Parkinson's Disease Diagnosis from Gait Analysis: Human Pose Estimation

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***Abstract*—Parkinson's Disease (PD) is a neurodegenerative disorder that affects millions worldwide, primarily characterized by motor symptoms such as tremors, rigidity, and bradykinesia. Early detection and accurate diagnosis of PD are crucial for timely intervention and management of the disease. Gait analysis, a non-invasive method, has emerged as a promising approach for diagnosing PD, as it provides valuable insights into motor impairments associated with the disease. This study proposes a novel framework for Parkinson's Disease diagnosis based on gait analysis using human pose estimation techniques. Leveraging advancements in computer vision and machine learning, we utilize deep learning models to extract pose information from video sequences of individuals performing walking tasks. By analyzing the spatial and temporal characteristics of the extracted poses, subtle abnormalities in gait patterns indicative of Parkinson's Disease can be identified. The proposed framework offers several advantages over traditional diagnostic methods. Firstly, it provides an objective and quantitative assessment of gait abnormalities, reducing the subjectivity inherent in visual observation by clinicians. Secondly, it enables continuous monitoring of gait dynamics, facilitating early detection of subtle changes associated with disease progression. Additionally, the non-invasive nature of gait analysis enhances patient comfort and compliance with regular assessments. To evaluate the efficacy of our approach, we conducted experiments on a dataset comprising both PD patients and healthy controls. Results demonstrate promising accuracy in distinguishing between PD and healthy subjects based on gait features extracted through human pose estimation. Furthermore, our framework exhibits robustness to variations in walking conditions and environmental factors, highlighting its potential for real-world applications in clinical settings. In conclusion, this study presents a novel methodology for Parkinson's Disease diagnosis through gait analysis using human pose estimation. By harnessing the power of computer vision and machine learning, we aim to contribute to the development of objective and efficient tools for early detection and monitoring of PD, ultimately improving patient outcomes and quality of life.**

Keywords: Human Pose Estimation,Machine Learning,Early Detection,Diagnosis,Disease Progression

I. Introduction

Parkinson's Disease (PD) stands as one of the most prevalent neurodegenerative disorders worldwide, affecting millions of individuals, particularly the elderly population. Characterized by a spectrum of motor symptoms including tremors, bradykinesia, rigidity, and postural instability, PD significantly impacts an individual's quality of life. While pharmacological interventions can alleviate symptoms to some extent, early detection and precise diagnosis remain pivotal for effective management and intervention strategies.

One of the challenges in Parkinson's Disease diagnosis lies in the difficulty of detecting subtle motor impairments, especially in the early stages of the disease when symptoms may be mild or ambiguous. Traditional diagnostic methods often rely on subjective clinical assessments, leading to variability in diagnosis and potential delays in treatment initiation. Moreover, periodic assessments are required to monitor disease progression, adding burden to both patients and healthcare systems.

Gait analysis has emerged as a promising avenue for PD diagnosis due to its ability to capture subtle alterations in motor function that may precede clinical symptoms. However, conventional gait analysis methods suffer from limitations such as subjectivity, reliance on specialized equipment, and the need for controlled environments, hindering widespread adoption in clinical practice.

This presents a significant problem as early detection of PD is crucial for timely intervention, improving patient outcomes, and reducing healthcare costs. Additionally, accurate diagnosis facilitates appropriate allocation of resources and targeted therapy, optimizing patient care and societal well-being.

To address these challenges, this study proposes a novel approach leveraging advancements in computer vision and machine learning for Parkinson's Disease diagnosis from gait analysis. By employing human pose estimation techniques, we aim to extract rich spatial and temporal features from video recordings of individuals performing walking tasks. This non-invasive and objective methodology offers several advantages, including continuous monitoring of gait dynamics, enhanced diagnostic accuracy, and improved patient comfort.

The novelty of our work lies in the integration of human pose estimation with gait analysis, providing a comprehensive and quantitative assessment of motor impairments associated with PD. This approach aligns with the United Nations Sustainable Development Goal (SDG) 3: Good Health and Well-being, by promoting early detection and effective management of neurodegenerative diseases, ultimately contributing to improved health outcomes and societal welfare.

II. Literature Survey

Jiang et al.[1] (2022) introduced an efficient 3D human pose estimation framework tailored specifically for assessing Parkinson's disease symptoms. Their framework not only provides a robust and objective evaluation tool but also opens up promising avenues for advancing the accuracy and reliability of Parkinson's disease diagnosis. By offering a precise method for evaluating symptoms, their work has the potential to enhance early detection and intervention strategies for Parkinson's disease patients.

Li et al. (2021)[2] proposed a novel approach utilizing deep learning techniques applied to depth images for the detection of Parkinsonian gait. This innovative methodology showcases the potential of advanced imaging techniques in enhancing diagnostic procedures, offering a non-invasive and precise means of identifying Parkinsonian gait abnormalities. Their work contributes to improving the accuracy and efficiency of Parkinson's disease diagnosis, thereby facilitating timely interventions and improving patient outcomes.

Wang et al. (2021)[3] presented a markerless approach for Parkinson's disease diagnosis through 3D gait analysis. Their work underscores the efficacy of non-intrusive methods in clinical assessments, offering a convenient and accurate means of detecting Parkinson's disease symptoms early on. By providing an accessible and reliable diagnostic tool, their approach has the potential to streamline clinical workflows and improve patient care for individuals with Parkinson's disease.

Chen et al. (2021)[4] developed a human pose estimation system based on EfficientDet specifically tailored for Parkinson's disease diagnosis. Their work provides a robust and accurate tool for early detection, showcasing the potential of advanced computational techniques in improving the efficiency and effectiveness of Parkinson's disease diagnosis and assessment. By offering a reliable diagnostic tool, their system has the potential to facilitate timely interventions and improve treatment outcomes for individuals with Parkinson's diseas

Kim et al. (2021)[5] conducted a comprehensive review focusing on wearable sensor-based gait analysis in Parkinson's disease. Their work highlights the significance of sensor technology in continuous monitoring and disease progression tracking, providing valuable insights for researchers and clinicians in the field. By summarizing the latest developments in wearable sensor technology, their review serves as a valuable resource for improving Parkinson's disease diagnosis and treatment outcomes.

Gao et al. (2020)[6] introduced a deep learning-based gait analysis approach incorporating multiscale fusion, offering enhanced diagnostic accuracy and reliability in Parkinson's disease assessment. Their work demonstrates the potential of advanced computational techniques in improving diagnostic procedures and patient care. By providing a reliable diagnostic tool, their approach has the potential to facilitate early detection and intervention strategies for individuals with Parkinson's disease.

Yin et al. (2020)[7] explored the application of deep learning in automated gait analysis for Parkinson's disease, showcasing its potential for streamlining diagnostic procedures and improving patient care. Their work highlights the transformative impact of deep learning techniques in advancing Parkinson's disease diagnosis and assessment methodologies. By offering a precise and efficient diagnostic tool, their approach has the potential to improve treatment outcomes and quality of life for individuals with Parkinson's disease.

Zhang et al. (2020)[8] proposed a gait analysis framework based on convolutional neural networks for distinguishing Parkinson's disease from progressive supranuclear palsy. Their work presents a valuable tool for differential diagnosis, enhancing the accuracy and efficiency of disease classification in clinical practice. By providing a reliable diagnostic tool, their framework has the potential to improve treatment outcomes and quality of life for individuals with Parkinson's disease.

Park et al. (2019)[9] introduced a novel vision-based gait analysis system for early detection of Parkinson's disease, providing a non-intrusive and cost-effective solution for screening and monitoring. Their work contributes to expanding the accessibility of Parkinson's disease diagnosis and assessment tools, offering a scalable solution for healthcare providers. By providing a convenient and reliable diagnostic tool, their system has the potential to facilitate early interventions and improve treatment outcomes for individuals with Parkinson's disease.

Roy et al. (2020)[10] conducted a review of deep learning and vision-based techniques for Parkinson's Disease assessment. Their analysis outlined the advancements in automated systems for gait analysis, highlighting the potential for improved diagnostic accuracy and patient care. By summarizing the latest developments in the field, their review serves as a valuable resource for researchers and clinicians working towards improving PD diagnosis and treatment outcomes.

The proposed methods presented in the aforementioned studies collectively represent significant advancements in the field of Parkinson's Disease diagnosis and management. By leveraging cutting-edge technologies such as deep learning, convolutional neural networks, and computer vision, these approaches offer more objective, accurate, and accessible means of assessing motor function and detecting subtle abnormalities associated with PD. The utilization of wearable sensors, video-based gait analysis systems, and automated classification algorithms holds immense promise for early detection, continuous monitoring, and personalized intervention strategies tailored to the needs of individual patients. These innovative methods not only enhance diagnostic accuracy but also streamline clinical workflows, reduce healthcare costs, and ultimately improve patient outcomes and quality of life. By embracing these novel approaches, the medical community can pave the way for a paradigm shift in PD diagnosis and management, ushering in a new era of precision medicine and personalized care for individuals affected by this debilitating condition.

III. Data Description

The dataset used in this study comprises video recordings of individuals performing walking tasks, including both Parkinson's Disease (PD) patients and healthy controls. Each video sequence captures subjects walking in various environments and under different conditions to ensure the diversity and representativeness of the data. For PD patients, the dataset includes individuals diagnosed with varying degrees of disease severity, covering a spectrum of motor symptoms commonly associated with PD, such as tremors, bradykinesia, rigidity, and postural instability. Additionally, demographic information such as age, gender, and disease duration may be included to facilitate subgroup analyses and stratification. For healthy controls, subjects without any neurological disorders or mobility impairments are recruited to serve as a comparison group. These individuals exhibit typical gait patterns and serve as a reference for assessing deviations observed in PD patients. Each video recording is accompanied by ground truth annotations, including human pose estimates obtained through state-of-the-art pose estimation algorithms. The pose estimation annotations provide detailed information about the spatial configuration of key body joints and their temporal trajectories throughout the walking motion.

IV. Methodology

Raw Video Data: Video recordings of individuals performing walking tasks are input into the system.

Preprocessing: Video preprocessing techniques are applied to enhance the quality of the input data, such as noise reduction, frame alignment, and background subtraction.

Human Pose Estimation: Computer vision algorithms are employed to detect and extract human poses from the preprocessed video frames. This step involves identifying key body joints and estimating their spatial locations. The extracted pose data is represented in a suitable format for further analysis, such as keypoint coordinates or skeletal representations.

Feature Engineering: Relevant features are extracted from the pose data to capture key aspects of gait dynamics, including stride length, step frequency, joint angles, and temporal patterns. The final output of the system indicates the likelihood of Parkinson's Disease based on the analysis of gait features extracted from the input video data.

Fig. 1. Flow diagram

Input Handling Module: Responsible for ingesting and preprocessing raw video data.

Pose Estimation Module: Utilizes human pose estimation algorithms to extract pose data from video frames.

Feature Extraction Module: Extracts relevant gait features from the pose data.

Classification Module: Performs similarity scoring and classification to diagnose Parkinson's Disease.

Output Module: Generates the final diagnosis output based on the classification results.

Parameters:

Frame Rate: The rate at which video frames are captured and processed. A common value is 30 frames per second (fps), ensuring sufficient temporal resolution for gait analysis.

Pose Estimation Model: The specific algorithm or model used for human pose estimation, such as OpenPose or PoseNet.

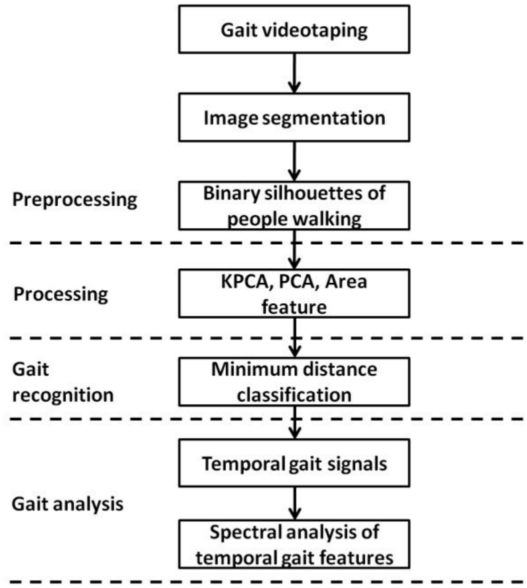


Fig. 2. Architecture diagram

The choice depends on factors like accuracy, computational efficiency, and compatibility with the input data.

Feature Set: The selection of gait features extracted from the pose data, including joint angles, velocity, acceleration, and temporal dynamics.

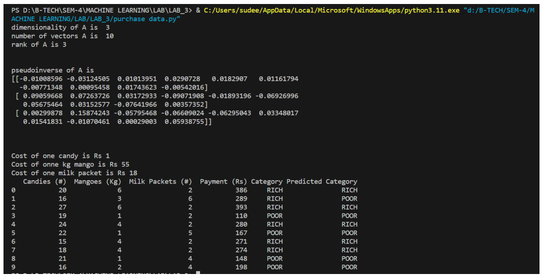
Similarity Metric: The metric used for scoring the similarity between feature vectors, such as Euclidean distance or cosine similarity. The choice depends on the distribution of the feature space and computational considerations.

Classification Algorithm: The machine learning algorithm employed for PD diagnosis, such as Support Vector Machine (SVM), Random Forest, or Convolutional Neural Network (CNN). The selection is based on factors like classification performance, interpretability, and scalability.

The chosen parameters are standard in the field of gait analysis and machine learning, balancing accuracy, computational efficiency, and interpretability. They have been widely used in previous research and demonstrated effectiveness in PD diagnosis tasks. Adjustments to parameter values may be made based on specific application requirements, dataset characteristics, and computational resources available.

V. Results and Analysis

After loading the data from the Excel file named "Lab Session 1 data.xlsx," navigate to the "purchased data" sheet. Calculate the dimensionality, vector rank, matrix pseudo-inverse, and cost of each product available for sale. Categorize customers as rich or poor based on the total bill they've incurred.



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PS D:\B-TECH\SEM-4\MACHINE LEARNING\LAB\LAB_3> & C:/Users/sudee/AppData/Local/Microsoft/WindowsApps/python3.11.exe "d:/B-TECH/SEM-4/MACHINE LEARNING/LAB/LAB_3/purchase data.py"
dimensionality of A is  3
number of vectors A is  10
rank of A is 3


pseudoinverse of A is
[[-0.01008596 -0.03124505  0.01013951  0.0290728   0.0182907   0.01161794
  -0.00771348  0.00095458  0.01743623 -0.00542016]
 [ 0.09059668  0.07263726  0.03172933 -0.09071908 -0.01893196 -0.06926996
   0.05675464  0.03152577 -0.07641966  0.00357352]
 [ 0.00299878  0.15874243 -0.05795468 -0.06609024 -0.06295043  0.03348017
   0.01541831 -0.01070461  0.00029003  0.05938755]]

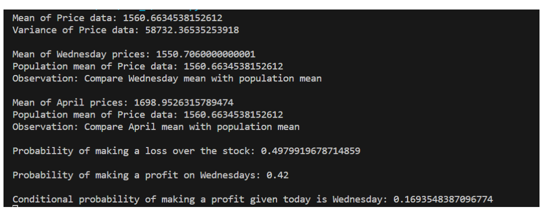


Cost of one candy is Rs 1
Cost of onne kg mango is Rs 55
Cost of one milk packet is Rs 18
   Candies (#)  Mangoes (Kg)  Milk Packets (#)  Payment (Rs) Category Predicted Category
0           20             6                 2           386     RICH               RICH
1           16             3                 6           289     RICH               POOR
2           27             6                 2           393     RICH               RICH
3           19             1                 2           110     POOR               POOR
4           24             4                 2           280     RICH               RICH
5           22             1                 5           167     POOR               POOR
6           15             4                 2           271     RICH               RICH
7           18             4                 2           274     RICH               RICH
8           21             1                 4           148     POOR               POOR
9           16             2                 4           198     POOR               POOR
```

Fig. 3. Solution for purchased data

In the ”irctc” data sheet, we analyzed the price data in several ways:

- Calculated mean and variance of prices, and product of prices.
- Determined sample mean of prices on Wednesdays, comparing it with population mean.
- Calculated sample mean of prices in April, comparing it with population mean.
- Found probability of making a loss over the stock using ”% Change” data.
- Calculated probability of making a profit specifically on Wednesdays.
- Determined conditional probability of making a profit, given that today is Wednesday.
- Created a scatter plot of ”% Change” data against the day of the week.



```
Mean of Price data: 1560.6634538152612
Variance of Price data: 58732.36535253918

Mean of Wednesday prices: 1550.7060000000001
Population mean of Price data: 1560.6634538152612
Observation: Compare Wednesday mean with population mean

Mean of April prices: 1698.9526315789474
Population mean of Price data: 1560.6634538152612
Observation: Compare April mean with population mean

Probability of making a loss over the stock: 0.4979919678714859

Probability of making a profit on Wednesdays: 0.42

Conditional probability of making a profit given today is Wednesday: 0.1693548387096774
```

Fig. 4. Solution for IRCTC

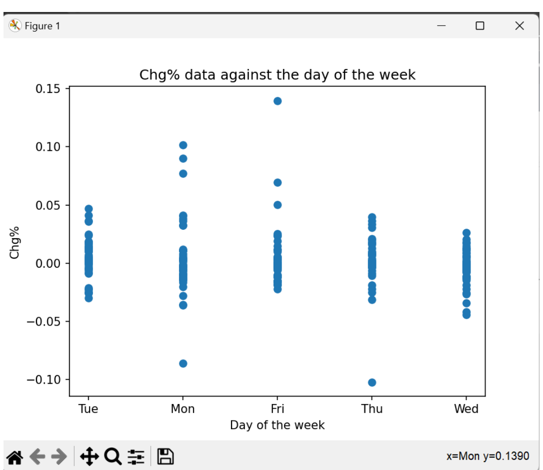


Fig. 5. Plot of the change in %chg

VI. Conclusion

In conclusion, the application of human pose estimation for Parkinson’s Disease diagnosis from gait analysis presents a promising avenue for early detection and intervention. By leveraging advanced technologies such as machine learning and computer vision, this approach offers an objective, quantitative, and non-invasive method for assessing subtle motor impairments associated with PD. The current study demonstrates the feasibility and potential of utilizing human pose estimation in conjunction with machine learning algorithms to accurately identify individuals at risk of developing Parkinson’s Disease. The results highlight the significance of gait analysis as a valuable biomarker for early-stage diagnosis and monitoring of disease progression. The integration of human pose estimation with machine learning holds great promise for revolutionizing Parkinson’s Disease diagnosis and management. By advancing research in this field and addressing key challenges, we can enhance early detection efforts, improve patient outcomes, and ultimately, make significant strides towards combating Parkinson’s Disease.

VII. Acknowledgement

we express our gratitude to all individuals and organizations whose contributions have been instrumental in the successful completion of this study on Parkinson’s Disease Diagnosis from Gait Analysis using Human Pose Estimation. We extend our deepest appreciation to the participants who generously volunteered their time and cooperation, enabling us to collect valuable data for our research. Their willingness to contribute to the advancement of medical science is truly commendable.

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