A RECENT SURVEY ON STROKE DISEASE SUPERVISION USING ARTIFICIAL INTELLIGENCE

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Abstract

Stroke is a second leading dangerous disease that is difficult for the patient if it will not be detected on time. So AI plays a significant role in stroke disease supervision.Artificial intelligence(AI), makes the system learn and rectify the problem automatically, which dramatically steps into all fields including medicine. AI-based disease prognosis, detection, and further treatment assist doctors and improve accuracy. Deep learning and machine learning are the subdivisions of AI. This review article offers a peek at the recent research works that underwent in AI-based stroke disease management.

Keywords: *Artificial Intelligence, Acute Ischemic Stroke, Hemorrhagic, Deep Learning, Machine Learning*

Introduction

Stroke is also known as brain attack is one of the hazardous diseases which leads to the major cause of mortality or long-term disability with no effective treatment. [1] over 80 million people have had a stroke around the world. So early prediction is appreciated which avoids the dead rates and protects valuable human life. October 29 is observed as world stroke day and encourages various preventative measures and lifestyle modifications to avoid cardiovascular disorders such as heart attack, stroke, heart failure, and other related conditions. A stroke is formed due to blocked blood circulation in the brain. Sometimes it can be generated because of insufficient oxygen and nutrients in brain tissue. 14Obstruction or rupture of brain caused by artery plaque. One-minute delayed treatment cost is tremendous. 1.9 million neurons, 14 billion synapses, and

12 kilometers (7.5 miles) of myelinated fibers are lost per minute[2]. Without treatment the ischemic brain ages 42 months every hour in contrast to usual neurons brain aging. Thus the treatment to brain damage is given quickly, all the affects can be eluded.

Despite ongoing new evidence on how to best treat stroke patients, the risk of stroke recurrence remains unacceptably high, demonstrating the need for newer therapeutics. Found a more than 3-fold increase in the burden of stroke in developing nations, with 4.85 million fatalities and 91.4 million Disability Adjusted Life Years (DALYs) compared to 1.6 million deaths and 21.5 million DALYs in high-income countries[3]. Considering the bad effects of stroke disease, it is significant to predict stroke disease.[25,26,27]Artificial Intelligence plays a vital role in cerebrovascular disease management.[29,28]Artificial intelligence (AI) could help to accelerate this collaboration and usher in a new era of automated stroke triage. This paper reviewed the methods and techniques available to predict stroke disease using AI Techniques. The overall work of this paper is divided into the following sections:

Section 1: This section lists the Challenges in stroke disease Prediction, Detection, and Treatment.

Section 2: This section gives details about the sources of research papers and the inclusion criteria followed for this review. It categorizes the latest research works into three types such as stroke disease prediction, detection, and treatment using data mining, deep learning, and machine learning.

Section 3: It summarises the most important findings from the recent research papers and compares the methods used in stroke disease detection and treatment.

Section 4: Finally, the paper concludes with the research gap and opportunities for further research.

Section 1

Challenges in Stroke Disease Prediction

The prevention of stroke disease is done based on the history of the previous patients. So adequate data is needed to find the possibility of disease occurrence. Deep learning and machine learning are some of the AI techniques which entail a vast number of data for processing. Thus data necessity is the main challenge in stroke disease prediction. It is obligatory to collect the stroke patient record to predict future possibilities. Several stroke predictive scores have been followed in many countries such as NIHSS, ISAN, PNA for the sake of stroke prediction. [30]The score did not reliably distinguish between patients at low and high risk of recurrent stroke, nor did it identify patients with serious artery blockage who needed immediate treatment.

Challenges in Stroke Disease Detection

The various clinical tests and CT, MRI scanning are generally used to detect stroke illness. The neurological expects to have to detect the type of stroke and affected area in the image. Accurate detection is very important because the delay or **erroneous detection** leads to the spread of illness to other parts of the brain. The automation in stroke detection will improve the efficiency of treatment. Similar to prevention, detection also needs cumbersome data when it goes for the AI technique. When symptom-based stroke detection has been applied the variance in the type of stroke has to be identified correctly.

Challenges in Stroke Disease Treatment

The major challenge in stroke disease treatment is on-time admission to the hospital. Because the deferral of every second causes the seriousness of the illness.[24]Advancements in drug intervention have shown improvement in Acute Ischemic Stroke treatment. Accurate detection of the damaged part is essential to give proper treatment. The severe health problem related to stroke disease is another challenge in treatment like pneumonia, which has to predict on time.

Section 2

Selection of Sources and Inclusion Criteria

Several studies had done in stroke disease management using AI techniques like deep learning, Machine learning, and Neural Networks(Figure 2). This literature review divides the previous research work into three categories like stroke prediction, stroke detection, and stroke treatment. The search has been done based on the following keywords: stroke disease management, Stroke disease prediction, detection, treatment, stroke disease, and deep learning, Stroke disease, and machine learning. The research articles were found in the PubMed, Scopus, Elsevier, and PMS. Totally 567 recent (Figure 1) articles were brought into being a consideration. Final filtration selects 52 articles which exclude review papers, stroke papers with AI techniques. This review article selects 30 papers among them.

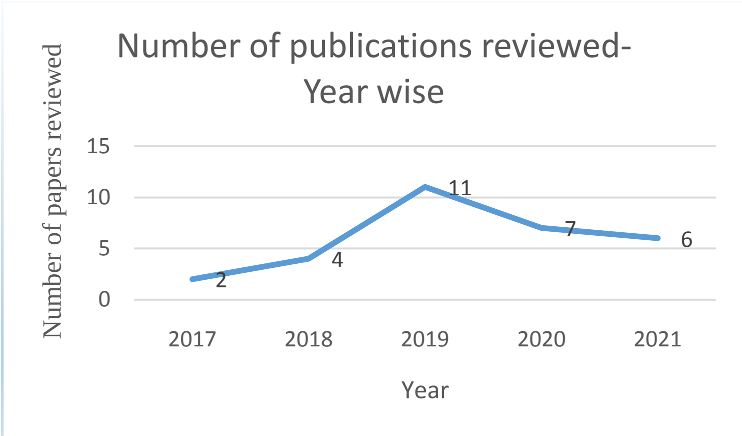

Figure 1 Year-wise representation of reviewed articles

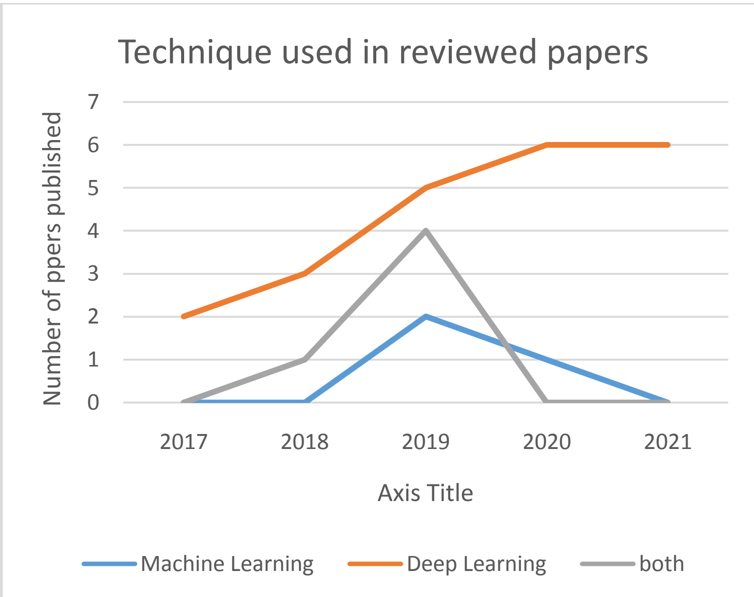

Figure 2 Technologies used in the reviewed articles

Stroke Prediction

[4]Suggested a model that is quick to compute and doesn't need image annotation. The Deep Learning models were contrasted with Machine Learning models that used conventional radiological image biomarkers.

[5]Demonstrated the machine learning algorithm to predict the long-term outcome of ischemic stroke patients. The authors highlighted that work is a retrospective study with registered ischemic stroke patients who have their symptoms start within seven days and are admitted. The result showed that deep neural networks (DNN) performed better than other models.

[10]Identified patients with stroke using a DNN that was trained on medical data. To extract significant background information from medical data, PCA with quantile scaling was utilized, which was then used to predict stroke mortality. Five other machine-learning methods were compared to a scaled PCA/ DNN approach. The AUCrate was 83.48 percent, indicating that it can be utilized by both patients and clinicians to screen for a potential stroke.

[14]Presented novel a solution to cIMT (Carotid intima-media thickness) measurements using a Deep learning-based intelligent system. The performance analysis was also carried out and concluded that the Deep learning-based cIMT measurement which mainly influences stroke disease comparatively high accuracy than conventional methods.

[16]Proposed a novel Prediction algorithm to address the imbalance in stroke data. This model allows external stroke data such as diabetes, hypertension etc., (which influences the stroke disease) in stroke risk prediction when the unavailability of stroke data in hospitals. The components of HDTL are: the training model using GIT applying GAN which can generate synthetic instances in external databases, NWT utilize data from connected diseases (Hypertension, diabetes etc.,), best-transferred parameters are identified using Bayesian Optimization (BO), the best informative synthetic instances are selected using Active Instance Transfer (AIT) which activate SRP (Stroke Risk Prediction) model.[18]offered a cost-effective way of stroke disease prediction system using EG (electroencephalography). Electroencephalography is a wearable electrode is attached to the head and quantity the brain nerve cells activity. The raw EEG data were extracted by using the Fast-Fourier Transform technique. EEG data are time

series in nature in sequence values over time. To address these time series values the four deep learning methods(listed in table2) were used. The performance of the system was analyzed and the result showed that the Bidirectional LSTM model has the highest predictive accuracy at 89.2%.

[22]Developed the machine learning model to predict the incidence of pneumonia after stroke. The authors specified that the ML model better predicts pneumonia than ISAN and PNA scores. These are the measuring scores that are used to predict the AIS in UK and Germany respectively. The Result showed that among six Machine learning models mentioned in the table2, the XGBoost model outperformed.

[23]Artificial Neural Network(ANN) based predictive model was developed in order to identify the type of stroke based on the historical patient dataset. The model achieved 95.15% accuracy and the confusion matrix was created to compare the predictive measure of type of stroke. The model had best result for hemorrhagic stroke and worst result for TIA.

Stroke Detection

[6]Collected stroke patients' details from various sources and classified the stroke disease by using machine learning algorithms such as KNN, Naïve Bayes, J48, and Random Forest. The performance of the algorithm was evaluated by using accuracy, precision, recall, and F1-score. The authors concluded that Random – Forest performs well among four.

[12]Automatically detected and analyzed the ischemic stroke lesion using deep learning methods. For this, the authors used four deep learning approaches as Faster R-CNN (VGG-16), Faster R-CNN (ResNet-101), YOLOv3, SSD. They achieved more accurate results in SSD because SSD combined the regression idea from YOLO and the anchor mechanism from Faster R-CNN. The analytical report has also been created using parameters such as gender, age, possible related diseases, lesion location, and lesion shape. The analytical report visualizes some facts that males are more likely to suffer from an ischemic stroke than females, elderly people(between 60 and 70) have the highest risk than younger people, possible related diseases are cerebral infarction, senile degeneration of the brain, and sinusitis. The lesion location is also been detected using natural language

processing that pointed out basal ganglia was the largest affected area covering more than 60 cases and the shape of the lesion is patchy. But the drawback of this statistical analysis is that the number of patients taken for this report is only 300.

[17]Presented ischemic stroke detection system using CNN. This method starts with pre-processing the image such as, skull removal, CSF (cerebral Spinal Fluid) removal, creating fixed size patch images to avoid error during training, data augmentation and analyzing the images using FFNN (Feed-Forward Neural Network). The investigational results presented that the training stage had 97.65 and the testing stage had 92.96%.

[19]Proposed an algorithm that extracts the main stroke lesion features from clinical data and combines them with normal DW data to construct realistic artificial stroke lesions data on diffusion-weighted (DW) MRI. By using combinatorial possibilities, this algorithm generated huge training datasets, and because of the artificial lesion data, the exact position of the lesion is known. The lesion detection sensitivity was exceeded by the 3D U-Net, which was trained on clinical stroke data with 40,000 artificial stroke data.

[20]Developed an automatic method to detect the existence of stroke using (Lenet) Convolution Neural Network. The technique also delineates the abnormal regions using Segnet architecture. The accuracy of the method is significant (97%) but the number of images used for detection is very less.

Stroke Treatment

[7]Compared several classical machine learning methods with DNN methods to predict pneumonia after stroke. Though the study predicts pneumonia after stroke, this can be considered a stroke treatment category. Because the major features used in this study are treatment parameters. The authors differentiate their work from previous studies by building prediction models for patients in terms of exact time frames after stroke occurance.

[8]Established and calculated a deep learning algorithm to select the suitable patients with AIS for endovascular treatment. The authors mentioned that the study used the Arterial spin labeling (ASL) MRI technique to estimate the penumbral tissue for a further selection of patients for the treatment because this

MRI technique does not have side effects, meanwhile, the contrast agent used in DSC perfusion MRI and CT techniques have side effects in patients.

[9]In a diverse sample of stroke patients, researchers convolutional neural networks (CNNs) to predict the severity of speech dysfunction using MRI images. The performance of CNN was compared to that of conventional(shallow) machine learning approaches. A hybrid strategy based on reusing CNN's high-level characteristics as additional input to the RR model was also proposed.

[11]Assessed brain MRI text using Natural Language Processing(NLP) and ML algorithms to predict functional outcomes of AIS patients in 3-month periods. The NLP approach was implemented in three ways such as word level, sentence level, and document level in the MRI text data. Various machine learning algorithms described in the table were used at different levels of the NLP process. And they concluded that the radiology text report revealedsuperior performance in the prognosis of AIS. The authors also pointed out the limitation of this method that external validation is needed to demonstrate the performance in predicting the output.

[13] Foretold the functional outcome of Intravenous thrombolysis treatment by using the combination of ANN and CNN. The study predicted the progress in NIHSS score at 24 hrs, Modified Rankin scale at 90days. The conclusion stated that in both cases(NIHSS score prediction &mRS scale prediction) the combination of ANN and CNN is performed well.

[15]Predicted the Hemorrhagic transformation (a serious problem that occurred after the EVT treatment) of stroke patients after Endovascular Thrombectomy (EVT) treatment by using a multiparameter on DWI and PWI. The experiment was done by using a single parameter(DWI, MTT, TTP, and clinical) and a multiparameter model. And the result showed that the model with a multi-parameter was better than the model with a single parameter.

[24]Designed and verified a prediction model of detecting and integrating AIS image data to properly predict eventual lesion size for them. For this purpose, CNN was used. CNNdeep was compared to a shallow CNN based on the PW(perfusion-weighted) biomarker. CNNdeep outperforms the generalized linear model in predicting the final outcome (AUC=0.880.12) and outperforms CNN shallow significantly.

Section 3

Finding and Comparison of Recent Research Work

This review work has been undertaken for 30 recent research works which include stroke disease prediction, detection, and treatment by using Artificial Intelligence encompassed with Deep learning and Machine Learning. Among 30 papers, 73% papers alone practiced Ischemic stroke, 0.3% papers involved in hemorrhagic stroke, 0.6% compares ischemic and hemorrhagic and 0.1% papers did not specify the types of stroke. 76% papers performed stroke disease management using Deep learning with Convolution Neural networks and Artificial Neural networks, three papers used Machine learning to predict stroke, 2% papers performed a comparative analysis between deep learning and machine learning, 0.3% paper used NLP and Deep Learning. The stroke disease analysis has been done by using image features and demographic information. In this survey 75 percentage works carried out based on image features like MRI and CT. Among them MRI image based stroke analysis gave better result than CT.

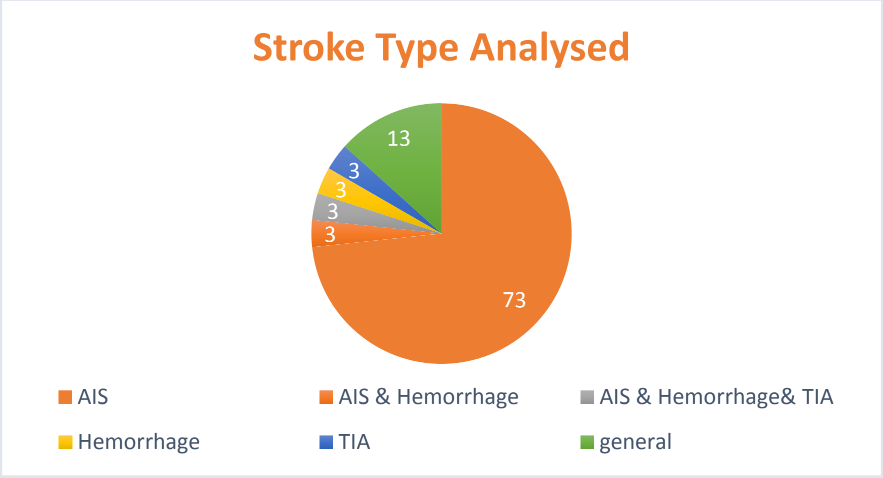

Figure 3 Stroke Types Analysed in this Review

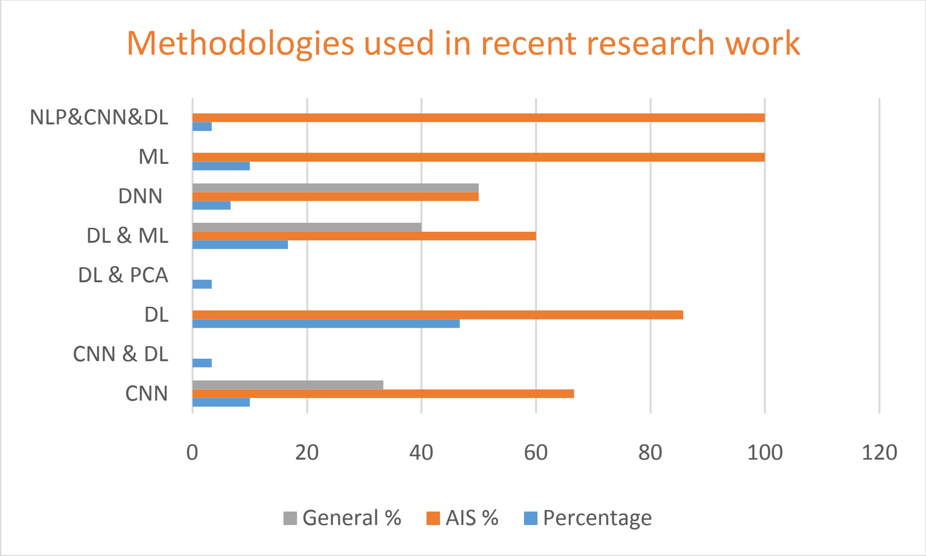

Figure 4: Analysis on Stroke Disease Management

Reference number, Authors & Year	Stroke type	Objective	methodology	Samples	Features	Feature Description	Accuracy
[4]Hilbert A et al.,[2019]	AIS	Predict reperfusion after Treatment (endovascular)	DL and ML	MR CLEAN Registry dataset with 1301 patients	CT Image	Image biomarkers	Not mentioned
[5]JoonNyung Heo et al.,[2019]	AIS	Predict long-term outcomes	ML	2604 patients data	DG & CD	NIHSS score mRS score etc.,	78%
[6]Tasfia Ismail Shoilyetal[2019]	AIS, Hemorrhagic, TIA	Detecting stroke disease using ML algorithms	ML	1058 stroke patients data	DG & CD	23 features including MRI, CT, ECG data	Not mentioned
[7]Yanqiu Ge et al.,[2019]	AIS	Post-stroke pneumonia prediction	ML and DL methods	13,930 EHR (Electronic Health Record) data set	DG & CD	Lab test, Medications etc.,	AUC -0.928
[8]Kai Wang et al.,[2019]	AIS	Treatment (Endovascular)	DL and ML	167 image set	DG & CD	ional pseudo-co arterial spin labeling (pCASL), d dynamic susceptibility contrast	92%

[9]Sucheta Chauhan et al.,[2019]	General	Treatment	DL and ML	132 stroke patients	MRI	Image Feature	Not mentioned
[10]Songhee Cheon et al., [2019]	AIS and Hemorrhagic	Prediction	DL model featuring scaled PCA	15099 patients health record	medical service use and health behavior data	DG Charlson Comorbidity Index (CCI) score etc.,	84.03
[11]Tak Sung Heo et l.,[2020]	AIS	Treatment	NLP and Multi CNN- DL algorithms	1840 radiology text report	MRI Text reports	DG NIHSS scale, mg/dl Dyslipidemia etc.,	80.5
[12]Shujun Zhang et al., [2021]	AIS	Detection	DNN	300 patients record	5668 MRI	Image features	89.77
[13]Stephen Bacchi et al., [2019]	AIS	Treatment	DL	204 patients images	CT	CD and CT	74
[14]Mainak Biswas et al.,[2018]	General	Prediction of the risk factor using cIMT measurement	DL and ML	204 patients images	396 B-mode ultrasound images	1.cIMT 2.LI 3.MA	AUC – 90%
[15]Liang Jiang et al.,[2021]	AIS	Predict the Hemorrhagic ansformation aft Endovascular Thrombectomy Treatment	CNN	568 patients	MRI (DWI and PWI images)	1.DWI 2.MTT 3.TTP 4. Clinical 5.CBF 6.CBV	Multi-parameter prediction is better than a single parameter.
[16]Jie Chen et al.,[2021]	General	Stroke risk prediction using hybrid deep transfer learning	DNN	2, 426 stroke incidents record	Hybrid database (Hypertension, diabetes etc.,)	HER	Not mentioned
[17]Chiun-Li Chin et al.,[2017]	AIS	Automatic early detection	CNN	256 patch images	MRI	Image features	92.96%
[18]Yoon-A Choi et al.,[2021]	General	Stroke prediction using Real-time bio signals	CNN	273 patients	Bio-signal data	non-invasive scalp EEG EEG	94%
[19]Christian Federau et al.,[2020]	AIS	Segmentation and detection of	DL	962 stroke images + 2027	MRI	Image feature	96%

		DWI images		Normal images			
[20]Bhagyashree Rajendra Gaidhani et al.,[2019]	AIS	Stroke detection using CNN and deep learning	CNN and DL models	406 images	MRI	Image feature	Classification- 96% - 97% Segmentation – 85-87%
[22]X.Li et al.,[2020]	AIS	Learning	ML	3160 AIS patients	DG, CD & NIHSS,	NIHSS, ISAN, PAN	90%
[23]Anis FitriNur Masruriyah, [2020]	TIA	Predictive Analytics using ANN	DL	18425 patients data	DG & CD	10 features including CT scan result, the deficit of dysphasia etc.,	95.15%
[24]Anne Nielsen et al. [2018]	AIS	Functional outcome of AIS treatment	DL	222 patients record	MRI	MRI image data	Not mentioned

Section 4

Conclusion: Research Gap and Future Opportunities

This review article deliberates recent AI-based stroke disease management. It discussed the type of dataset used and the type of methodology involved in the prognosis, detection, and treatment of stroke. Several studies evidenced that deep learning methods achieved good results when compared to machine learning. But substantial data is needed to achieve a better outcome. Based on the above review several works lack dataset collection which can be further improved in the future.

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AIS- Acute Ischemic Stroke; DL – Deep Learning; ML- Machine Learning; SDT-single decision tree; RF-random forest; SVM-support vector machine; CNN-convolutional neural network;MLP-multilayer perceptron; LSTM-long short-term memory; VGG – Visual Geometry Group; FCN – Fully Convolutional Network; cIMT- Carotid intima-media thickness; LI - Lumen-Intima; MA - Media-Adventitia; CBF – Cerebral Blood Flow; CBV – Cerebral Blood Volume; MTT – Mean Transit Time; DWI – Diffusion-Weighted Imaging; TTP – Time to Peak; GAN – Generative Adversarial Network; HER – Electronic Health Record; EEG – Electro Encephalo Graphy, AUC-Area Under Cover, PCA- Principle Component Analysis, rfc-random forest classifier; ADB, AdaBoost classifier: GNB, Gaussian naive Bayes; KNNC, K-nearest neighbor classifier; SVC, support vector machine; DNN, deep neural network, RRCNN- a recurrent residual convolutional neural network, DWI- Diffusion-weighted Images, ADC- Apparent Diffusion Coefficient, icc- intraclass correlation coefficient, DG- Demographic Information, CD – Clinical Data