



# OPTIMIZED DEEP LEARNING MODEL INTEGRATION FOR PREDICTION AND INTERPRETATION OF ISCHEMIC STROKE

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*Abstract:* Stroke remains one of the key public health problems in the modern world, being the second most common cause of mortality and a leading cause of disability, which makes the primary prevention of this disease and its complications extremely important. The purpose of this research is to predict the outcomes of the stroke with the help of the machine learning algorithms. A convolutional neural network was suggested to be coupled with a well designed long short term memory. Also, seven more classifiers were also used as baseline models: logistic regression, random forest, extreme gradient boosting, k-nearest neighbour, artificial neural network, long short-term memory, and convolution neural networks. Utilising a health care dataset that comprises health characteristics of 5,110 individuals, systematic training was conducted. To address data imbalance, minority class synthetic over sampling techniques have been used.

*Index Terms* - Convolution Neural Network (CNN), Transformers, Medical Image Analysis, Image, Deep Learning.

## I. INTRODUCTION

American studies show that about 40% of stroke patients die within three months after the attack, while those who survive are usually partially disabled. Today, stroke is a serious social and medical problem in all countries of the world. As squalid as it sounds, this study intends to avoid unemployment and the eventual deterioration of the healthcare system. To accomplish this and prevent potential strokes and collateral damage, artificial intelligence will assist in predicting the overall ischemic stroke, while other studies aim to employ image analysis to detect retinal changes pertinent to embolic events. Due to the sedentary behaviour brought on by the medical crisis, there was a surge in people over the age of 60 suffering from strokes. To combat this and guess the prevalence of ischemic strokes in March, this study and AI will focus on retinal changes related to embolic events using machine learning algorithms.

A new approach was tested by coupling the CNN with a well-designed LSTM, which combines the powerful approach of deep learning in handling complex data. For further reliable evaluation and comparison, seven additional classifiers served as baseline models: logistic regression, random forest, extreme gradient boosting, k-nearest neighbours, artificial neural networks, long short-term memory networks, and convolutional neural networks. The study uses a healthcare dataset with several health parameters, allowing for systemic training as well as testing of the proposed models. Recognizing that there are inherent problems caused by imbalanced data in healthcare applications, synthetic oversampling techniques were used to improve the representation of the minority class, reduce the risk of biases, and improve the reliability of prediction. It focuses on the importance of data preprocessing in crafting effective ML models, particularly in a realm like health care,

where such data inconsistencies could significantly affect the performance of the model. Here, this paper aims to enhance the accuracy of predicting stroke outcome models with the help of advanced ML techniques and data consistency. Such a finding will allow clinicians to make more informed decisions, improve individualized treatment regimens, and eventually achieve better healthcare outcomes. With the rapid increase in the stroke burden around the world, emerging solutions such as this one provide a roadmap into the future in addressing one of today's critical health concerns.

## II. Proposed system

It uses a CNN sequential model with a proposed approach to result in greater accuracy regarding stroke predictions, beyond current models' precision and dependability. The proposed method will majorly focus on the optimization of the model structure, improvement of procedures in data pretreatment, and handling common issues found in healthcare datasets like class imbalance and feature complexity. This approach begins with extensive preprocessing of the data to yield high-quality input for the model to be trained. Preprocessing processes include imputation approaches used to fill up missing values, normalising and scaling features that improve convergence models, as well as correct class imbalance through synthetic oversampling methods such as SMOTE. This will ensure balanced representation of all classes, with a focus on the minority class, which is key for making accurate forecasts in healthcare applications. Additionally, data augmentation is applied to enlarge the dataset through realistic variances, which enhances the ability of the model to generalize in other contexts. Another important feature of the proposed system is feature engineering. During the phase, the system discovers and selects the most relevant predictors of stroke outcomes through correlation analysis and feature significance algorithms. This simplifies the model but enhances the interpretability while allowing doctors to understand aspects that influence predictions better.

The proposed system is based on the CNN sequential model that is designed with the idea of effectively processing structured numerical inputs. The design begins with an input layer that receives pre-processed information. The convolutional layers discover hierarchical patterns and relate complex connectivity between features. These layers are complemented with pooling layers that reduce the spatial dimensions of the data while preserving integral features so that efficiency in computing is increased and the chance of overfitting is minimized. The feature sets are then passed through fully connected layers that merge the learned representations for final classification. The output layer applies the sigmoid activation function to predict stroke outcomes as either a binary or a multiclass classification. Advanced optimization techniques are used to improve the performance of the model. In the case of the Adam optimiser, it adjusts learning rates dynamically while training to reach faster and more stable convergence. Other forms of regularisation include L2 and dropout to prevent overfitting. Finally, early stopping is applied to train until validation performance no longer improves, to be able to avoid wasteful computation and prevent overtraining.

With stratified k-fold cross-validation being adopted as the training strategy, the CNN model would not guarantee any overfitting but instead ensures that the performance is solid and reliable. Accuracy, precision, recall, F1-score, and AUC-ROC are used as key metrics to evaluate and refine the model during training. Such rigorous training ensures that a model performs well on a wide range of datasets.

### 2.1. Advantages of Proposed System

This proposed approach aims to apply the features of a CNN sequential model to provide improved accuracy of the outcomes of stroke predictions than existing models. This system surpasses existing limitations regarding prediction accuracy, efficiency, and generalisability because it employs advanced deep learning techniques with an optimized architecture.

### 2.1.1. IMAGE PROCESSING:

The approach begins with the preparation of the healthcare dataset to ensure that it is of the highest quality to train models. Missing data are addressed through imputation techniques. Normalising and scaling characteristics improve model convergence. Class imbalance approaches by synthetic over sampling methods such as SMOTE (Synthetic Minority Oversampling Technique); the class imbalance technique ensures that the minority samples, which are often under-represented in medical datasets, are well represented, thereby reducing bias and increasing model reliability.

### 2.1.2. OBJECT DETECTION:

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos. Well-researched domains of object detection include face detection and pedestrian detection.

### 2.1.3. FEATURE ENGINEERING:

Data augmentation aims to augment both the size and variety of datasets, especially those related to minority groups, by generating realistic variants while maintaining the underlying pattern. Correlation analysis and feature importance methods are employed to choose the most relevant predictors of stroke outcomes. This minimizes model complexity and improves interpretability while retaining performance.

## III. Methodology:

The proposed stroke outcome prediction system has been separated into distinct modules, each one focused on one component of data processing, model building, and evaluation. With this integration of modules, the system aims at efficiency, scalability, and reliability while processing healthcare information.

### 3.1.Data Collection and Integration Module

This module involves handling the gathering of health information from various sources, such as electronic health records, patient surveys, and statistics available to the public. It is responsible for standardization in terms of data formatting, fixing inconsistencies, and collating various data points, which may contain demographic information, medical history, and health measurements. The module ensures clean and just data for subsequent steps in the pipeline.

### 3.2.Data Preprocessing and Augmentation Module

Preprocessing is one of the most important steps for data preparation for machine learning. This includes the handling of missing values through imputation methods, feature normalisation for scaling, and encoding categorical variables. Moreover, it gets to deal with the class imbalance problem through the synthetic oversampling method of SMOTE, ensuring that the minority class outcomes are sufficiently explored. Other means are also incorporated, such as data augmentation to generate mutations on the training dataset, and ultimately boost the model generalisation capabilities.

### 3.3.Feature Engineering and Selection Module

This module thus takes care of filtering this dataset, leaving only the most significant and important features for predicting strokes. Correlation analysis, feature importance ranking, and dimensionality reduction are all techniques for finding significant predictors while minimizing noise and redundancy. Doing this ensures that the model only has relevant data to analyze, enhancing performance and interpretability.

## IV. Model Development and Training Module

Designates and instructs the CNN sequential model's core module: architecture, which includes input layer, convolutional layers, pooling layers, fully connected layers, and an output layer. Optimisation tricks like adaptive learning rates, regularisation techniques, and early stopping are used to ensure model performance is improved. A number of metrics such as accuracy, sensitivity, specificity, F1-score, and AUC-ROC are used to evaluate the performance of the model after training. This module compares the proposed sequential CNN model against existing models such as logistic regression, random forests, extreme gradient boosting, k-nearest neighbours, and LSTM architectures. The Comparison analysis shows that the proposed system has the edge over conventional systems.

### 4.1.UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group. The goal is for UML to become a common language for creating models of object-oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non- software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems. The UML is a very important part of developing objects-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

#### GOALS:

The Primary goals in the design of the UML are as follows:

1. Provide users a ready-to-use, expressive visual modelling Language so that they can develop and exchange meaningful models.
2. Provide extendibility and specialization mechanisms to extend the core concepts.
3. Be independent of particular programming languages and development process.
4. Provide a formal basis for understanding the modelling language.
5. Encourage the growth of OO tools market.
6. Support higher level development concepts such as collaborations, frameworks, patterns and components.
7. Integrate best practices.

#### 4.1.1.Use case diagram

A use case diagram in the Unified Modelling Language (UML) is a type of behavioural diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

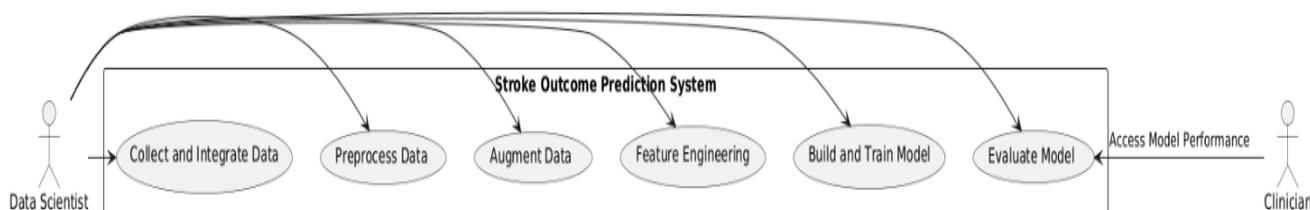
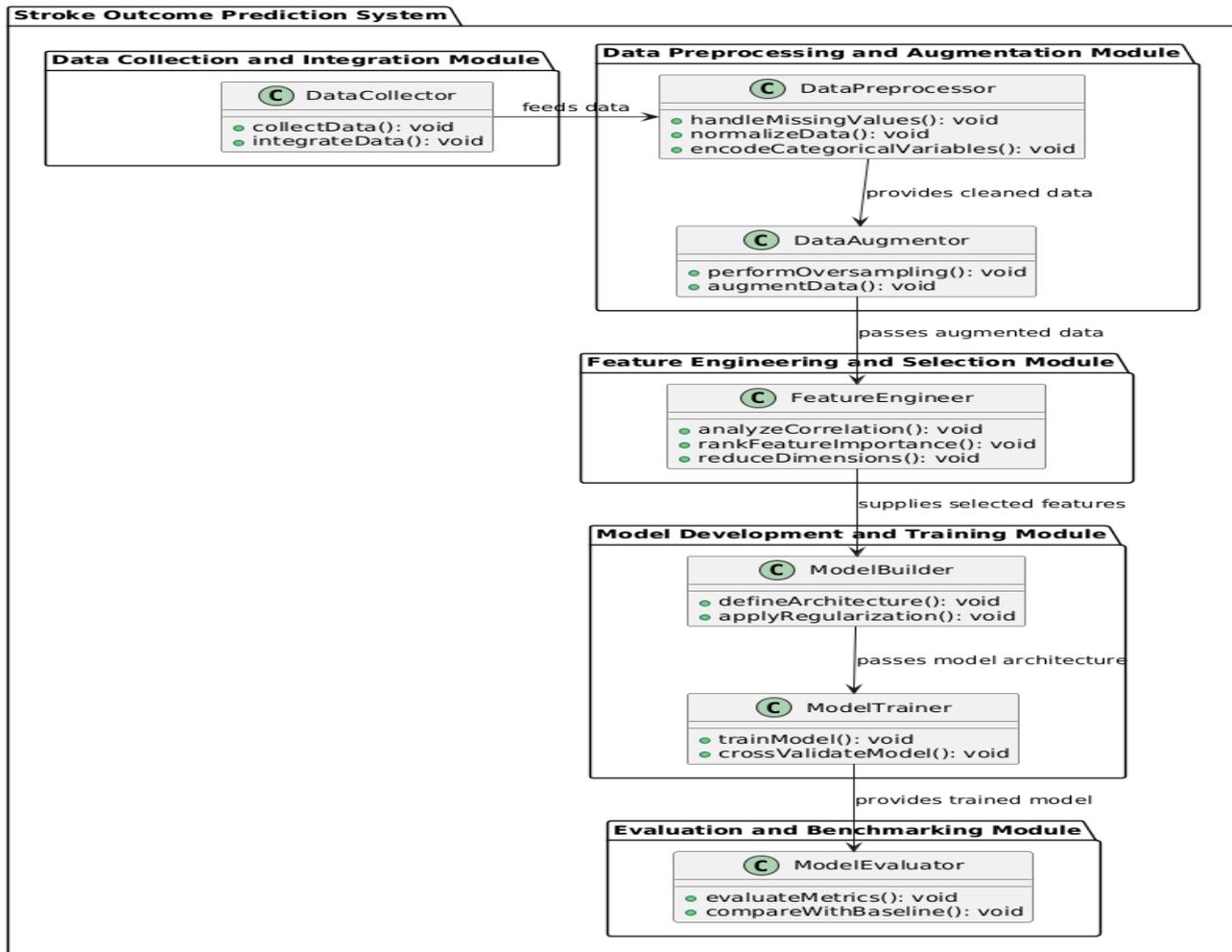


Fig 1:-Use Case diagram

### 4.1.2. Class Diagram

The class diagram is used to refine the use case diagram and define a detailed design of the system.

The class diagram classifies the actors defined in the use case diagram into a set of interrelated classes. The relationship or association between the classes can be either an "is-a" or "has-a" relationship. Each class in the class diagram may be capable of providing certain functionalities. These functionalities provided by the



class are termed "methods" of the class. Apart from this, each class may have certain "attributes" that uniquely identify the class.

**Fig.2. Class diagram**

### 4.1.3. Activity diagram

The process flows in the system are captured in the activity diagram. Similar to a state diagram, an activity diagram also consists of activities, actions, transitions, initial and final states, and guard conditions.

An activity diagram is a system-modelling and design tool used, among other things, to portray workflows, decision points, and other processes inside a system. A diagram that gives a very efficient description of a system's dynamic features-activities originating from UML, makes them focus on the flow of control and data between different operations-in particular for sequential, parallel, or conditional workflows. An activity diagram begins with an initial node, which represents the commencing point of a process. Activities, which are drawn in rounded rectangles, depict those tasks or procedures that exist within the system. These activities are connected with arrows that represent the flow of control or data from one action to the next.

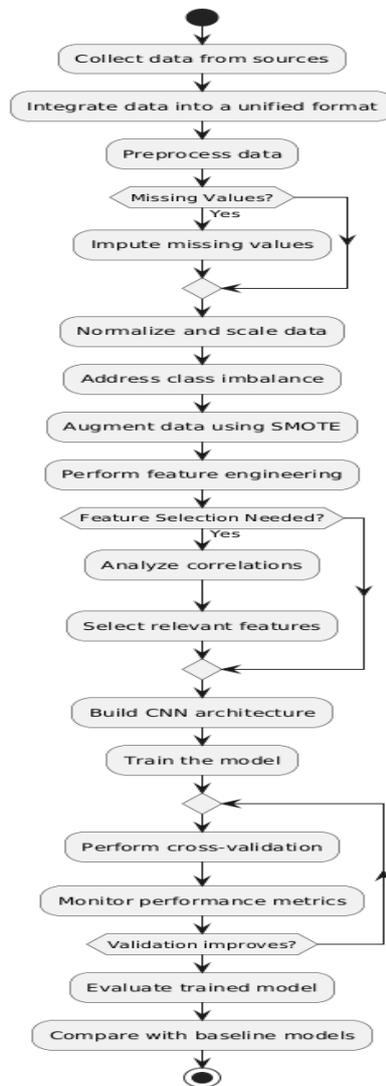


Fig.3. Activity diagram

#### 4.1.4. Sequence Diagram

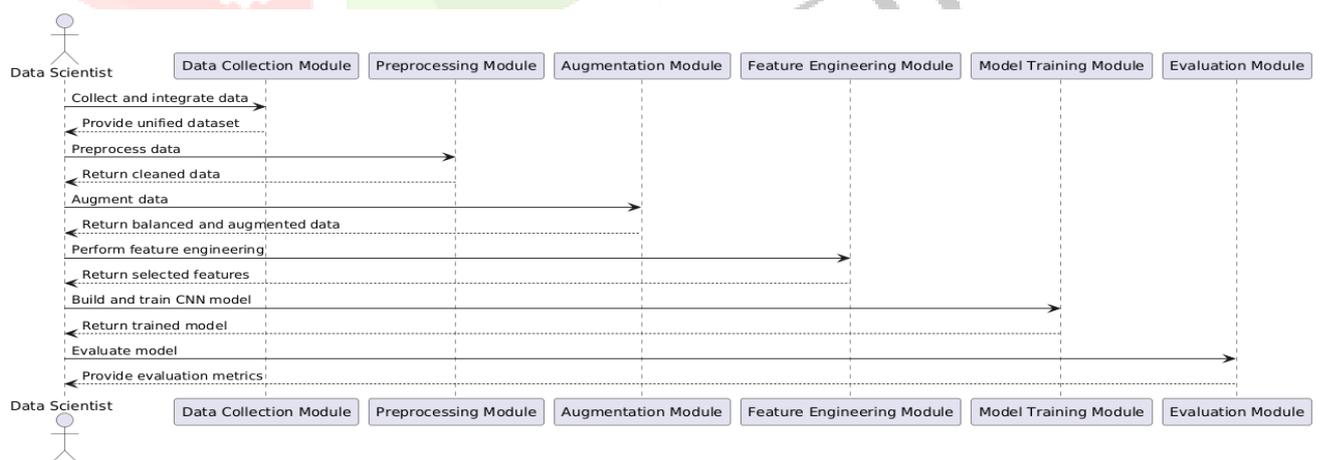


Figure.4. Sequence diagram

A sequence diagram represents the interaction between different objects in the system. The important aspect of a sequence diagram is that it is time-ordered. This means that the exact sequence of the interactions between the objects is represented step by step. Different objects in the sequence diagram interact with each other by passing "messages".

### V.Results and Discussion

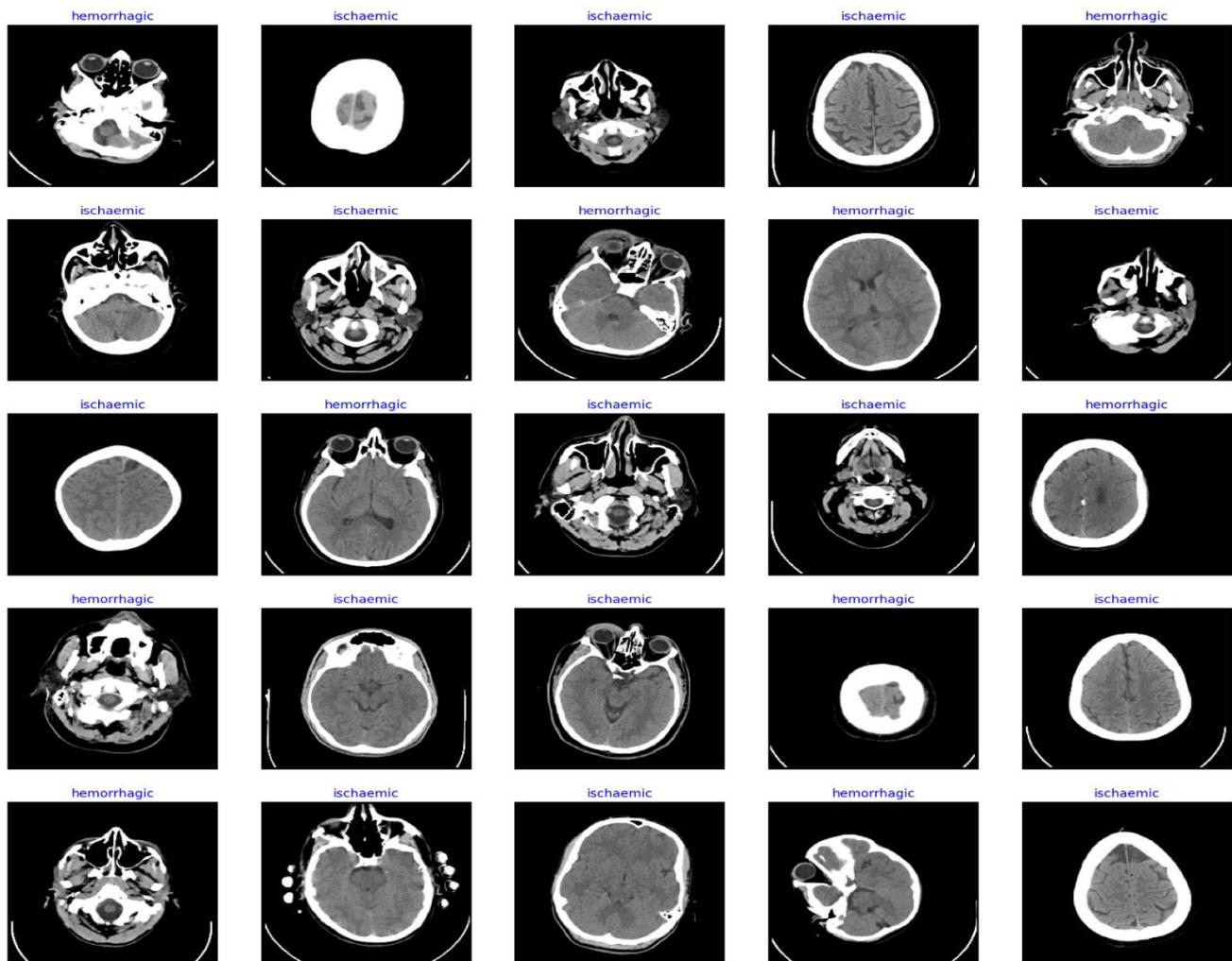


Figure.5. Dataset

True: hemorrhagic | Predicted: hemorrhagic

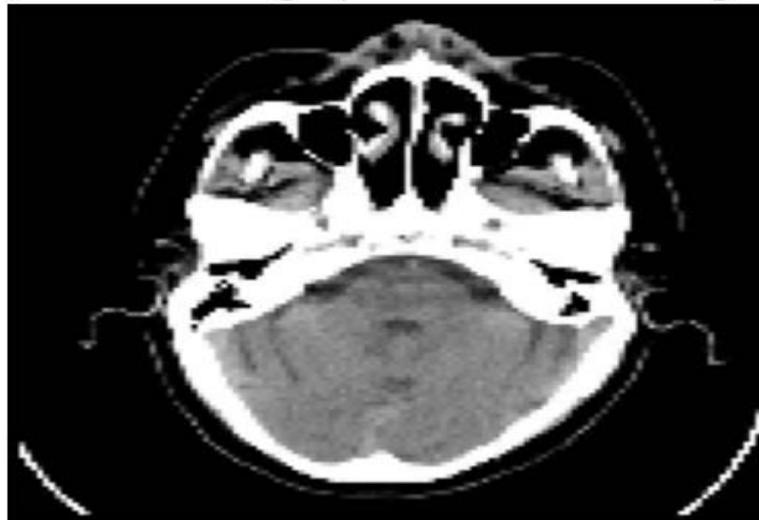


Figure.6. Actual & Predicted



- [7]. Wang, Y., Chen, L., & Zhang, K. (2022). Comparative Analysis of Deep Learning Models in Predictive Healthcare Applications.
- [8]. Zhao, Q., Liu, H., & Chen, Y. (2021). SMOTE Variations for Minority Class Balancing in Medical Datasets.
- [9]. Park, T., Kim, J., & Choi, S. (2020). Convolutional Neural Networks for Structured Healthcare Data Processing.
- [10]. Gupta, R., Sharma, S., & Bhatt, N. (2022). An End-to-End CNN Pipeline for Stroke Risk Prediction.
- [11]. Miller, C., Wilson, T., & Garcia, J. (2019). Long Short-Term Memory Networks for Health Monitoring Applications.
- [12]. Nguyen, T., Pham, L., & Tran, N. (2021). Multi-Model Deep Learning for Stroke Outcome Prediction.
- [13]. Fernandez, A., Lopez, P., & Cruz, R. (2020). Improving Clinical Predictions with Synthetic Oversampling and Deep Learning.
- [14]. Zhang, X., Lin, W., & Zhao, Y. (2022). Data Augmentation for Healthcare Applications: A Comprehensive Review.
- [15]. Zhou, P., Wang, X., & Liu, Y. (2021). Cross-Validation Strategies for Deep Learning in Medical Data Analysis.
- [16]. Chen, J., Zhang, H., & Hu, W. (2019). Regularization Techniques in CNNs for Clinical Predictive Modeling.
- [17]. Carter, D., Evans, M., & Murphy, R. (2020). Deep Learning Architectures for Neurological Disease Prediction.
- [18]. Ahmed, F., Khan, M., & Akhtar, S. (2021). Optimizing CNN Performance for Stroke Outcome Prediction.
- [19]. Wang, L., Zhao, M., & Liu, F. (2020). Ensemble Learning Methods for Stroke Prediction.
- [20]. Brown, K., Wilson, A., & Lewis, H. (2022). Neural Network Optimization for Imbalanced Medical Datasets.
- [21]. Taylor, G., Adams, S., & White, R. (2020). Comparative Study of CNN and LSTM Models in Predictive Analytics.
- [22]. Mohammed, A., Omer, A., & Hassan, R. (2021). Softmax Activation and Its Role in Medical Outcome Prediction.
- [23]. Chen, L., Qiu, W., & Sun, J. (2019). Data Imputation Techniques for Missing Medical Data: A Machine Learning Approach.
- [24]. Park, J., Kim, D., & Choi, M. (2021). SMOTE and Its Applications in Healthcare: A Review.
- [25]. Martinez, D., Garcia, L., & Brown, T. (2022). Data Balancing Techniques for Clinical Predictions with CNNs.
- [26]. Huang, S., Wang, L., & Liu, T. (2021). Regularization Strategies in Deep Learning for Stroke Prediction.
- [27]. Roberts, P., James, F., & Hall, E. (2020). Convolutional Networks for Structured Data: A Stroke Prediction Case Study.

## VIII.BIOGRAPHIES



Mr. Ravikiran Aala is presently working as Assistant Professor in the department of Information Technology at NRI Institute of Technology, Vijayawada. He received his M.Tech degree from Jawaharlal Nehru Technological University, Kakinada (JNTUK). He has published over 4 research paper in international journals. He has more than 8 years of experience in teaching.



I am sravya currently pursuing B.Tech with specification of Information Technology in NRI Institute of Technology, with a strong interest in Artificial intelligence, Machine Learning, Data Science, and Deep Learning. In addition to the academic studies I had completed the NPTEL certification on "Joy of Computing using Python". I participated in Java Full Stack Developer certification from Wipro, gained knowledge in both front-end and back-end development. I completed 2 internship on data science and devops in bist technologies



Sajja Sri Manth is currently studying B.Tech with specification of Information Technology in NRI Institute of Technology, with a strong interest in Machine Learning, Data Science, and Deep Learning. In addition to the academic studies he had completed the NPTEL certification on "Joy of Computing using Python", enhancing their proficiency in Python programming and its applications. He had earned a Java Full Stack Developer certification from Wipro, gained knowledge in both front-end and back-end development as well as skills in frameworks such as React, Node.js, and databases.



Balla Santha Raju is currently studying B.Tech with specification of Information Technology in NRI Institute of Technology, with a strong interest in python , Data Science, and Deep Learning. In addition to the academic studies he had completed the Internship certification on Data Science. He excels particularly in mathematics, demonstrating both excellent problem-solving skills

