MACHINE-LEARNING AND DEEP-LEARNING BASED PARKINSON DISEASE DETECTION SYSTEM

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ABSTRACT

As Parkinson Disease patients show unique and characteristic vocal features and change in writing patterns**,** their voice recordings and drawings would prove to be an invaluable procedure for diagnosis as it is also non-invasive. The work on "Machine-learning and Deep learning-based Parkinson disease detection system" aims to provide a web application and a system for diagnostic purpose in hospitals or any testing centres. Machine Learning and Deep learning Algorithms are used to identify Parkinson's disease. The status provided to the users will be displayed based on accuracy of multiple machine learning algorithms for voice dataset and Convolutional neural network for spiral dataset. Therefore, this work aims to provide a convenient and non-invasive way of predicting Parkinson's disease.

Keywords: Parkinson Disease, Convolutional neural network

I. INTRODUCTION

Parkinson disease (PD) is a disease that results in shaking and stiffness due to brain disorder that is caused by the impairment of neurons that control movement. Even if the disease worsens, patients who receive an early diagnosis can enhance their quality of life. the diagnosis of Parkinson disease generally entails a number of steps, including acquiring a thorough neurological history of the patient and observing the patient's motor skills in various contexts. Any way to diagnose Parkinson disease without continual clinic visits would be more than appreciated by patients and would prove to be beneficial for them. This opens up an entirely new door of opportunities for Machine Learning algorithms to work on in-house voice recording datasets of Parkinson disease patients and then go on to efficiently predict or diagnose Parkinson disease.

II. LITERATURE SURVEY

Amreen Khanum D et al. (2022) [1] In this the Parkinson disease data provided by the UCI Machine Learning Repository consisting of 195 patient data with 23 features of voice data set was used. They used five supervised learning techniques were used which include decision tree classifier, logistic regression, naïve Bayes, KNN classifier and XG boost. Various measurement criteria, namely classification accuracy, F1-score, Recall, Precision, R2-score. And it was inferred that KNN achieved the highest performance with an accuracy of 96%.

Mohesh T et al. (2022) [2] The voice dataset of Parkinson's ailment from the UCI device mastering library was used as input. Various machine learning algorithms like Logistic Regression, Support Vector Machine (SVM), Ada Boost, Gradient Boost, Random Forest, Naive Bayes, Neural Network, XGBoost and Decision Tree were implemented. Here building a classifier using Decision Tree results in an accuracy of 94.7774555%.

Supriya Kamoji et al. (2021) [3] In this Freezing of the gait dataset which was obtained from UCI ML repository. Second dataset used was speech dataset which comprised of 195 entries and 22 attributes. Various algorithm like logistic regression, decision tree, random forest, naïve bayes, extra tree classifier, k-nearest neighbours and support vector machine were implemented on FOG and speech dataset. For the FOG dataset decision tree classifier outperformed other models with and accuracy of 94.98% and for speech dataset KNN gave the best accuracy of 97.44%.

Sabyasachi Chakraborty et al. (2020) [4] Here 55 participants were gathered for the data collection process, including 27 from the Parkinson Group and 28 from the Control Group. The architecture of the system is divided into three sections: generator, convolutional neural network architecture, and meat classifiers to analyze the prediction probabilities. The complete model was trained on the data of 55 patients and has achieved an overall accuracy of 93.3%, average recall of 94%, average precision of 93.5% and average f1 score of 93.94%

Anitha R et al. (2020) [5] In this, the voice dataset of Parkinson's disease from the UCI Machine learning library was used as input. Various machine learning algorithms like KNN, random forest, decision tree (hybrid tree) for both spiral and voice dataset. The output for voice data analysis resulted with an accuracy of 88 % K-Means and in hybrid architecture with an accuracy of 83% for random forest classification.

III. OBJECTIVE

The objectives of this work are:

1. To perform survey of research papers and analyse different machine learning algorithms and their role in predicting Parkinson's disease.
2. To obtain the voice and spiral dataset required to detect the Parkinson's disease.
3. Implement various Machine Learning algorithms like XGBoost, Random Forest, K-Neighbors, Decision tree and Convolutional neural Network to predict the presence or absence of the disease and analyze the results.
4. Developing a user-friendly web app for easier user interface using the developed machine learning and deep learning model with python framework.

IV. SYSTEM DESIGN AND IMPLEMENTATION

Two different models were implemented for the prediction of Parkinson disease. Audio dataset was employed to train various classification machine learning algorithms. The spiral drawings dataset was employed to train CNN algorithm.

Architecture for prediction Parkinson's using audio data

The architecture for the model trained using audio dataset is shown in Fig 1. Steps used to predict the Parkinson's disease using voice dataset:

1. **Collecting the data**
   The data set is obtained from UCI machine learning repository, that is "Parkinson Data Set". The data set contains 23 columns and 195 entries of data, the data present consists of vocal measurements like frequency, jitters and many more. https://archive.ics.uci.edu/ml/datasets/Parkinsons
2. **Cleaning and transforming the data.**
   The obtained data is pre-processed and scaled using standardization and normalisation techniques. Standardization is applied while training the model on Random Forest algorithm and normalization is applied for XG Boost. Also, the 'name' attribute is dropped from the dataset as it is of no significance.

3. Splitting the data

On completion of the above step the data is split into test and train in the ratio 8:2. Different splits were performed and analysed which is discussed in chapter 4. But the performance of the model was better when it was split in 8:2.

4. Fitting the model

The training data and the algorithms are fit together. Four Machine learning algorithms are implemented which are K Nearest Neighbor, Decision Tree, Random Forest and XGBoost.

The parameters chosen for these four algorithms are as follows:

K Nearest Neighbor: Number of neighbours random state value is also set to **5**.

Decision tree: Random state value is set to **42**.

Random forest: Random state value is set to 42 and n_estimators is set to **200**.

XG Boost: Random state is set to **42**.

Random state value ensures that same results are generated every time. If this is not set, then each time different split will be produced. Here the n_estimators in random forest denotes the number of decision trees to be implemented.

5. Evaluation

The trained model is then evaluated based on testing dataset. Evaluation metrices is chosen consisting of all the four accuracy, F1-score, Recall and Precision score to analyse the performance of various ML algorithms which were implemented in the previous step.

6. Prediction

Finally, four predictions are obtained from four models. Based on this prediction an analysis is made and a result is given which can either be "Person has Parkinson's disease" or "Person is likely to have Parkinson's disease" or "Person does not have Parkinson's disease".

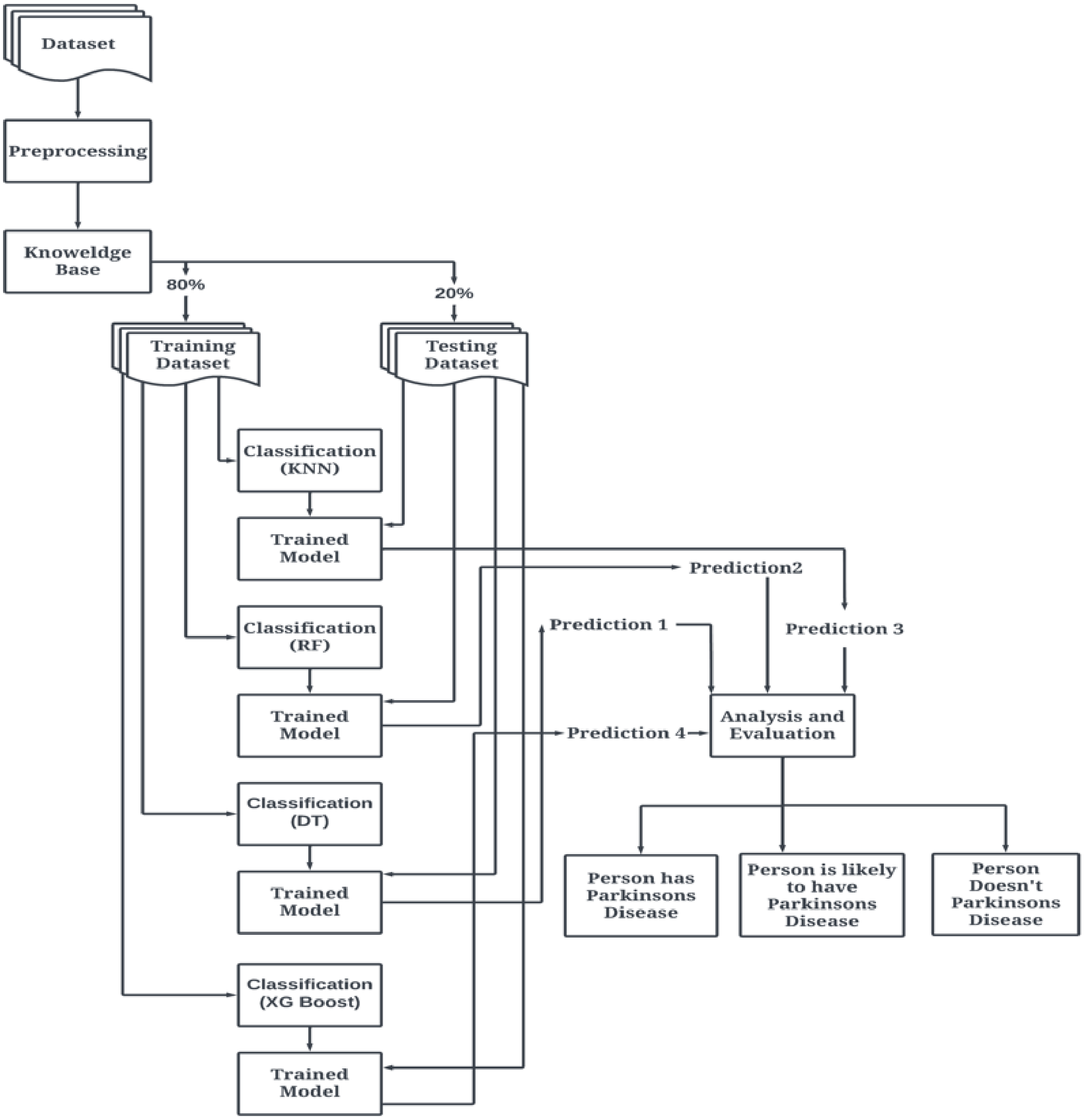

Fig. 1 Architecture for prediction using audio data

Architecture for prediction using spiral data

The architecture for the model trained using spiral dataset is given in Fig. 2. A Convolutional neural network by making use of transfer learning is implemented.

Steps used to predict the Parkinson's disease using spiral dataset:

1. **Collecting the data**

   The data set is obtained from Kaggle, that is “Parkinson’s Drawings”. The dataset contains images of healthy and patients with Parkinson’s spiral drawings. The images are further divided into training and testing. https://www.kaggle.com/datasets/kmader/parkinsons-drawings.

2. **Splitting the data**

   The acquired dataset is already split into train and test data for both healthy and PD (Parkinson’s Disease) affected people. The training data has 72 spiral images, and the testing data has 30 spiral images.

3. **Defining a sequential model**

   A sequential model called classifier is defined to which the ResNet 50 model is added. The ResNet model is only used for feature extraction that is the fully connected layers are not included. This model is initialized with pre-trained weights of imagenet dataset and the output of this model will be learned features of input layers.

   This is followed by a flatten layer which is used to flatten the output of feature maps generated by ResNet model into 1D array. That is the 3D tensor output of ResNet model will be converted to 1D array of features. This is done because fully connected layer requires a 1D input tensor and it reduces complexity.

   This layer is followed by two dense layers, where the first layer has Rectified linear unit (ReLU) as the activation function, and it consists of 128 units. And the second dense layer has the sigmoid activation function with 1 unit.

4. **Data augmentation**

   Real time data augmentation is performed only on training data. Images are read from directory and batches of augmented images are generated where the batch size is specified be 32. Rescaling is done on both training and testing data to be between 0 and 1 by dividing them by 255 (rescale=1./255). Augmentation techniques like shear range and zoom range are applied by the factor 0.2 where the images are zoomed and tilted at an angle.

5. **Fitting the model**

   The sequential classifier and the training data are fit together. Along with this two-callback function are defined. Early stopping is a callback function which is used to stop the training process of neural network when the monitor metric stops improving. This helps reduce the risk of overfitting. Reduce learning rate is another callback function which reduces the learning rate when the monitored metric stops improving. The factor by which the learning rate is reduced is 0.2. And the monitored metric in both the callback function is loss value. Trained model is then evaluated based on testing dataset.

6. Evaluation

Trained model is then evaluated based on testing dataset. Finally, the accuracy scores of every iteration in CNN Algorithm was noted and prediction was made based on the drawing for the presence or absence of the Parkinson disease.

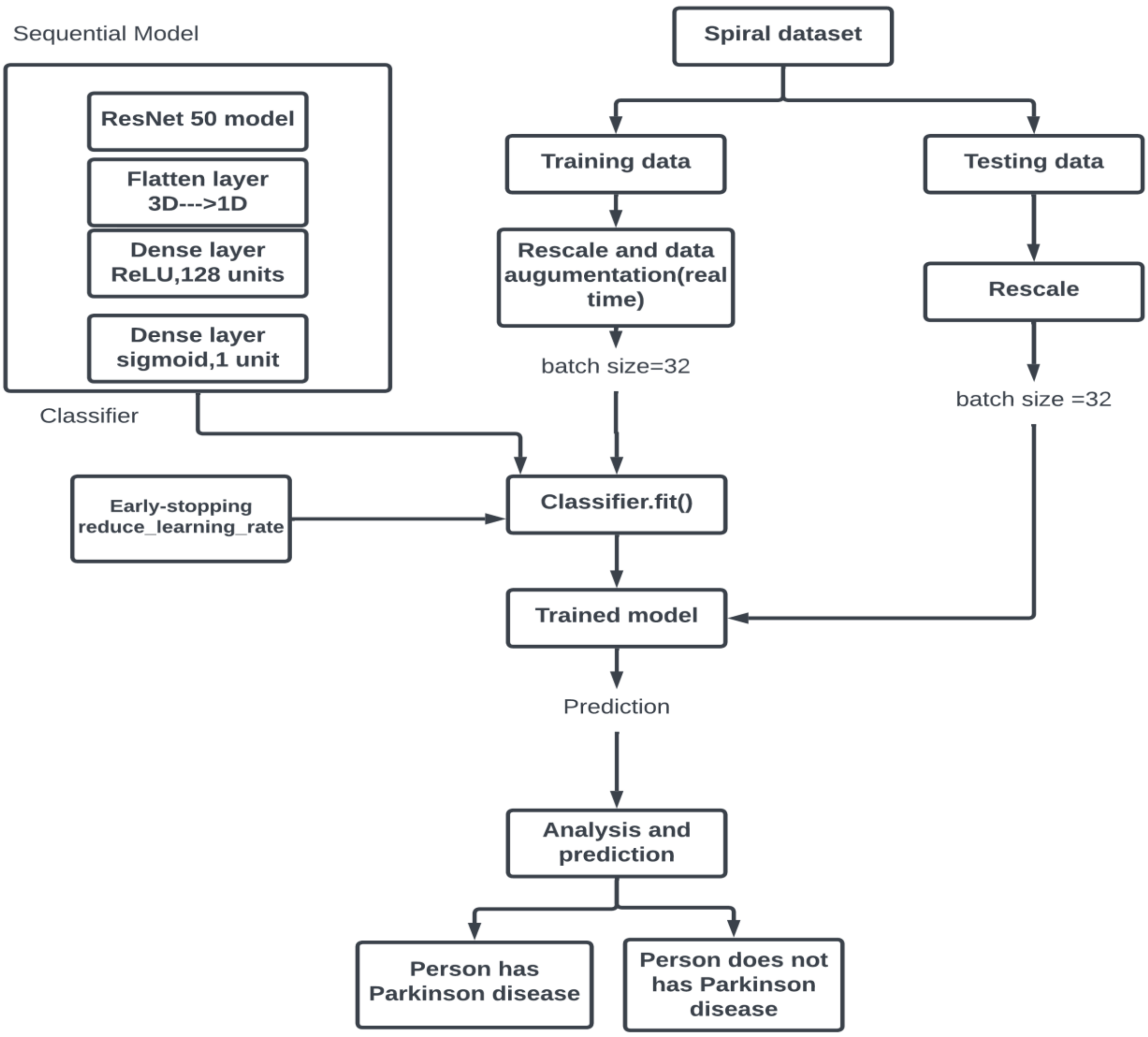

Fig. 2 Architecture for prediction using spiral data

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

V. RESULTS AND ANALYSIS

After developing models for both voice dataset and spiral drawing dataset, the final work was to build a simple User Interface for the user to interact with the Machine Learning Models. A simple and user-friendly web-application was developed by making use of Bootstrap framework, JavaScript, HTML and CSS.

While training the models in the system, the audio dataset was split in the ration 80:20 for training and testing respectively. Also, standardization and normalization were applied while training the XG Boost and random forest models respectively. Random state and the number of neighbours was set to 5 in KNN. For training of the rest three models, random state was set to 42 and n_estimators was set to 200 in random forest. Table. 1 shows TP, FP, TN, FN accuracy, recall, precision and F1-score values for all the models when the above mention values for the parameters are set.

Similarly, spiral pictures were divided earlier in the dataset for training and testing, and users just needed to input their spiral drawings for which predictions for the absence or presence of the disease were made.

Table. 1 Summarizing the values of all paramenters

80-20										
	TP	FP	TN	FN	Accuracy	Recall	Precision	F1-score	Random state	
KNN	27	4	6	2	84.61	93.1	87.09	90	**5**	**neighbors=5**
DT	31	2	5	1	92.3	96.8	93.9	95.3		
XGB	32	2	5	0	94.8	100	94.1	96.9	**42**	
RF	32	2	5	0	94.8	100	94.1	96.9		**n_estimators=200**

VI. CONCLUSION

In this project, the occurrence of the Parkinson's Disease is predicted using two datasets, one containing the voice features of the patient and the other composed of spiral drawings. Out of four algorithms used to detect the disease using voice dataset XGBoost, RF and KNN showed the highest accuracy of 94.87%, followed by DT with 92.3% accuracy. In addition to this, the CNN algorithm with transfer learning showed the highest accuracy of 98% in predicting the disease using spiral dataset. Detecting the disease in the early stage could be a great help to the affected people. After using more data, the work will have more hidden patterns and dimensions. An application is developed for an individual or whole organization for medical purposes.

New technologies can be created to make it easier to generate speech datasets. For the spiral dataset, the training dataset may be expanded with more and more images to improve prediction and accuracy. More data is needed from different regions around the globe with patients having an early stage of Parkinson to improve the reliability and the robustness of the models. Another way that may improve the performance of the system is applying ensemble learning with more classification algorithms, such as, the support vector machines, enhanced k-nearest neighbours and kernel dictionary learning.

VII. REFERENCES

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