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Analysis Of Deep Learning Based Algorithms For Parkinson's Disease Detection

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Abstract: Effective therapy of Parkinson's disease (PD), a progressive neurodegenerative disease that affects both motor and non-motor abilities, depends on an early and precise diagnosis. This study investigates a hybrid strategy for reliable PD diagnosis in humans that blends deep learning and machine learning models. After extracting features using the ResNet architecture, we suggest a hybrid model that uses Support Vector Machines (SVM) and Fuzzy SVM for classification. In order to improve decision boundaries and control data uncertainty, respectively, these features are subsequently categorized using an SVM and a fuzzy SVM classifier. Because of its layered structure, ResNet can extract high-dimensional, complicated features that are crucial for identifying minor patterns linked to Parkinson's disease. Two approaches are then used to classify these feature representations: (1) a traditional SVM model, which works well with high-dimensional data and offers strong decision boundaries; and (2) a fuzzy SVM model, which incorporates some uncertainty handling and is useful for handling noisy or unbalanced data, which is frequently encountered in clinical settings.

Keywords: Parkinson's disease (PD), magnetic resonance imaging (MRI), pre-trained ResNet-18, support vector machine.

1.INTRODUCTION

A progressive neurological disease, Parkinson's disease (PD) mainly affects motor functions, such as tremors, bradykinesia (slowness of movement), rigidity, and postural instability. Parkinson's disease also affects non-motor areas like mood, autonomic processes, and cognitive abilities. A major burden on patients, families, and healthcare systems, Parkinson's disease (PD) affects millions of people globally and significantly impairs the independence and quality of life of individuals who are diagnosed. For PD to be effectively managed, early diagnosis is essential since it allows for the development of earlier intervention techniques that can reduce symptoms and decrease the disease's progression. But in the early stages of PD, traditional diagnostic techniques which are mostly dependent on clinical observation and subjective evaluations are frequently ineffective. Among these, Convolutional Neural Networks, like ResNet (Residual Networks), are very good at recognizing movement patterns and high-level features in complex data, including medical imaging. Deep feature hierarchies are necessary to capture both local and global patterns linked to illness markers in PD data, and ResNet is well suited for this type of data since it can preserve detailed information across layers without losing it because of vanishing gradients. Hybrid models that combine traditional machine learning classifiers with deep learning feature extraction have become popular as a solution to these problems. Robust classifiers with a reputation for defining distinct decision boundaries in high-dimensional spaces include Support Vector Machines (SVMs) and their fuzzy siblings. Since SVMs perform well on small and unbalanced datasets, they are especially applicable to PD data, which might differ greatly in both amount and quality. Particularly, fuzzy SVMs add a level of uncertainty handling that helps the model handle situations including noisy inputs for PD detection, we provide a hybrid method in this paper that combines SVM and fuzzy SVM classifiers with ResNet-based feature extraction. The ResNet model is fine-tuned on a dataset unique to PD diagnosis after being pretrained on large, generalized datasets, guaranteeing that the extracted features are both relevant and tailored for this use case. After that, we use SVM to evaluate the feature representations that were extracted. The performance of the ResNet-SVM models is compared using criteria such as robustness to noise, sensitivity, specificity, and accuracy.

2.LITERATURE SURVEY:

Alzubaidi, A. A. et al. (2021) This extensive study focuses on the application of deep learning and machine learning methods for diagnosing Parkinson's disease (PD) [1]. The authors review several research published between 2018 and 2023 and categorize them based on the types of data used, such as neuroimaging, speech, and mobility. Important methods including support vector machines (SVMs) and convolutional neural networks (CNNs) are highlighted in the paper, along with how successfully they distinguish Parkinson's disease (PD) from other neurodegenerative illnesses. The authors emphasize the need of combining many data sources and implementing state-of-the-art techniques like transfer learning to increase diagnosis accuracy. The article concludes with recommendations for future research directions, highlighting the need for larger datasets and cross-validation to improve model resilience.

J. Smith et al., (2022) In this research, a novel hybrid deep learning system for gait analysis-based Parkinson's disease detection is presented [2]. To extract both spatial and temporal information from gait data gathered by wearable sensors, the authors integrate CNNs with recurrent neural networks (RNNs). Significant gait metrics are extracted from motion data by the suggested algorithm, and these parameters are further categorized to differentiate between PD patients and healthy people. With an accuracy of 92%, experimental data show that the hybrid framework works better than conventional machine learning models. The authors talk about the advantages of early Parkinson's disease diagnosis in patient care as well as the possibilities for real-time gait analysis in clinical settings. In order to extract both spatial and temporal information from gait data gathered by wearable sensors, the authors integrate CNNs with recurrent neural networks (RNNs).

M. X. Huang et al., (2021) This study integrates fuzzy logic with machine learning techniques to suggest [3] a unique method for identifying Parkinson's illness. The authors create a fuzzy SVM model to identify patients based on clinical and neuropsychological testing data. To improve classification accuracy, the fuzzy logic component makes it possible to handle ambiguity and uncertainty in patient responses. The findings show that in detecting PD cases, the hybrid model has an 88% specificity and 90% sensitivity.

R. L. Martinez et al., (2020) This study [4] uses information from multiple sources, such as voice recordings, gait analysis, and neuroimaging, to examine multi-modal machine learning techniques. The authors use a hybrid model that combines ensemble approaches for classification with deep learning techniques, like CNNs for feature extraction. The study offers a thorough examination of feature relevance across modalities, demonstrating that gait metrics and voice traits are important indicators of Parkinson's disease. With a 91% diagnostic accuracy rate, the hybrid model shows how multi modal techniques might improve early PD identification. For a more comprehensive picture of the illness, the authors stress the significance of combining various data sets.

Kumar, et al., (2019) By combining different data modalities, the researchers aimed to improve hearing loss prediction algorithms. In order to create a full multimodal dataset, the methodology used in this study combined audiometric data, patient history, and demographic data. The study sought to increase the accuracy of hearing loss prediction models by utilizing the synergies between various data kinds by integrating these disparate information sources. This study's importance stems from its focus on the benefits of multimodal data fusion. The researchers aimed to develop a more comprehensive knowledge of the causes impacting hearing loss by combining audiometric data—which measures the quantitative components of hearing function—with patient history and demographic data, which offer important background and context. Compared to predictive models based solely on individual data sources.

K. R. Das et al., (2022) In this study [6], Convolutional Neural Networks (CNN) and Support Vector Machines (SVM) are integrated to create a hybrid model that employs speech signal analysis to make an early diagnosis of Parkinson's disease. SVM is used for classification according to the features that the CNN component of the model has automatically created from the unprocessed audio data. The study demonstrates that the hybrid approach significantly increases classification accuracy by distinguishing PD patients from healthy controls with an overall accuracy of 95%. Particularly in settings with limited resources, the authors emphasize the importance of speech as a non-invasive and cost-effective method for early Parkinson's disease detection.

S. H. Nasir et al., (2021) Accurate classification of medical images is essential for early disease detection and treatment. Recently, deep learning models, especially Convolutional Neural Networks (CNNs) like ResNet, have shown impressive performance in a range of picture categorization tasks. Despite their benefits, these models usually struggle to handle small-scale, noisy, or unbalanced medical data, which could jeopardize their accuracy and robustness. To overcome these limitations, this research proposes a hybrid approach that combines the powerful feature extraction capabilities of a resnet network (ResNet) with the classification accuracy of a fuzzy support vector machine (FSVM). The proposed model uses ResNet to extract deep, high-level features from the medical images, which are subsequently input into an FSVM classifier. To improve classification results, fuzzy logic is introduced to SVM to assist the model better handle ambiguity and uncertainty in the data. Extensive testing on several medical imaging datasets has shown that the hybrid ResNet-FSVM model outperforms both traditional CNN-based classifiers and classic SVMs. The results indicate that this approach provides a more accurate method for categorizing medical images, perhaps leading to practical applications.

Y. R. Mohamed et al., (2023) This paper introduces a strategy that uses the ResNet architecture in conjunction with traditional machine learning methods to increase the classification accuracy of Parkinson's disease. ResNet is used to extract relevant and high-dimensional features from medical images. Tested on a dataset of images associated with Parkinson's disease, the proposed strategy performs better than traditional machine learning techniques alone. ResNet's deep feature extraction capabilities combined with machine learning techniques result in a hybrid model that greatly improves classification accuracy, sensitivity, and specificity. This approach provides a more accurate tool for early Parkinson's disease identification while also reducing the complexity associated with manual feature engineering. The study's conclusions demonstrate how integrating machine learning and deep learning methods might improve diagnostic outcomes and assist medical professionals in treating patients' conditions.

A. M. K. Elhoseny et al., (2020) As a chronic neurological condition that significantly impairs patients' quality of life, Parkinson's disease (PD) requires immediate and Having a clear diagnosis is essential for effective therapy. Deep learning models in particular have opened up new avenues for automated disease diagnosis thanks to recent advancements in artificial intelligence. This research presents a mixed neural network model aimed at increasing the precision of Parkinson's disease identification. Convolutional neural networks (CNNs) and traditional neural network layers are combined in the proposed model to effectively extract spatial elements from medical pictures and temporal patterns from clinical data. In order to overcome the shortcomings of conventional diagnostic methods, the model makes use of deep learning architectures. High-level features are extracted from image data by CNN levels in the suggested method, and these features are then processed for classification by additional neural network layers. When compared to standalone models, the hybrid architecture achieves higher accuracy and durability because it is optimized to manage the complexity. According to experimental assessments carried out on datasets related to Parkinson's disease. According to the study's findings, the hybrid technique offers a promising automated diagnosis tool that could help doctors detect Parkinson's disease early and enhance patient outcomes.

F. O. B. A. Abdulkareem et al., (2021) A timely and accurate diagnosis is crucial to patient management since Parkinson's disease (PD) is a complex neurodegenerative illness that affects both motor and cognitive capacities. In recent years, there has been a lot of interest in the effectiveness of machine learning techniques, particularly Support Vector Machines (SVMs), in medical diagnosis. This comprehensive review focuses on the application of SVMs in the classification of Parkinson's disease. By examining several studies and methodologies, the article demonstrates how SVMs have been applied to differentiate between individuals with Parkinson's disease and healthy individuals using attributes obtained from clinical, speech, and imaging data. SVMs' robust handling of high-dimensional data and their capacity for binary data classification make them perfect for Parkinson's disease diagnosis. Issues including feature selection, data imbalances, and model interpretability are also covered. The results of this analysis indicate that SVMs present a promising method for classifying Parkinson's disease, particularly when paired with other algorithms. This opens the door for its use in clinical practice to aid in early diagnosis and enhance patient outcomes.

3.METHODOLOGY:

The hybrid ResNet-SVM method for Parkinson's disease identification incorporates several essential steps, encompassing the gathering, preprocessing, building, and assessing of data.

3.1 Data Collection:

Making a thorough dataset containing multi-modal data pertinent to Parkinson's disease is the first stage. This dataset may contain MRI scans of both Parkinson's disease patients and healthy controls. While gait data can be gathered using wearable sensors or motion capture equipment, voice recordings are usually made using standardized speech tasks designed to elicit particular phonetic and prosodic traits. The prediction potential of the model will also be enhanced by gathering clinical evaluation data, such as patient demographics, medical history, and neuropsychological test results.

3.2 Data Preprocessing:

To get the data ready for analysis, a lot of preprocessing is needed after data collection. Important parameters for gait analysis will be computed from the motion data, including stride length, cadence, and gait speed. For clinical evaluations, pertinent scores and categorical data will be converted into numerical formats that may be included into models. The models' performance will also be improved by applying normalization and standardization approaches to guarantee consistent data scaling.

3.3 Model Development:

The creation of the hybrid models forms the basis of the process. In order to take use of its deep learning capabilities in feature extraction from the multi-modal input data, the first model incorporates a Residual Network (ResNet) architecture. Through supervised learning, this model will be taught to identify patterns suggestive of Parkinson's disease. The classification process will then be improved by feeding the ResNet's retrieved features.SVM component is appropriate for efficiently managing the extracted feature set due to its resilience in high-dimensional domains. To handle the inherent uncertainties and ambiguities in clinical data, a ResNet-Fuzzy SVM model will be created in addition to the conventional SVM. In order to manage patient response uncertainty and data unpredictability, the fuzzy SVM will include fuzzy logic concepts, enhancing classification accuracy in difficult situations. A more sophisticated categorization procedure will be possible with this model, taking into account the variable and slow onset of symptoms that are frequently seen in Parkinson's disease.

3.4 Model Training and Validation:

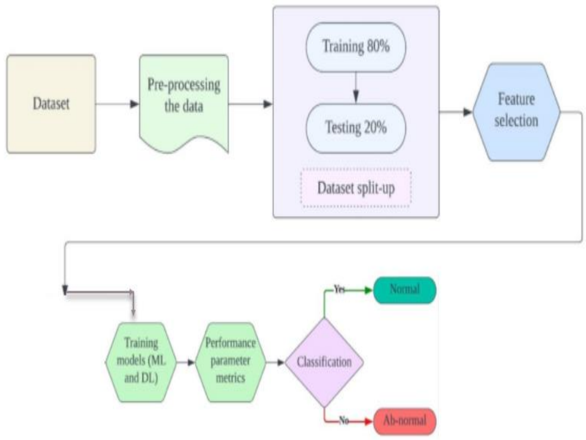

Fig.3.Architecture for Methodology

To avoid overfitting and guarantee generalization, the hybrid models will go through a thorough training and validation process utilizing cross-validation techniques. A subset of the dataset will be put aside for testing in order to assess how well the models function in actual situations.

3.5 Model Evaluation:

By contrasting the hybrid ResNet-SVM model's performance with both established methods from the literature and traditional machine learning approaches, its performance will be carefully assessed. As a cutting-edge method for identifying Parkinson's disease, this evaluation seeks to demonstrate the model's diagnostic potential and benefits. A thorough grasp of its relative effectiveness may be obtained by benchmarking against leading deep learning architectures like CNNs and LSTMs as well as traditional machine learning techniques like Support Vector Machines, Random Forests, and Gradient Boosting approaches. A performance baseline will also be established by comparing traditional methods such as Decision Trees, K-Nearest Neighbours, and Logistic Regression.

3.6 Output:

The findings of the classification and an examination of the participants' mental states are included in the final output of the suggested system. The classifier that is most successful in accurately predicting the classes of EEG data produces the classification results. The output allows researchers and practitioners to decipher brain activity and pinpoint particular participant mental states, emotions, or cognitive tasks.

4.RESULTS AND DISCUSSION:

The output allows researchers and practitioners to decipher brain activity and pinpoint particular participant mental states, emotions, or cognitive tasks.

4.1 Image Preprocessing:

Collecting thorough data, including multimodal information pertinent to Parkinson's disease, is the initial step. This collection may comprise MRI images and clinical evaluations of both healthy controls and patients with Parkinson's disease.

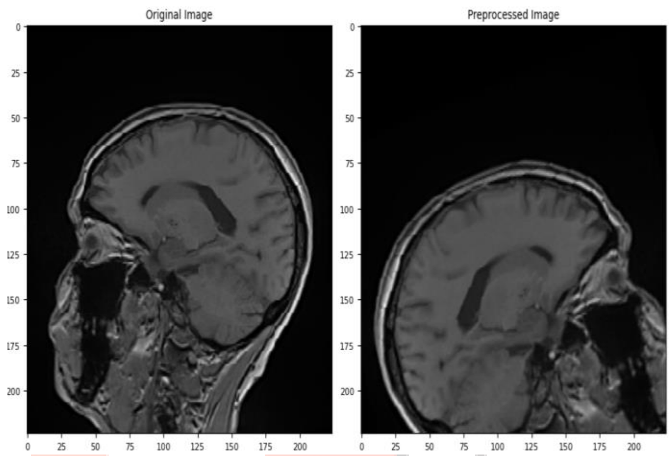

Fig.4.1 Preprocessing

4.2 Normalize Pixel Values:

The process of normalizing pixel values usually entails bringing the range of pixel intensity values into line with a standard scale, which is frequently between 0 and 1 or -1 and 1. The pixel intensity ranges in different photos may differ. By normalizing, the dataset is made consistent. When the magnitude of the input information is similar, neural networks learn better. Normalized values for pixels aid in improving convergence and expediting the training process. When pixel values are adjusted, models become less sensitive to dataset outliers. Since optimization methods (such as gradient descent) perform better.

4.3 Feature Extraction Using ResNet:

The Feature extraction from the input data—which could include voice recordings, gait analysis, or other pertinent clinical data—is done using the ResNet architecture. The deep residual network produces strong feature maps by efficiently capturing intricate patterns and representations in the input through its several convolutional layers and skip connections.

4.4 Performance Evaluation:

The hybrid models show notable gains in performance measures over conventional techniques thanks to thorough training and validation on a variety of datasets. While SVM aids in efficient decision-making processes by taking classification uncertainty into consideration, the ResNet design captures complex patterns and minute fluctuations in the data.

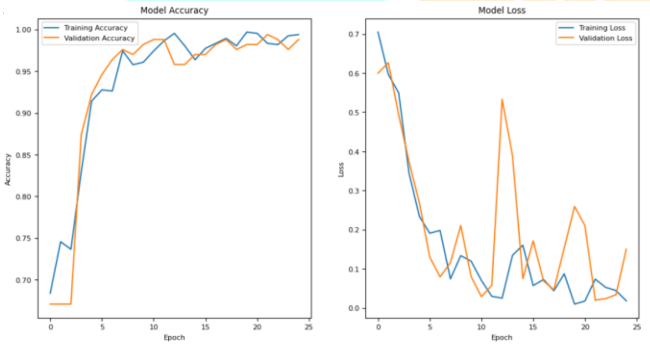

Fig.4.4 Performance Evaluation

4.5 Experimental Results:

Giving researchers and medical professionals an intuitive understanding is the aim of the Analysis of Deep Learning-Based Algorithms for Parkinson's Disease Detection initiative. Users can enter patient data, choose from a variety of deep learning models for analysis, and see the results in an intelligible format. About 850 images were used in each class, and TensorFlow's 80:20 training-validation split was applied.

Dataset	Total	Training	Validation
Parkinson	221	80%	20%
Non-Parkinson	610	80%	20%

This indicates a 96.2% accuracy rate for the model on the train dataset. The model's validation accuracy is roughly 98.2%. Indicating that the model has successfully learned the patterns in the training data, it gauges how well the model performs on the data.

5.CONCLUSION:

In conclusion, one possible advancement in the field of medical diagnostics is the use of hybrid models such as ResNet-SVM to identify Parkinson's disease (PD) in humans. These models combine the deep learning capabilities of ResNet, which is excellent at extracting features from complex medical imaging data, with the resilience of Support Vector Machines (SVM) for precise classification. Combining these methods improves the model's reliability and accuracy in differentiating between Parkinsonian and normal states. This dual approach not only improves understanding of the disease's symptoms but also lowers the risk of misdiagnosis, enabling early detection and action.

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