activation function for processing, ultimately producing an output. ANN is usually trained through optimization methods such as backpropagation algorithm and gradient descent to adjust the connection weights between neurons so that the network can learn and adapt to the patterns and characteristics of the input data to achieve various tasks such as classification, regression, Clustering etc. In 2019, Chen et al. analyzed the feasibility of ANN for stroke risk stratification and concluded that ANN is very effective in predicting stroke (Chan, 2019).

The structure of an Artificial Neural Network consists of the input layer, hidden layers, and output layer. The input layer receives external input data, with each node representing a feature of the input data. The hidden layers, composed of multiple layers of neurons, learn the complex relationships between input data through adjustment of connection weights and bias parameters. Eventually, the output layer generates the final output of the model, with the number of nodes determined by the type of task the model performs. During training, ANN utilizes the backpropagation algorithm to continuously adjust connection weights and biases to minimize the loss function and enhance the model's performance. This network structure and learning algorithm enable ANN to effectively handle various types of data, performing prediction and classification tasks, and find wide applications across multiple domains, including stroke analysis.

2.2.2 CNN

Convolutional Neural Network is an artificial neural network model that specializes in processing grid-structured data (such as images, audio). Its core components include convolutional layers, pooling layers and fully connected layers. The convolutional layer extracts the features of the input data by sliding the convolution kernel, the pooling layer reduces the size of the feature map and enhances the translation invariance of the model, and finally performs classification or other tasks through the fully connected layer. CNN has achieved great success in the field of computer vision and is widely used in tasks such as image recognition and target detection.

It has also demonstrated promise in areas like natural language processing, particularly in the analysis of images related to strokes. Identifying the location of an ischemic stroke in CT images can be challenging, as it's not always clearly visible. Consequently, diagnosis often depends on a physician's assessment of the images. CNN can be highly effective in aiding with this task. In 2017, Lin et al. studied the accuracy of CNN in identifying ischemic stroke. The accuracy rate was as high as 90%, which shows that CNN has great potential in predicting cerebral stroke (Chin, 2017).

The structure of a Convolutional Neural Network comprises several key components. Firstly, convolutional layers extract features from input data using filters, generating feature maps. Pooling layers reduce spatial dimensions while preserving essential information. Fully connected layers connect extracted features to the output layer for classification or regression tasks. Activation functions introduce non-linearity to the network. Batch normalization layers enhance training stability by normalizing feature maps. Through the combination and stacking of these components, CNNs effectively extract features from input data, enabling efficient processing and learning of complex data such as images and audio.

3 DISCUSSIONS

Although significant progresses have been made, the application of AI in the context of brain stroke diagnosis and treatment presents several limitations and challenges. Firstly, interpretability of AI models remains a significant concern, particularly in complex medical scenarios such as stroke diagnosis, where clinicians require clear explanations for model predictions to make informed decisions. Secondly, privacy concerns arise due to the sensitive nature of medical data, including patient imaging scans and health records, necessitating robust data protection measures. Thirdly, the applicability of AI algorithms across diverse healthcare settings and patient populations poses challenges due to variations in data quality, accessibility, and clinical practices. Fourth, there are limitations in the research on predicting risk factors for various types of strokes (Bandi, 2020).

To address these challenges, several solutions have been proposed. For interpretability, techniques such as Shapley Additive Explanations (SHAP) provide insights into model predictions, enabling clinicians to understand the rationale behind AI recommendations. Privacy concerns can be mitigated through the implementation of privacy-preserving AI approaches, including techniques such as federated learning, which allows model training on decentralized data without exchanging raw data between institutions. Additionally, ensuring the applicability of AI algorithms involves developing adaptable models that can accommodate variations in data sources and clinical contexts, as well as fostering collaborations between AI researchers and healthcare professionals to tailor solutions to specific clinical needs. In addition, some models such as random forests can also help to accurately predict risk factors, and it is possible to use image datasets to derive different types of strokes and risk levels in the future (Bandi, 2020).

Looking ahead, the prospects of AI in brain stroke management are promising. SHAP and similar interpretability techniques will continue to evolve, providing deeper insights into AI decision-making processes and enhancing trust in AI-driven clinical decision support systems. Expert systems that combine domain expertise with AI algorithms hold potential for personalized stroke management by integrating clinical guidelines and patient-specific data. Federated learning offers a pathway for collaborative model development across institutions while preserving data privacy, facilitating the creation of robust and generalizable stroke prediction models. Furthermore, transfer learning techniques enable the transfer of knowledge from related tasks or domains to improve the performance of AI models in stroke diagnosis and prognosis. Overall, the continued advancement and integration of these AI approaches hold great promise for enhancing stroke care outcomes and reducing the burden of this devastating neurological condition.

4 CONCLUSIONS

In this work, this paper summarized research on AI's prediction of stroke and how it can help in this regard. In the previous prediction and analysis of stroke, various traditional machine learning (SVM and random forest) and deep learning algorithms (ANN and CNN) were used to construct a model that improved the accuracy and efficiency of prediction. In the process, it can be found that there are still some limitations and deficiencies, and the sample size is not comprehensive, which means that in the future, the AI model for predicting and analyzing stroke can be improved, and more samples can be obtained to improve the accuracy of prediction.

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