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A BrainNet (BrN) based New Approach to Classify Brain Stroke from CT Scan Images

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***Abstract*— Worldwide, brain stroke is known as the 2nd leading cause of death, and based on Indian history, three people have suffered every minute. There are mainly two different types of brain stroke: ischemic stroke and Hemorrhagic stroke used to train the proposed models. Ischemic stroke is the most common and it contributes mostly to 80% of the brain stroke and Hemorrhagic stroke contributes mostly to 20% of the brain stroke. In the proposed model, there has been used a hybrid model called BrainNet (BrN) as CNN(Convolutional Neural Network) and SVM(Support Vector Machine)to classify brain stroke disease. After applying the required proposed model, it has produced a smart score of 91.91% accuracy, and compared to the existing model it performs pretty well. The BrainNet (BrN) model is mainly designed based on a deep neural network with dataset collection, preprocessing, and feature extraction with the desired model and make the classification concerning SVM. With compare to the existing model, it is an acceptable performance that belongs to the collected dataset designed with Ischemic stroke and Hemorrhagic stroke disease within the total number of 2515 data.**

Keywords— BrainNet, SVM, CNN, Hybrid Model, Ischemic Stroke, Hemorrhagic Stroke.

I. INTRODUCTION

Brain stroke has developed into a serious illness that is now fatal. Stroke is an extreme cerebrovascular disorder with a high risk of morbidity, mortality, and disability. It is often referred to as a "clean cerebrovascular accident." Numerous risk factors include using tobacco, having diabetes, being overweight, having experienced a transient ischemic attack in the past, having high blood cholesterol, having end-stage kidney disease, and having pre-fibrillation [1]. There are 2 main categories of stroke: ischemic (when the bloodstream is absent) and hemorrhagic (where bleeding occurs). Blood channel obstruction is the usual cause of an ischemic stroke, although there are other, less prevalent reasons as well. Space between the brain's membranes or bleeding right into the brain lists is the main cause of hemorrhagic strokes. Possible causes of the bleeding include burst brain aneurysms. If symptoms persist for less than one or two hours, a transient ischemic attack, often known as a mini-stroke, has occurred, which damages both brain regions. The signs of a stroke may be persistent. Insufficiency in bladder control and pneumonia could be among the long-term issues [1]. Hypertension is the main risk factor for stroke. Numerous people are dying as a result of the increasing difficulty and time-consuming nature of early brain stroke prediction [2].

Clinicians must act quickly and accurately when making decisions during the acute stage of a stroke, even expert operators need hours to label something manually since it takes so much time and effort. To get around this, we employ deep learning techniques and develop a model to determine whether or not a person is experiencing a brain stroke. In this study, we can forecast the outcome while taking into account different patient characteristics. Physical testing and clinical imaging tools like an MRI or CT scan are typically used to support analysis. Medical imaging, where CT demonstrates low density and DWI demonstrates high signal that can detect ischemic tissue, is the primary tool for ischemic stroke diagnosis and the crucial foundation for doctors to choose treatment [3]. We take occurs when the brain receives insufficient blood flow, resulting in death. Deep learning-based early stroke detection, automatic infarct size estimation, and vascular occlusion detection all had improved outcomes.

In this paper, the introduction is described in section (I), and section (II) related work is explained elaborately, section (III), (IV), (V) are the proposed system, dataset description, and system operation. After the system operation result analysis is described in section (VI), the discussion part is explained in

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section (VII), and at the end, the conclusion is added in section (VIII), and their references are added.

II. Related Work

An improving segmentation approach of the brain stoke based on a multi-tasking learning process was proposed [4]. It's mainly performed by supervised learning with Anatomical Tracings from the total dataset and has used 4.76% of constructed CT and 7.97% of the open-source dataset. They [5] have designed a segmentation system of Ischemic-Stroke-Lesion under Brain MRI Slice and have split 25 slices from each patient. After executing the U-Net supporting segmentation mostly achieved the values of 90% for Jacquard, 95% for Dice a, and from the whole dataset as 500 images, it provided 98% accuracy. Researcher [6] designed COA a VID-SEGNET system based on Mask R-CNN to predict Covid19 cases on the Radiological image dataset providing 8.25curacy. The existing model proposed a false-negative result based on the limited viral loaded.

The Author [7] proposed the Malabar disease approach based on the deep learning model and there have used 100 epochs to train the model where each epoch gathered up to 85% accuracy and the final accuracy is 96.77%. They [8] proposed a multiclass classification AI system to recognize brain cancer by applying the Machine Learning algorithm. MP (Multilayer Perceptron) has better performance with applied machine learning algorithms and the feature selection of the medical dataset. Author [9] designed a deep neural network-based model for breast cancer and the brain tumor recognition classification to promote E-Health. Researchers [10] proposed papaya disease classification using the deep learning approach and achieved 91% accuracy and the total dataset has been split into three parts. They [11] proposed a combined CNN concerning recognizing the novel disease coronavirus and there have used CNN-LSTM. It provides better performances compare to CNN which are accuracy is 99.4%, specificity is 99.2%, sensitivity is 99.3%, F1-score is 98.9% and AUC is 99.9%. Author [12] proposed a machine learning-based approach to learning the risk factors of liver disease where it is used to clarify the risk factor of liver disease. They [13] designed a transfer learning-based model to classify the disease. They have used several Keras pre-trained models and 98.13% is the best accuracy of the VGG19 model.

III. Proposed Method

The proposed approach is designed to classify the Brain Stoke disease from the collected dataset. The main approach cemented based cemented model BrainNet concerning the neural network like CNN, CNN, and SVM (Support, Vector Machine) shown in fig.1.

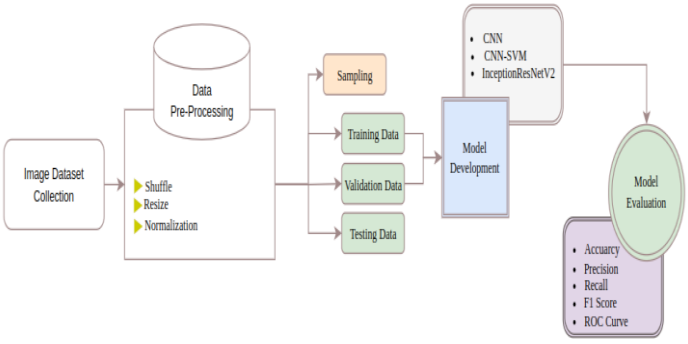


Fig.1. Block Diagram of Proposed Scheme

After collecting the Brain Stoke dataset, it's prepared for pre-processing data, which mainly supports the use of the Shuffle, Resize, Normalization on the whole dataset and on and converted three parts Training, Validation, and Testing. Training and Validation datasets have been used to train the proposed approach where CNN and InceptionResNet-v2 are directly used to classify the proposed model. In the case of CNN-SVM provides a balanced acceptable accuracy because of feature extraction of each data of Brain Stoke and Normal and SVM (Support Vector Machine) is used to classify the Stoke and Normal. To classify the disease, the same number of image sizes like 224x224x3 and the same number of epochs have been used.

A. BrainNet (BrN) Model

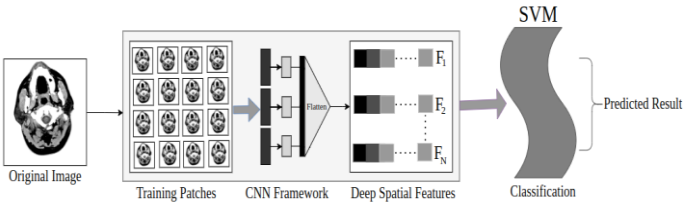


Fig.2. BrainNet Model Architecture

A BrainNet model has been proposed to predict the Brain Stoke and Normal Brain. The unique combined solution with concerning and SVM is mainly proposed to implement the BrainNet model. After collecting the imageageNet dataset of stroke and the normal brain, it resizes all of the images into 224x224x3 and then is under pre-processing, and then it is feature extracted to convert imageageNet to binary [14]. From fig.2 there also have a CNN framework in the hidden layer and here dropout and flatten are used for overfitting the desired model and converted into a 1-Dimensional. Then Deep Spatial Features are mainly used to measure the resemblance between the brain stoke and the normal brain. Finally, the Support Vector Machine (SVM) has been used to classify brain stoke and normal brain with deep learning.

B. BrainNet (BrN) Model Flow Chart

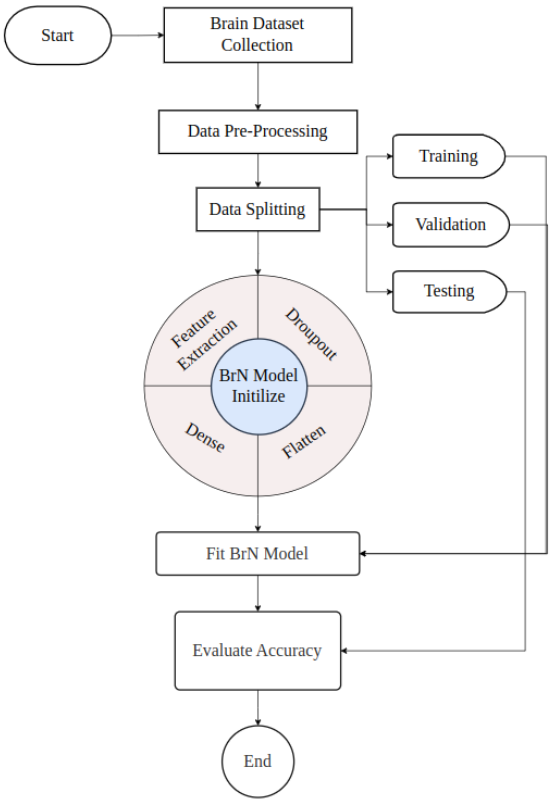


Fig.3. BrainNet Model Flowchart

C. BrainNet (BrN) Model Pseudo Code

1. Input the CT scan images
    - Input data converting into a single size(Training Data, Validation Data, Testing Data)
    - tf.keras.applications.applied model CNN/InceptionresNet-v2/BrainNet fine models:
    - firstConvolutionalLayer
    - Second first convolutional baselayers. layers.Flatten(),
    - tf.keras.layers.Dropout(),
    - tf.keras.layers.Flatten(),
    - tf.keras.layers.Dense()
2. Compile the model
3. Fit the model concerning Training Data and Validation Data with 100 epochs
4. Evaluate the model compare to the trained model and Testing Data
5. End

IV. DATASET DESCRIPTION

From Table.1 there is 2515 stroke data haven used to predict the stroke in his early stage. Here, 1843the data are used for training, 235 data are used for validation, and 437 data are used for testing. CNN, InceptionRestNet-V2, and BrainNet models are applied to find out the models' best model stance, and best fit for the dataset collected from Kaggle.

TABLE 1: Dataset description.

	Normal	Stroke
Training Data	1087	756
Testing Data	307	130
Validation Data	157	78

A. Data Pre-processing

The dataset contains RGB images and the images are shaped as a 224x224 input shape function. The dataset is rescaling in 1./255, zooming range of 0.2, rotational range of 10, brightness range [0.5,1.5], and vertical and horizontal flips are false in the preprocessing stages [15]. In the training set, the image batch size is 32, validation and testing set image batch size is 4. Applying 70% image data for the training, and 10% data for the validation, and testing purposes the model gives high performance.

V. SYSTEM OPERATION

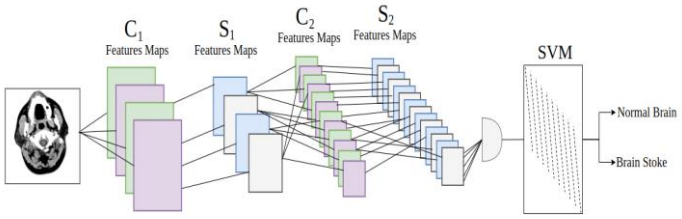


Fig.4. System Operation of the Proposed Scheme

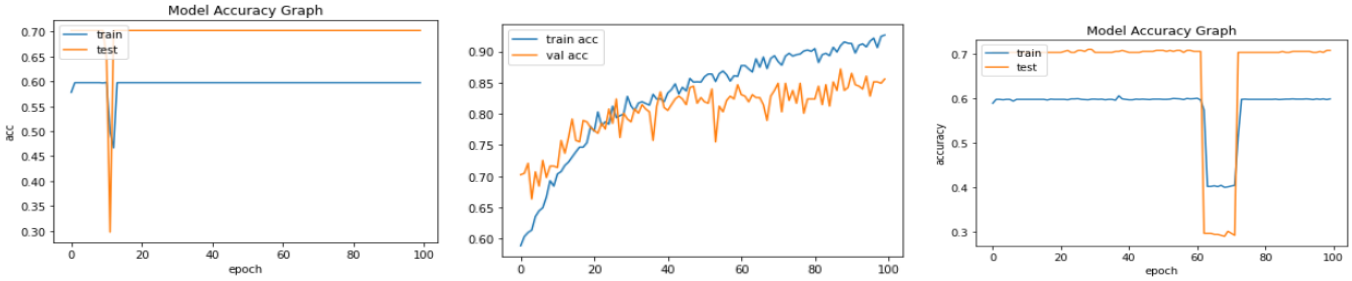
In fig.4 the system architecture explains most easily. There has been used the hybrid model to classify and recognize brain stroke disease or healthy brain and used three different types of algorithms like CNN (Convolutional Neural Network), CNN-SVM, and InceptionResNet-v2 with different accuracy, precision, recall, and f1 score. The proposed model has used different software libraries and frameworks like Tensor Flow, keras, matplotlib, numpy, sklearn, pandas, and seaborn and for training the desired model needs to active the GPUs for better performance and is used. After the data collection needs to be preprocessed because of the perfections. The whole dataset is divided into three parts like Train, Validation, and Test [17]. After the dataset is customized, it is the next step to preprocess resizing, normalizing, and reshaping and then did the sampling with different algorithms as mentioned in the fig-1 proposed model. The whole process defines new techniques with combined algorithms like CNN-SVM and produces better accuracy like 91.91% and the process is defined as BrainNet.

VI. RESULT ANALYSIS

There have been used three different neural networks models CNN(Convolutional neural Network), CNN-SVM(Hybrid Model), and keras pre-trained model InceptionResNet-V2 and

the whole model using the same batch size and input image share as 224x224x3 to detect the brain stroke diseases [16].

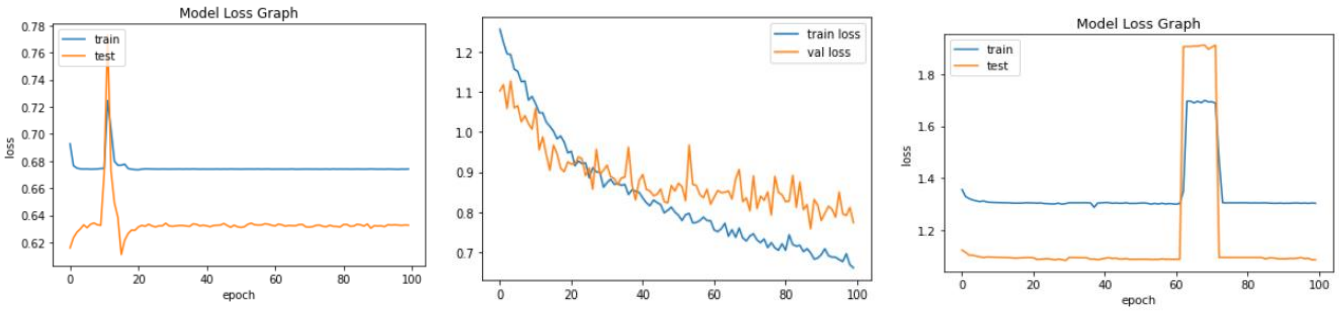
After collecting the image dataset of brain stroke, it was pre-processed of the model and feature extraction with a neural network model and then used the SVM (Support vector Machine) to get the model performance. There have used 100 epochs to train the proposed model. After Training the three models, it provides different performances shown in Fig.5.



CNN BrainNet InceptionResNet-V2

Fig. 5. Model Accuracy Graph.

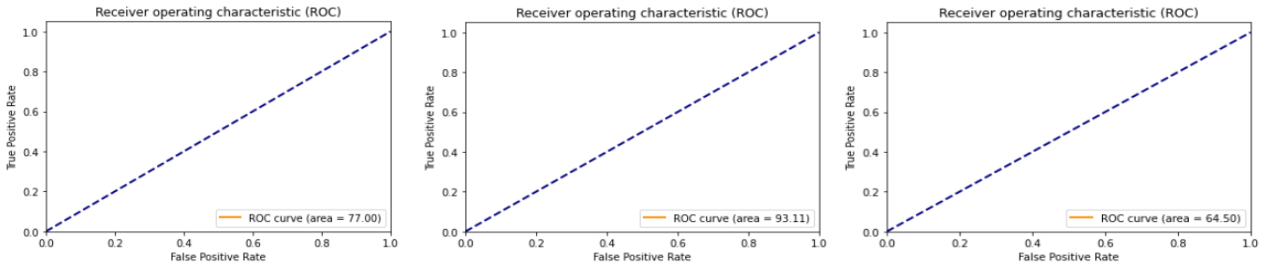
Due to the Model Accuracy Graph, BrainNet performance is better than CNN and InceptionResNet-V2 because of increasing the training accuracy with concerning raising the number of training epochs.



CNN BrainNet InceptionResNetV2

Fig. 6. Model Loss Graph

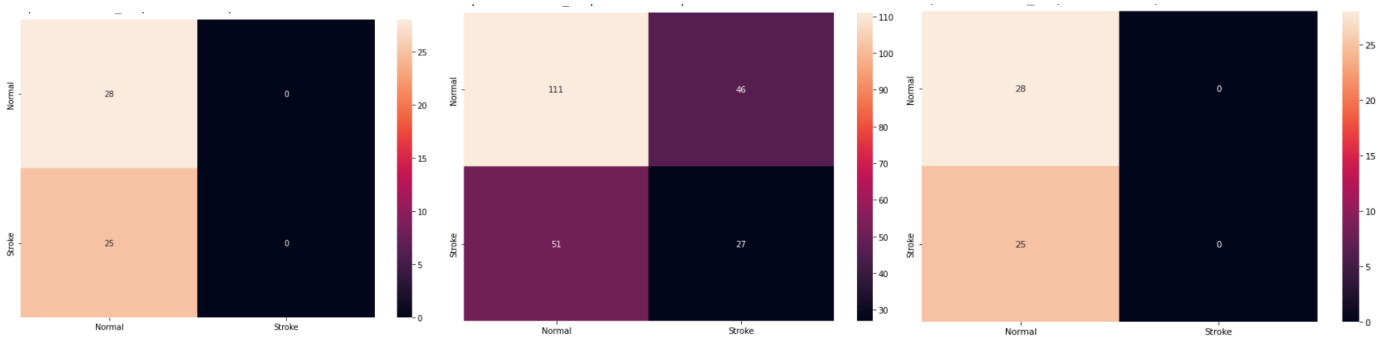
In the same case, here is also BrainNet performed better than CNN and InceptionResNetV2 because of decreasing the loss concerning the rising number of epochs shown in Fig.6.



CNN BrainNet InceptionResNetV2

Fig.7. ROC Curve Graph.

The table of the ROC Curve Graph which plots the graph into 2 parameters as TPR (True Positive Rate) and FPR (False Positive Rate) is mentioned in equations of (v) and (vi). Here CNN-SVM performance is better because of increasing the True Positive and False Positive. From Table.4, the ROC curve area of CNN is 77.00%, BrainNet ROC curve area is 93.11% and InceptionResNet-v2 ROC curve area is 64.50%.



CNN BrainNet InceptionResNetV2

Fig.8. Confusion Matrix

Due to the confusion matrix result, it's pretty sure that CNN-SVM performance is because of True Positive and False Positive values concerning the training model and test dataset.

Accuracy=TP + TNTP + TN + FP + FN ——---(i)
Precision=TPTP + FP ——--(ii)
Recall=TPTP + FN ——-(iii)
F1 Score=2 *Recall * Precision Recall + Precision ——--(iv)
True Positive Rate=TPTP + FN ——-----(v)
False Positive Rate=FPFP + TN ——-----(vi)
Here,
TP = True Positive, TN = True Negative, FP = False Positive, FN = False Negative.
With the help of equations (i), (ii), (iii), (iv), calculated the Accuracy, Precision, Recall, and F1 Score from the confusion matrix is given table: Accuracy, Loss, Precision, Recall, F1 Score,

TABLE 2: Accuracy, Loss, Precision, Recall, F1 Score

Algorithm	***Accuracy***	***Precision***	***Recall***	***F1 Score***
CNN	70.12%	53.00%	1.00%	69.00%
BrainNet	91.91%	69.00%	71.00%	70.00%
InceptionResNetV2	52.83%	53.00%	1.00%	69.00%

The proposed model defines a comparative model and BrainNet provides an acceptable performance model with the best accuracy at 91.91% Precision, Recall, and F1 Score are also combined better than other applied models. This model will help the doctor to find the brain stoke with the fasted predicting mechanism.

VII. DISCUSSION

Brain Stoke is veritably deathly for geriatric. Scientists are an unbridling act to find smooth and applicative results with the assist as the assistance of modern technology. Deep learning is the technique that dramatically improves medical treatments as it's veritably effective, low on cost, and saves momentous time for doctors and cases. Convolutional neural networks play a vital role in the development of Medical and Health Sciences [29]. This study aims to pinpoint early brain stroke prediction from images by using BrainNet (BrN) deep learning models. The accuracy of BrainNet (BrN) is 91.91% which can deploy any medical dataset effectively with high accuracy.

The dataset was collected from Kaggle. CNN, BrainNet, and InceptiononResNet-V2 are applied to identify brain stroke. All of the experimented algorithms didn't provide high accuracy. CNN has provided 70.12% and InceptionResNet-v2 52.83%. Among these algorithms, BrainNet provides the highest accuracy 91.91%. BrainNet also gives up the perfect precision, recall, F1 score, and AUC the motherland InceptionResNet-v2 shows the lowermost outcome and the accuracy is only 52.83%. The key finding of this article is that it lowers the population's death rate from causes like brain strokes. Using this method, we can identify brain strokes early and take the necessary precautions to lessen their effects. So that it might save the patients' lives without perishing. It is feasible to expand the research in subsequent work by utilizing other categorization approaches. Additionally, it is possible to forecast strokes by supplementing the current dataset with non-stroke data.

VIII. CONCLUSION

The prognostic and identification of any disease are exceedingly complicated and based on a variety of clinical and personal factors. A stroke is a potentially fatal medical condition that has to be treated right away to prevent future consequences. To increase prognostic and identification accuracy, thorough data assimilation and collection are necessary for the construction of ideal DL systems. A sizable dataset of stroke patients with attacks has been properly diagnosed in this study. The newly developed machine learning technology has been quickly used in several areas of medicine, including stroke [18]. This study found that men and persons between the ages of forty and sixty are more likely than women to get a stroke. Patients with ischemic strokes were more numerous than those with hemorrhagic strokes. The model can assist those who have a warning sign that they may be experiencing a stroke. This, even for a subject-matter expert, is quite tough to link to one another. The doctor will benefit from having a better understanding of the illness kind.

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