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Neurointel: A Cognitive Neural Disorder Prediction System Using Machine Learning Algorithms and Sequential CNN

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Abstract
The rise in neurological disorders within modern society emphasizes the critical need for accurate diagnosis and immediate treatment. Traditional diagnostic methods mostly depend on specialized Neurologists and primarily utilize MRI scans and related neuroimaging techniques to evaluate the neurological health of patients. With today's growing need for diagnosing neural disorders, we need more prominent automated diagnostic tools to enhance medical practices. In this system, we propose a novel approach to diagnosing neurological disorders such as Alzheimer's Disease, Brain tumor and Brain stroke using Sequential Convolutional Neural Networks (CNNs) and machine learning algorithms. Our system utilizes the CNN at most of its capabilities in analyzing neuroimaging data and extracting key features that indicate neurological disorders. Through rigorous training and validation processes, the system achieves notable accuracy in the identification and classification of neurological disorders based on neuroscan findings. This enhances healthcare delivery by improving patient outcomes in the field of neurology.

Keywords: *Machine Learning; Neuroimaging; Neurological Disorder; Pattern Recognition; Sequential CNN; Symptom diagnosing.*

1. Introduction
Neurological disorders have wide range of conditions that affects the brain, spinal cord, and nervous system of the body. These disorders may have a remarkable impact on an person's life, that leads to rational harm, defect in motor system, and damages in sensory nerves. Understanding the hidden mechanisms of neurological diseases is important for accurate diagnosis and effective treatment strategies.

1.1 Common Neurological Diseases
The field of neurology consists variety of disorders including Alzheimer's disease, brain tumors, and brain strokes. Each of these neurological disorders has prominent challenges in terms of early detection, accurate diagnosis, and appropriate treatment. Alzheimer's disease (AD) is a disorder that could damage the cognitive functions, behavior, and memory. Early detection of these behavior is important as it can minimizes the damages caused by AD [1].

Table 1 Neural Disorders

Neural Disorder	Definition
Alzheimer's disease	A type of Dementia where the brain shrinks over time, causes from mild memory loss to eventually losing the ability to do the simplest tasks.
Brain Tumor	The growth of malignant or non-malignant tissues near the brain
Brain Stroke	The blockage of supply of blood to the brain that leads to damage of cells or even death.

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With the help of magnetic resonance imaging (MRI), the deep learning algorithm is used to create models for the Brain Tumor detection and categorization. This allows quick and simple identification of brain tumors [2]. Advancements in neuroimaging, data analytics, and machine learning have produced new possible solution for improving the prediction and treatment of these complex neurological disorders. Machine learning and deep learning are incrementally integrated into the clinical workflow and applied in neuroimaging interpretation. Table 1 shows Neural Disorders [5]

1.2 Proposed Systematic Plan

On handling the shortcomings of predicting multiple diseases such as Alzheimer's, Brain Stroke, and Brain Tumor needs an approach that is comprehensive which involves collection of data, system development and early detection. The machine learning domain has become popular through deep learning, including convolution neural networks (CNNs)[3]. The systematic approach consists of pre-processing and model training using sequential CNN and machine learning algorithms to improve disease prediction accuracy and early intervention strategies. The Neural network is built from the inspiration of how the human brain processes information, the building blocks of DL neural networks − known as “artificial neurons” − are loosely modeled after biological neurons. Artificial neurons are organized in layers. A deep neural network consists of an input layer, two or hidden layers and an output layer. [4]

2. Method

The methodology contains various steps like Data Collection, Preprocessing, Model Training, Model selection, Deployment, Validation and Evaluation, UI development.

2.1 Systematic Plan

2.1.1 Data Collection

A dataset which is inclusive of all the medical records holding the patient’s information and all the pertinent features related to medical related to the neurological disorders is collected.

2.1.2 Data Preprocessing

The gathered data is being preprocesses in order to handle all the missing values, outliers and feature scaling in the dataset. The medical images (MRI) is appropriately scaled and the quality of the data is ensured for effective training of the model.

2.1.3 Model Training

The several machine Learning algorithms comprehending Decision Tree, Random Forest, Linear Regression, KNN and CNN are being used for training the preprocessed data. Each of the algorithm is adapted to the particular characteristics of the dataset and the disease prediction requirements

2.1.4 Model Selection

The execution of many machine learning algorithms is measured by using key metrics. The metrics may include accuracy, precision, recall and the most reliable and accurate model is chosen for execution.

2.1.5 Model Evaluation

The model is tested on separate testing dataset to evaluate its accuracy and reliability in predicting multiple neurological disorders. There are metrics for the evaluation such as Accuracy, precision, recall, confusion matrix, F1 score, AUC (Area Under Curve) and Mean Square Error.

2.1.6 User Interface

The system is developed with a friendly user interface for an easy and efficient interaction of the public with the system. It provides accessible feature to the users to produce inputs and get the respective predictions as results.

2.2 Algorithms

2.2.1 Machine Learning Model Algorithms

K-Nearest Neighbours (KNN) Algorithm: It uses the nearest neighbor approach for classifying and effectively recognizes the relationships between the data points which is used to make accurate predictions.

2.2.2 Decision Tree Algorithm

A decision tree is a structure used to make decisions based on input features produced by the user , which facilitates understandable and innate decision making processes. The algorithm works by dividing the data into subsets based on the input key features. The most specific feature that takes the major part in partitioning is selected though this algorithm. Thus it is used in classification problems where the data is split to create branches that represent different classes and in regression, the data is split to minimize the variance. (figure 1)

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2.2.3 Random Forest Algorithm

This algorithm harnesses the power of group (of performers or objects) learning by collecting multiple decision trees, resulting in strong and healthy and very close to the truth or true number (statements about possible future events) through agreement voting.

2.2.4 Ensemble Learning

It is a machine learning technique that combines multiple models to improve prediction accuracy and robustness. the voting classifier, where multiple base models (classifiers) are trained independently, and their predictions are combined through a voting mechanism. Multiclass classification problem and the voting classifier can deploy methods like "hard voting" and "soft voting". Hard voting is selecting the class with the most votes, where soft voting sees the probabilities assigned by each base model and selects the class with the highest average probability (figure 3)

2.2.5 Sequential Convolution Neural Network (CNN)

Convolutional neural network (CNN) is a multilayer neural network, and is the most traditional and common deep learning framework. It's training algorithm is a variant of Back Propagation algorithm. By local connection and weight sharing, the network structure is more similar to the biological neural network, reduces the network parameters and keeps the deep structure of the network, so that the model is easier to train. [6] Sequential CNN is one of the neural networks architecture where each of the layers are stacked sequentially. CNNs are popularly used in many computer vision tasks such as classification of images, object detection, and image segmentation on owing to their ability to capture spatial hierarchies in data. In sequential CNN, the linear nature of the network implies the output of one layer that serves as the input to the next layer. It implements sequential architecture to recognize spatial hierarchies in data, particularly for image-based prediction tasks such as Alzheimer's and Brain Tumor detection. (figure 2) Components Sequential CNN contains Convolution layers, ReLU activation functions, pooling layers, fully connected layers and normalization layers. Each and every component in this plays a vital role in extracting and processing the features from the input data in order to facilitate accurate disease predictions.

2.2.6 Deployment and Validation of the Model

The model that is trained in clinical settings for the real time disease prediction along with the validation and refinement with respect to the feedback from the users. Continuously monitored and evaluated to ensure that the model is effective and relevant in diagnosing neurological diseases more accurately and efficiently.

2.3 Modules

2.3.1 Symptoms Diagnosis

This module analyzes the patient's symptoms and their medical history to determine the possibilities of neural disorders. It makes use of machine learning models to classify the found symptoms and make primary diagnoses. We have made combination of Decision tree algorithm and Random forest Algorithm using the Voting classifier in Ensemble learning method which enhanced the accuracy levels. The system questions the user regarding his/her symptoms and diagnoses to be tested positive or negative for a particular disorder. Experimental input parameters for diagnosing symptoms are the clinical data such as 'Acidity', 'Vomiting', 'Indigestion', 'Headache', 'Blurred and distorted vision', 'Excessive hunger', 'Stiff neck', 'Weakness of one body side', 'Depression', 'Irritability', 'Altered sensorium', 'Visual disturbances', 'Paralysis', 'Speaking issue', 'Memory loss', 'Confusion', 'Mood swings', 'Muscle weakness', 'Hearing problem', 'Sleeplessness'.

2.3.2 Brain Scan Analysis

This module analyzes medical imaging scans, such as MRI or CT scans, to identify abnormalities or signs of neural disorders. It employs image processing techniques, patten recognition, deep learning models and neural networks using Multiclass classification with activation functions ReLU in the hidden layers and SoftMax in the Output layer, for feature extraction and analysis. The input parameters are MRI (Magnetic Resonance Imaging), CT (Computed Tomography) and PET (Positron Emission Tomography) scans. The system (figure 4) shows the design and flow of working.

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2.4 Figures

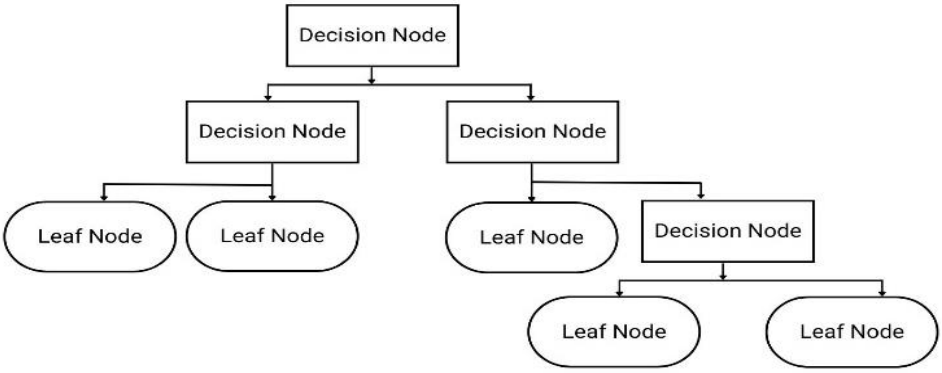

Figure 1 Decision Tree Algorithm

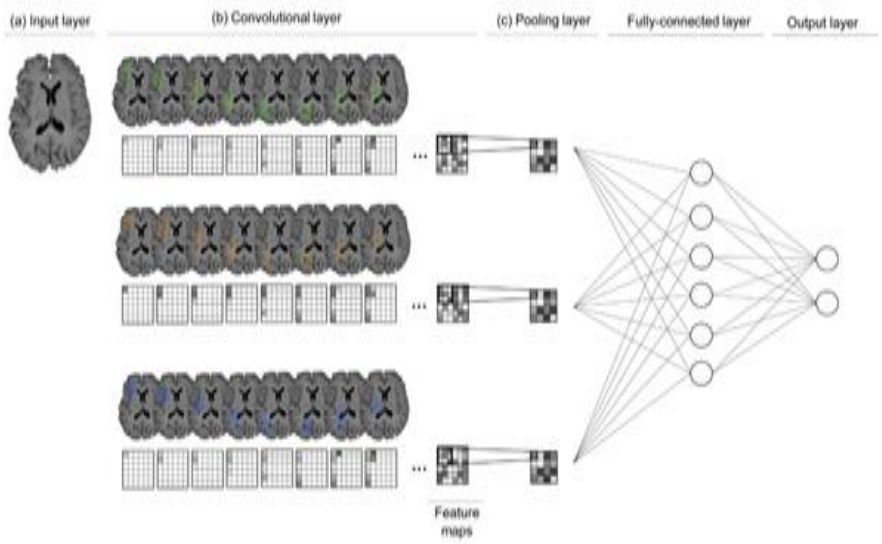

Figure 2 Brain Tissue Classification

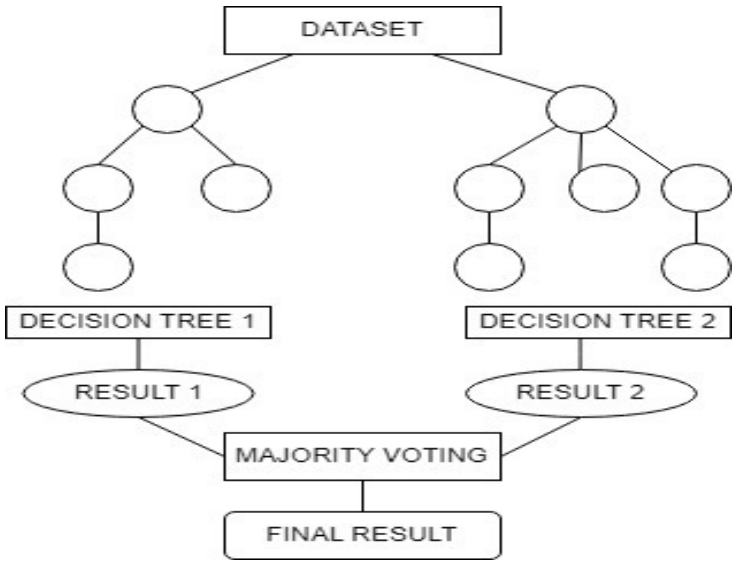

Figure 3 Voting Classifier

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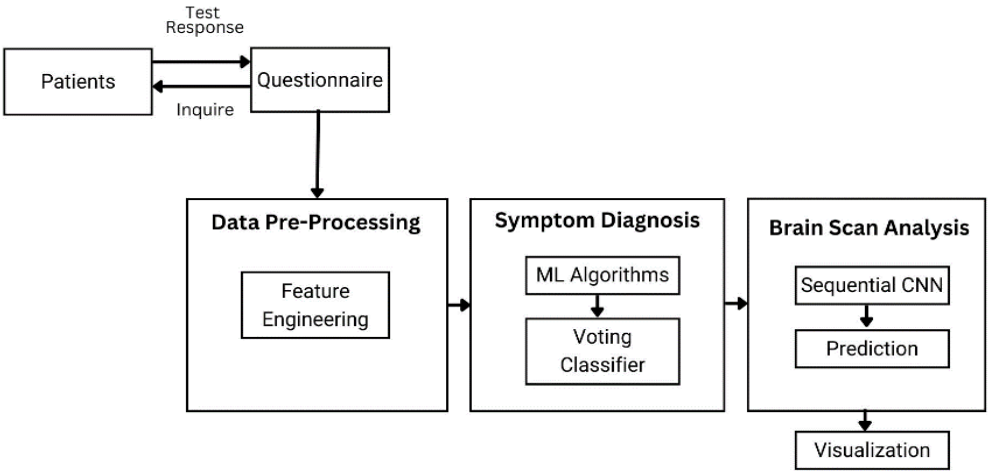

Figure 4 System Design CNN Architecture [4]

3. Results and Discussion

3.1 Results

The models were able to accurately classify and predict conditions such as Brain Stroke, Alzheimer's, and Brain Tumor based on the input data. The results are shown in Table 2 to 5.

Table 2 Results for Symptom Diagnosis

Algorithm	Accuracy	ROC
Decision Tree	98.35%	0.98
Random Forest	99.38%	1.00
KNN	97.22%	0.97

By combining Decision Tree and Random Forest using a Voting Classifier, the accuracy is given as

Table 3 Decision Tree and Random Forest

Hybrid Model (Voting Classifier)	99.79%

3.2 Results for Brain Scan Analysis

Table 4 Alzheimer's Disease

Alzheimer's Model	Training	Testing/Validation
Accuracy	79.03%	79.80%
AUC (Area Under Curve)	0.9538	0.9557

Table 5 Brain Tumor

Brain Tumor Model	Training	Testing/Validation
Accuracy	93.24%	91.58%
AUC (Area Under Curve)	0.9897	0.9859

3.3 Discussion

The system aims to predict multiple neurological disorders that diagnose symptoms and make predictions in a single platform that consists of two modules – Symptoms Diagnosis and Brain Scan Analysis. In the Symptom Diagnosis module, a Voting Classifier is used to enhance the accuracy whereas the previous studies have not utilized an ensemble model to predict the brain related disorders. The prediction results to 99.79% Accuracy of predicting symptoms for a Neural Disorder which in turn proceed with the prediction of precise neurological disease that produces an accuracy of 91.58% Testing and 93.24% Training for Brain Tumor and 79.80% Testing and 79.03% Training for Alzheimer's Disease.

Conclusion

Neurological disorders of certain types of headaches or transient neurological conditions can be cured but the diseases that are degenerative like Alzheimer's, Brain tumor and brain stroke will persist and worsen over time. These diseases must be identified at an early stage which when delayed is crucial to stop its

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progression. Machine learning and deep learning models are used to detect them in a timely manner NeuroIntel offers accurate real-time prediction of cognitive neural disorders and can revolutionize the way neurological diseases are managed. The future enhancements could involve incorporating diverse imaging modalities to expand diagnostic capabilities and improve treatment planning.

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