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Parkinson's Disease Detection using YOLO Algorithm

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I. Abstract

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by motor and non- motor symptoms, which significantly impact patients' quality of life. Early and accurate diagnosis is important for effective management and treatment planning. Recent advancements in deep learning techniques, particularly with the You Only Look Once (YOLO) algorithm, have shown promise in enhancing medical imaging analysis and automated diagnosis. This study explores the use of YOLO, a real-time object detection algorithm, for identifying Parkinson's disease-related abnormalities in medical images such as MRI and PET scans. The YOLO framework is modified and trained to detect specific biomarkers and structural changes associated with PD in imaging data, which allows for rapid and accurate identification of disease patterns. Results demonstrate that YOLO's high-speed detection and localization capabilities make it suitable for processing large volumes of medical data, offering an efficient and cost- effective solution for PD screening. This application of YOLO in PD detection may improve early diagnosis, aid in monitoring disease progression, and support the development of individualized treatment strategies. Further research is needed to refine the model for greater accuracy and clinical applicability across diverse patient populations.

Keywords—YOLO, F1 Score, Parkinson's Disease, Convolutional Neural Networks, Neurodegenerative disorder, Parkinson's Progression Markers Initiative (PPMI).

II. Introduction

Parkinson's Disease (PD) is a progressive brain disorder caused by the loss of dopamine-producing cells, which are essential for controlling movement, mood, and motivation. Early symptoms are often mild and include subtle tremors in one hand, but as the disease advances, symptoms such as stiffness, slow movements, tremors, and balance problems become more severe. These changes can make daily tasks, speech, and mobility increasingly difficult, often leading to falls and injuries. In addition to physical symptoms, PD can affect memory, mood, behavior, and sleep, causing depression, anxiety, and cognitive decline.

Diagnosing PD early is difficult because initial symptoms, such as sleep disturbances or slight cognitive changes, are hard to detect and are often dismissed.

Traditional diagnostic methods rely on visible movement problems, which typically occur in later stages of the disease.

This delay in diagnosis can reduce the effectiveness of treatments and limit opportunities for early intervention. Newer approaches using advanced tools like machine learning can analyze both movement and non-movement symptoms, offering the potential for earlier and more accurate detection.
Early diagnosis could improve patient outcomes, reduce the impact on quality of life, and support better management of the disease's progression.

III. Literature Review

According to Shreevallabhadatta G, Suhas M S, Vignesh(2022), The authors employ multiple machine learning algorithms, such as Support Vector Machines (SVM), Random Forest, and k-Nearest Neighbors (k-NN), with a focus on preprocessing steps like feature selection and normalization to enhance accuracy. The results demonstrate that machine learning models can achieve high accuracy in detecting PD, with specific metrics like precision, recall, and F1-score validating the approach. The study underscores the potential of AI-driven methods in healthcare for early diagnosis and improved outcomes, while also suggesting future work involving larger datasets, multimodal analysis, and real-world deployment challenges.

With reference to YOLO-v1 to YOLO-v8 the rise of YOLO and its complementary nature toward digital manufacturing and industrial defect detection (2023) it explains how these versions have improved in speed, accuracy, and efficiency, making them useful for identifying defects in manufacturing processes. The authors highlight YOLO's ability to detect problems in real-time, which helps automate quality control in factories. The paper also discusses challenges like dealing with poor lighting or crowded environments and suggests ways to improve YOLO's use in industrial settings, such as combining it with smart technologies like IoT. Overall, the study shows how YOLO has transformed manufacturing by making defect detection faster and more reliable.

In reference to The Parkinson progression marker initiative (PPMI). It outlines a robust study design involving newly diagnosed PD patients, healthy controls, and participants with prodromal features of PD. The study emphasizes collecting comprehensive data, to track disease progression over time. Standardized protocols ensure data quality and comparability across centers, while open data sharing aims to accelerate global research collaboration for developing diagnostic tools and therapeutic interventions.

According to A Comparison of Multiple Classification Methods for Diagnosis of Parkinson Disease (2010) they assess these methods on their ability to accurately classify Parkinson's patients and identify the most effective algorithm based on metrics like accuracy, sensitivity, and specificity. The results show that certain models perform better in terms of diagnosing PD with high precision and low error rates, emphasizing the importance of selecting the right algorithm for medical diagnosis. The paper concludes by recommending optimal techniques and highlighting how machine learning can improve early detection and assist healthcare professionals.

These papers collectively demonstrate the significant impact of machine learning and AI in various industries. In healthcare, the use of algorithms like Support Vector Machines (SVM), Random Forest, neural networks, and even YOLO-based techniques is shown to enhance the early detection of diseases like Parkinson's, potentially leading to better outcomes for patients. The studies explore how different classification methods, including YOLO, can be applied to analyze patient data, improving diagnostic accuracy and supporting healthcare professionals in making informed decisions. In the manufacturing sector, YOLO algorithms are highlighted for their ability to detect defects in real-time, automating and enhancing quality control processes. These advancements not only speed up diagnosis and defect detection but also demonstrate how AI, including YOLO, can integrate with technologies like IoT and edge computing, paving the way for smarter, more reliable systems across various domains, including healthcare, home usage and in various other sectors.

Furthermore, these studies underscore the versatility of AI models like YOLO, proving their ability to address complex challenges in diverse environments. By combining these algorithms with advancements in data processing, cloud computing, and real-time analytics, industries can achieve unprecedented levels of efficiency and accuracy. As these technologies continue to evolve, they hold the potential to redefine workflows, improve decision-making, and create innovative solutions that benefit society at large.

IV. METHODOLOGY

A. Data Collection

Relevant data is sourced from medical imaging Public datasets, like the Parkinson's Telemonitoring dataset, may also be used for training and testing.

B. Data Preprocessing

The collected data is preprocessed to ensure consistency. This involves normalizing and scaling the data and annotating key features. Normalize pixel values to improve model stability. For example, bounding boxes are used to highlight tremors in video frames, and spectrograms are created to analyze voice abnormalities.

C. YOLO Model Adaptation

For the model choice, select an appropriate version of YOLO, depending on the size and complexity of your dataset. Next, label the training data to highlight features or abnormalities related to Parkinson's Disease, marking them as "objects" for YOLO to detect.

D. Model Training

YOLO's architecture is trained to detect patterns such as tremors, rigid movements. This involves providing the preprocessed data into the model and adjusting its parameters for medical feature detection. The trained model is evaluated for accuracy, focusing on its sensitivity (ability to detect true positives) and specificity (ability to avoid false positives) to ensure reliable early-stage detection.

Implement additional steps to refine the prediction, such as analyzing the severity of detected abnormalities or combining the output with clinical data for more comprehensive diagnosis.

E. Optimization

Techniques like hyperparameter tuning and data augmentation are applied to refine the model's performance, making it more robust and effective for medical diagnosis. These methods help the model handle complex, high- dimensional medical data and reduce overfitting to training datasets. By improving generalization, they ensure that the model delivers consistent and reliable predictions in real- world clinical applications.

V. SYSTEM DESIGN

This work focuses on using the YOLO (You Only Look Once) version 8 deep learning algorithm to detect Parkinson's Disease. The detection process is based on an image dataset that includes two types of images: one showing body posture

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related to Pisa Syndrome (a symptom of Parkinson's) which reflect hand tremors associated with the disease. This approach aims to provide a reliable and automated diagnostic tool that can assist in early disease detection.

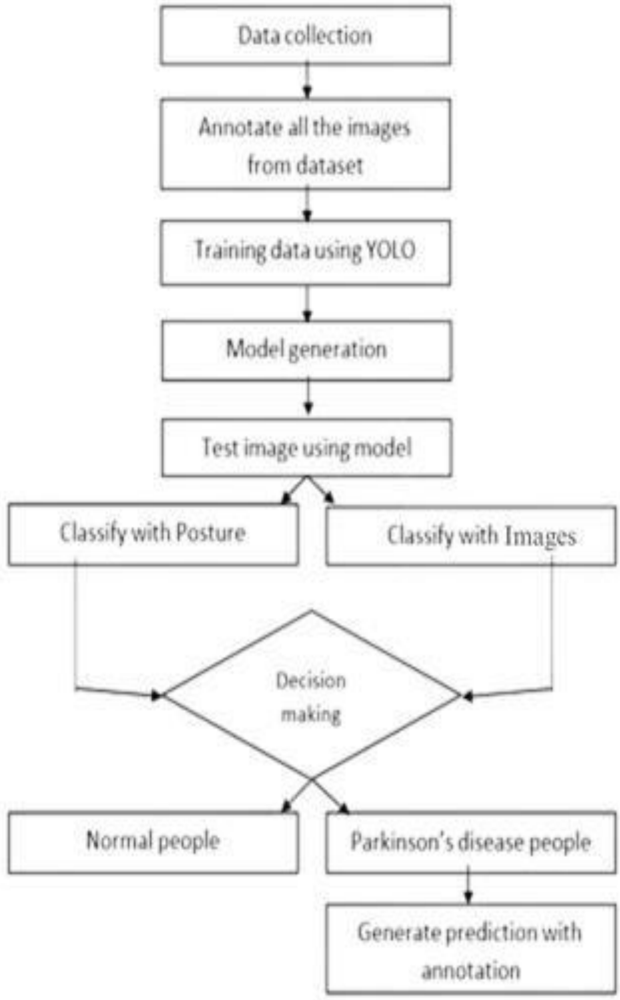

Figure 1: Flowchart of proposed method

The methodology starts with data collection, gathering images of body postures from both Parkinson's patients and healthy individuals, along with spiral drawings from both groups. These images are then annotated using the LabelImg library to create bounding boxes around relevant features. After annotation, the images are used to train a YOLO v8 model, which focuses on the areas within the bounding boxes to detect features indicative of Parkinson's Disease.

The YOLO model is trained to recognize these features and generate a pre-configured model, capable of real-time object detection. The model is then tested with images to verify its accuracy in detecting Parkinson's-related symptoms, such as the bent posture from Pisa Syndrome. The decision-making process involves analyzing the output from the model to classify whether an individual exhibits signs of Parkinson's Disease or not. The overall goal is to create a reliable tool for detecting Parkinson's Disease based on these visual indicators

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VI. Architecture

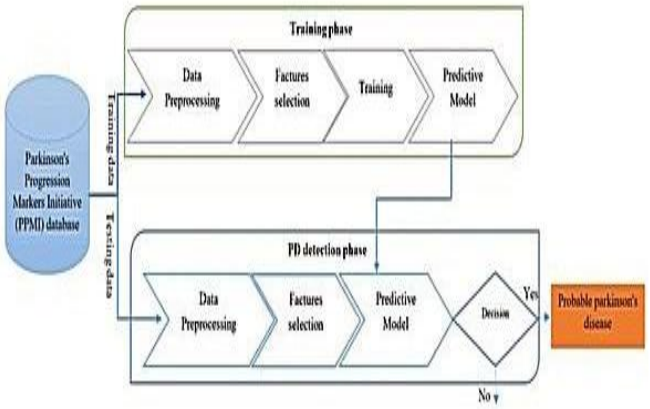


Figure 2: Architectural diagram

To implement the system for Parkinson’s disease detection, data is first collected from the Parkinson's Progression Markers Initiative (PPMI) database, which includes clinical, genetic, and imaging data. In the training phase, the data is pre-processed (cleaning, normalization, and encoding) to ensure consistency. Key features are selected using methods like PCA to focus on the most important factors for detecting Parkinson’s. A machine learning model, such as Decision Trees or SVM, is trained on the data and optimized through cross-validation and hyperparameter tuning.

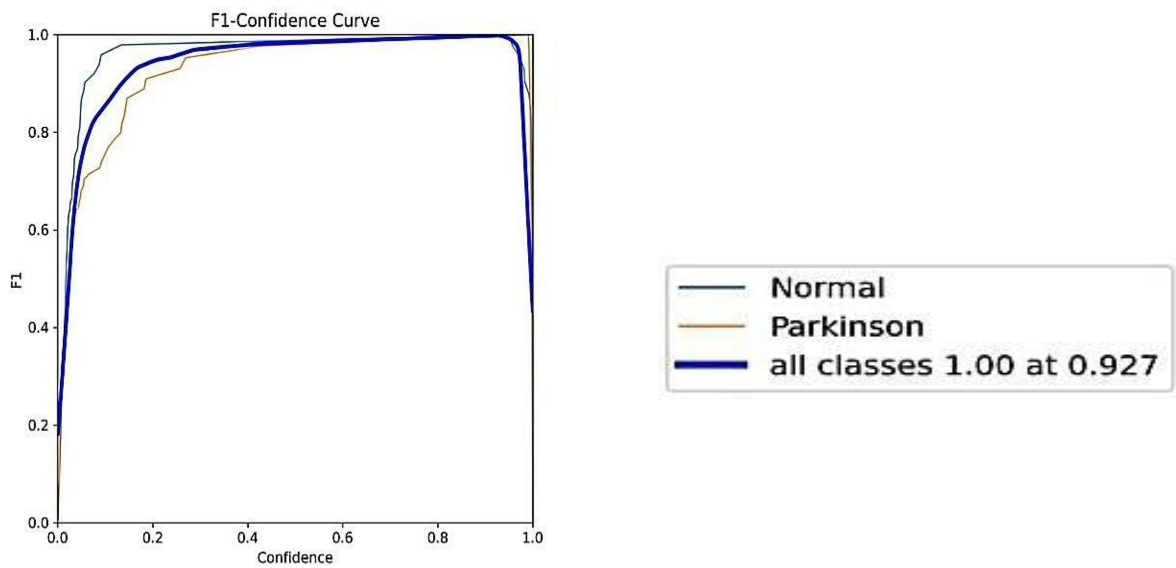
In the detection phase, the model is tested on new data, with the same pre-processing and feature selection steps applied. The trained model then predicts whether the individual person has Parkinson’s disease. Finally, the model’s performance is evaluated using accuracy, precision, recall, and F1-score. If the results are not satisfactory, adjustments are made to improve the model's performance.

VII. Result Analysis

The YOLO v8 model for Parkinson’s disease prediction is evaluated using key metrics like accuracy, precision, and recall. Accuracy shows how well the model identifies both Parkinson’s and non-Parkinson’s cases overall. Precision measures how many of the cases predicted as Parkinson’s are actually correct, reducing false positives. Recall indicates how well the model identifies actual Parkinson’s cases, minimizing missed detections. These metrics together help determine the model's reliability in detecting symptoms like abnormal postures or tremor patterns, making it a useful tool for early diagnosis and medical support.

A. F1-Confidence curve

The graph illustrates how accurately a model identifies Parkinson's disease compared to normal cases at various confidence levels. The F1 score, which reflects both the accuracy and completeness of the model's predictions, is plotted against these confidence levels. The light blue line represents normal cases, the orange line represents Parkinson's cases, and the dark blue line shows the average performance for all cases. As the confidence level increases, the F1 scores also improve, reaching their peak at a confidence level of about 0.927. At this point, the model is exceptionally accurate, meaning it is very effective at distinguishing between normal and Parkinson's cases when it is highly confident in its predictions.

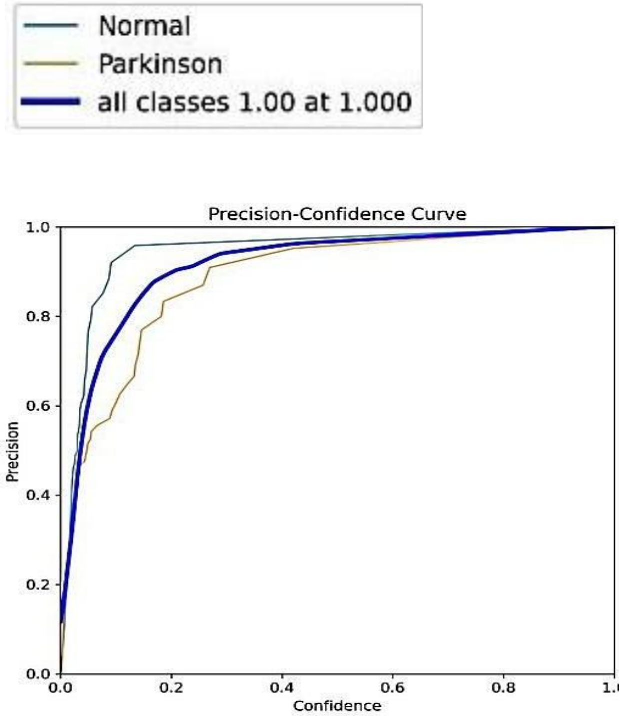


B. Precision-Confidence Curve

The provided graph is a Precision-Confidence Curve illustrating the performance of a classification model for two classes: "Normal" and "Parkinson." The x-axis represents the confidence level of the model's predictions, while the y-axis shows the precision, which is the proportion of true positive predictions to the total number of positive predictions (true positives plus false positives). The light blue curve represents the "Normal" class, while the orange curve represents the "Parkinson" class. Additionally, the dark blue curve indicates an ideal scenario where the precision is 1.0 for all classes at all confidence levels.

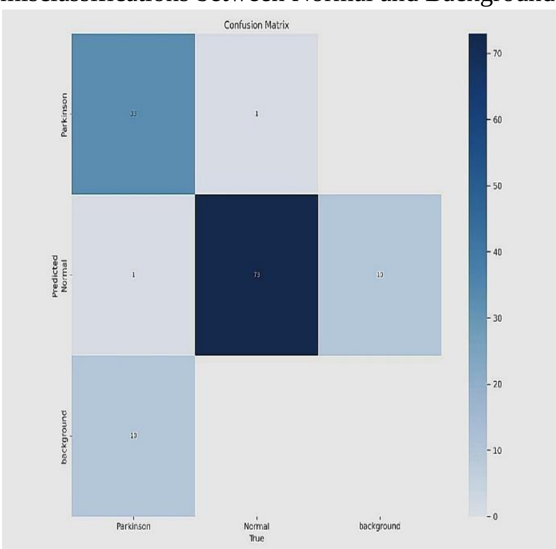
The distance between the actual curves and the ideal curve highlights areas where the model's performance can be improved. Such analysis helps in identifying the thresholds at

which the model performs optimally, enabling fine-tuning for better classification outcomes.



C. Confusion Matrix(Normalized)

The confusion matrix shows the performance of a classification model designed to differentiate between Parkinson's disease, Normal, and Background cases. The model correctly identified 33 Parkinson cases, with one misclassified as Normal and none as Background. For Normal cases, it correctly classified
73 but misclassified 10 as Background and 1 as Parkinson. Background cases were correctly identified 10 times, with no misclassification into Parkinson or Normal. The model performs well for Normal cases but has minor misclassifications between Normal and Background, indicating areas for improvement.



VIII. Conclusion

In conclusion, the application of deep learning, particularly the YOLO (You Only Look Once) algorithm, in the detection and management of Parkinson's disease represents a significant advancement in medical technology. YOLO's real-time object detection capabilities enable healthcare professionals to accurately identify and analyse visual symptoms associated with Parkinson's disease, such as tremors and gait abnormalities. This capability not only enhances diagnostic precision but also facilitates timely interventions, potentially improving patient outcomes. By integrating YOLO with wearable technologies and telehealth platforms, continuous monitoring of patients can become a reality, allowing for personalized treatment plans and proactive management of the disease. As research progresses and datasets expand, the efficacy of YOLO and similar algorithms will likely improve, paving the way for more effective and accessible solutions in the fight against Parkinson's disease. Ultimately, leveraging deep learning in this context holds promise for transforming the landscape of neurological care, providing patients with better support and enhancing their quality of life.

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