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The Novel Method for Prediction of Neurodegenerative Diseases Using Human GAIT Analysis

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***Abstract:** Analyzing human motion is essential for diagnosing movement disorders and guiding neurodegenerative diseases like Parkinson's diseases and Alzheimer's diseases. Optical motion capture systems are the standard for estimating diseases, but the equipment is expensive and requires a predefined space, while wearable sensors systems can estimate in any environment and the use of these technological instruments can be of great support in both clinical diagnosis and severity assessment of these pathologies. Here the sensors, features and processing methodologies have been reviewed in order to provide a highly consistent work that explores the issues related to human gait analysis. First, the phase of human gait cycle are briefly explained, along with some non-normal gait patterns (gait abnormalities) typical of some neurodegenerative diseases. Then the most common processing techniques for both feature selection and extraction and for classification and clustering. Finally, a conclusive discussion on current open problem and future directions is outlined.*
***Keywords:** Wearable sensors, neurodegenerative diseases, classification of features, gait patterns.*

I. INTRODUCTION

In the last decades, the number of patients with neurodegenerative diseases (NDDs) has been growing rapidly, given the remarkable improvements in life expectancy. Currently, neurodegenerative diseases, such as Alzheimer's Disease (AD), Multiple Sclerosis (MS), Parkinson's disease (PD), Huntington's disease (HD), dementia, etc., are not curable. The World Health Organization (WHO) predicted that within 2030, neurological disorders will represent the second leading cause of death, worldwide. Currently available treatments can only limit the rapid progression of the disease. Neurodegenerative diseases share symptoms that involve progressive cognitive decline, limiting everyday functional abilities and leading to motor dysfunctions, including deficits in gait and balance. The link between cognitive impairment and altered mobility performance has been widely studied and recognized. The continuous and regular monitoring of the mobility performance of elderly people may help diagnosis and assessment of the severity of neurological disorders. In the last years, technological and methodological advances have opened up the potential to provide objective measures of mobility performance in order to aid understanding neurological conditions in an automatic fashion. Quantitative measurements of mobility performance have major advantages from different perspectives: social, clinical and patient-centered.

It can provide clinicians with pivotal information on health status and cognition informing about the disease severity and progression; help to distinguish cognitive impairments; help to timely intervene for maintenance and promotion of self-independence of patients; help to capture mobility variations during time (both improvements or degenerations); improve patients' quality of life; be of support to evaluate fall risk and so to prevent falls; reduce the heavy burden of relatives and caregivers; reduce socio-economic costs .

Several fine reviews on instrumented gait performance evaluation have been published in the last years, demonstrating considerable interest in this area.. The previously mentioned reviews are mostly related to medical and motor aspects of diseases and do not contain specific aspects connected to the methodologies that can be applied. Other reviews focus only on technologies either investigating their usability and acceptability by older adults with MCI and dementia or exploring ambient sensors for elderly care and independent living or exploring wearable sensors. Few works exist which examine the methodological approaches to gait analysis by both computer vision and pattern recognition points of view. However these last works address Big data issues related to gait or methodologies for recognizing an individual (i.e. biometric recognition) by his/her gait. Differently from previous reviews, this article provides a self consistent overview of all the aspects related to the instrumented evaluation of gait parameters in neurodegenerative diseases.

The article describes how the biometric technologies and methodologies (data sensing, signal processing, feature engineering, pattern recognition and Computer Vision) can be used for the specific aim of neurodegenerative diseases evaluation.
To this aim, referenced papers have been selected by searching IEEE Xplore, ScienceDirect, Scopus, PubMed and ACM scientific databases considering those published in the last decade.
The search terms used to categorize articles were “gait analysis” joined with AND/OR connectives with the key terms “neurodegenerative disease”, “Parkinson” and “Alzheimer Sclerosis”. As this is not a systematic review, a screening method has been applied for selecting studies that better covered the different aspects of applied technologies and methodologies useful for the discussion carried out.
As a result, the work has been organized taking into account the pipeline of a typical pattern recognition system. The gait cycle is firstly introduced along with most frequently abnormal patterns associated with the most common neuromuscular diseases. Gait sensing technologies are organized in terms of ambient sensors, wearable sensors and hybrid approaches.

II. LITERATURE REVIEW

The classification of gait fluctuations helps improve the life quality and enhance clinical diagnosis ability in neuro-degenerative patients. In this work, we firstly embed the time series of multiple gait fluctuations into the phase space. Then we use persistent homology to extract the topological signatures of barcodes. Together with a random forest classifier, we proposed a topological motion analysis (TMA) framework to analyse the gait fluctuations. Further, we proposed a comprehensive comparison study using the TMA framework in the neuro-degenerative classification tasks for stance-, stride-, and swing-based gait fluctuations. In the tasks of comparing amyotrophic lateral sclerosis (ALS), Huntington’s disease (HD), and Parkinson’s disease (PD) to the healthy control (HC) group, the best achieved AUC scores were 0.9135, 0.9906 and 0.9667 respectively, which show the effectiveness of TMA framework. In summary, our study proposed a TMA framework towards gait fluctuations classification in the neuro-degenerative analysis tasks.
The proposed method shows promising clinical application value in earlier interventions and state monitoring for neurodegenerative patients. The time series of multiple gait fluctuations are processed with an outlier detection procedure, the pre processing of the time series is necessary. 2) The processed time series are embedded into data point clouds, in which the dimension adopted is 2, and the lag parameters are from the set of {4, 5, 6, 7, 8}. The time series samples are transformed into point clouds. Each point cloud represents one topological space. 3) To model the corresponding topological spaces, the data points are adopted to construct simplicial complexes with different radius parameter. As one gradually increases the radius from 0 to ∞, a sequence of simplicial complexes is generated, termed as filtration.
The filtration of the point cloud can be used for modelling the topological space. 4) The barcodes are extracted as features of the space, which illustrates the duration for the topological objects. 5) The persistence diagram and persistence landscape are generated based on the barcodes, which is more favourable for statistical analysis and machine learning tasks. 6) With the former transformations, the time series set is transformed into a persistence landscape set, from which the HC vs ALS, HC vs HD, and HC vs PD binary classification tasks are performed with leave one-out cross-validation. The random forest classifier is used in the classification tasks. In this study, a TMA framework transforming gait fluctuations time series into data point clouds using time-delay embedding, with a followed TDA technique, was used to extract persistence landscape features for gait fluctuations analysis toward neurodegenerative disease classification.
A comprehensive study using the proposed framework with multiple human gait fluctuations is proposed for understanding the pathological characteristics of neurodegenerative diseases. The built classification systems have shown excellent performance and great distinguishing ability in the neurodegenerative analysis. Therefore, the insights brought with the TDA technique greatly enrich the gait analysis tools. The proposed TMA framework shows promising ability in the modelling for disease state analysis or even clinical prediction studies. We validated the TMA framework in multiple gait fluctuations that shows good distinguishability. However, the dataset adopted is based on a limited number of experiments. Further validations should be performed on a larger scale. Meanwhile, the optimal time delay lag in the embedding stage is hard to determine. We can see that the overall performance could be affected by several stages.
The optimal combination of parameters from each stage is hard to search. Thus in the proposed experiments, we have to adopt several arbitrary parameter settings. From the achieved results, we can tell that the topological features are powerful in revealing class discrepancies. An investigation of shorter length time series distinguishing ability is meaningful in the short-length and sample limited-time series analysis tasks.

III. METHODOLOGY/ IMPLEMENTATION

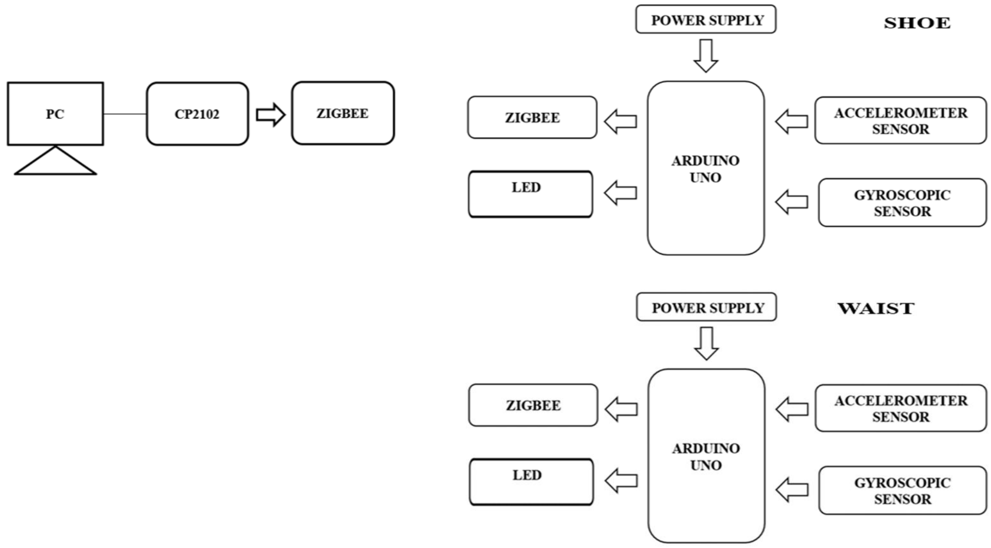

Fig 1 : Block diagram

The proposed model uses a two Wearable sensors that are gyroscopic sensor and accelerometer sensor which are attached at the waist level and lower limbs such as foot in order to reconstruct their attitude. The sensor output and inevitably influences the subsequent phase of feature extraction. The data gets sensed and recorded, therefore it get transmitted through wireless connection through Zigbee. Once the date is sensed and recorded, it is classified and clustered by the gait characteristics. Hence the result will be displayed on the serial monitor and the respective led gets blinked when it predicts the diseases.

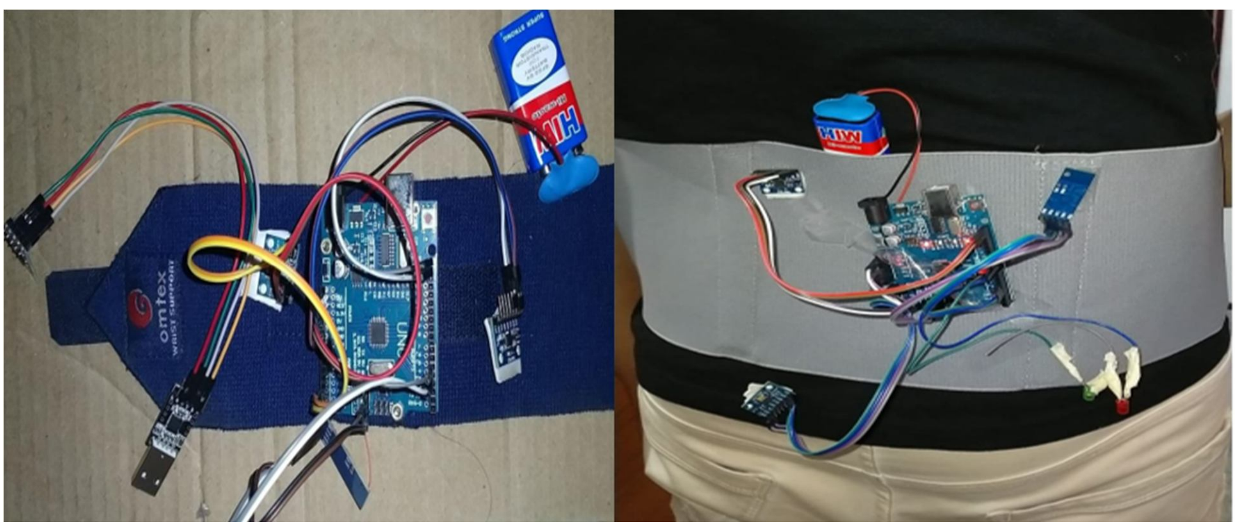

Fig 2 : gadgets used for feet and waist

This project aims to predict the neurodegenerative diseases using human gait analysis using Arduino uno as a microcontroller, and wearable sensor such as accelerometer sensor and gyroscopic sensor which is wored on the body to collect the data from the waist and feet through wireless communication using ZigBee, and the collected data from the sensor is sent to the controller and the values are calibrated according to the dataset of the diseased people. Once the values are calibrated the sensors are wore so the gait analysis involves measuring of features like spatio-temporal and kinematic features. Spatio-temporal features are principally related to distance measurements of various parts of the body during the walk and to the duration of the different phases of gait, With spatio-temporal features we mean a set of parameters that can be calculated starting from distance and time measurements involved during the gait cycle: step length, step width, times of stance, swing, single and double support, step number, stride length

IV. RESULT

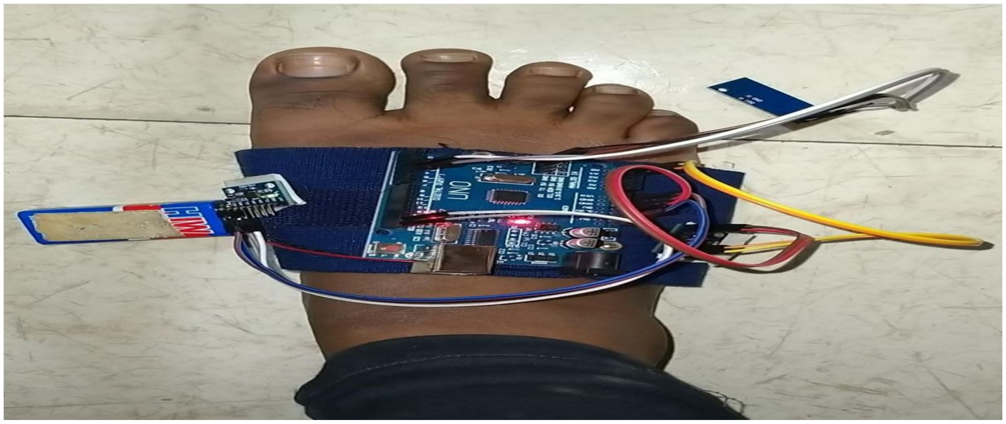

Fig 3 : Gadget wearing it on foot

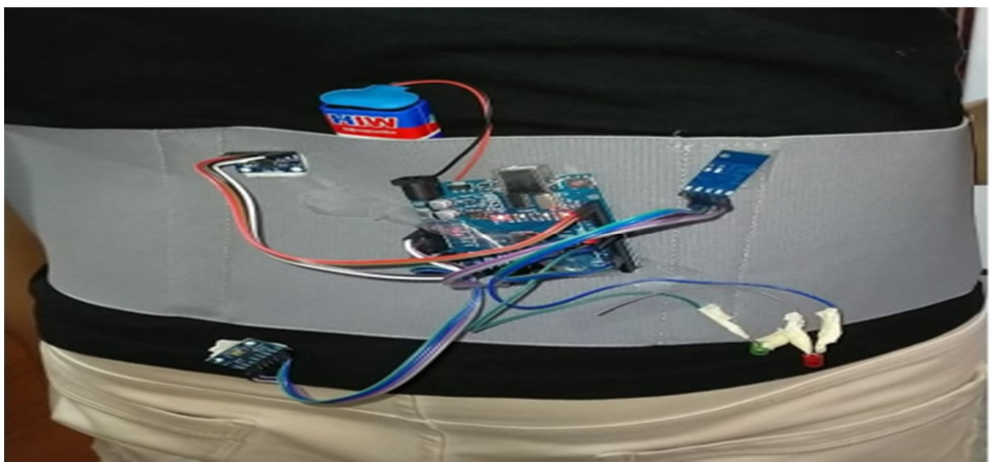

Fig 4 : Gadget wearing it on waist

Collected data from the sensor is sent to the controller and the vales are calibrated according to the dataset of the diseased people. Once the values are calibrated the sensors are wore so the gait analysis involves measuring of features like spatio-temporal and kinematic features, and analysing human motion is for diagnosing movement disorders and guiding neurodegenerative diseases like Parkinson's diseases and Alzheimer's diseases. . Here the sensors, features and processing methodologies have been reviewed in order to provide a highly consistent work that explores the issues related to human gait analysis.

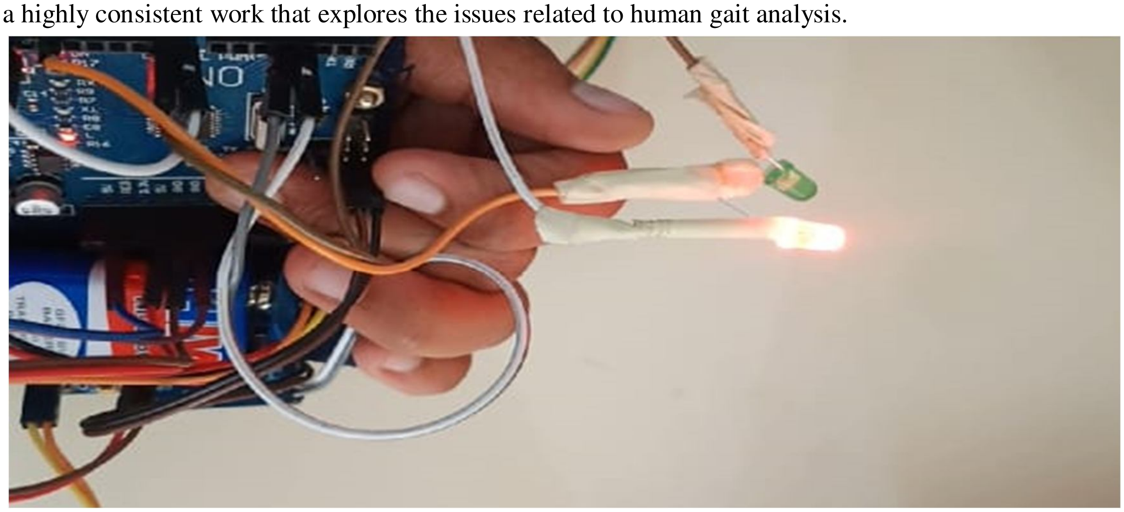

Fig 5 : led gets blinked when disease is predicted

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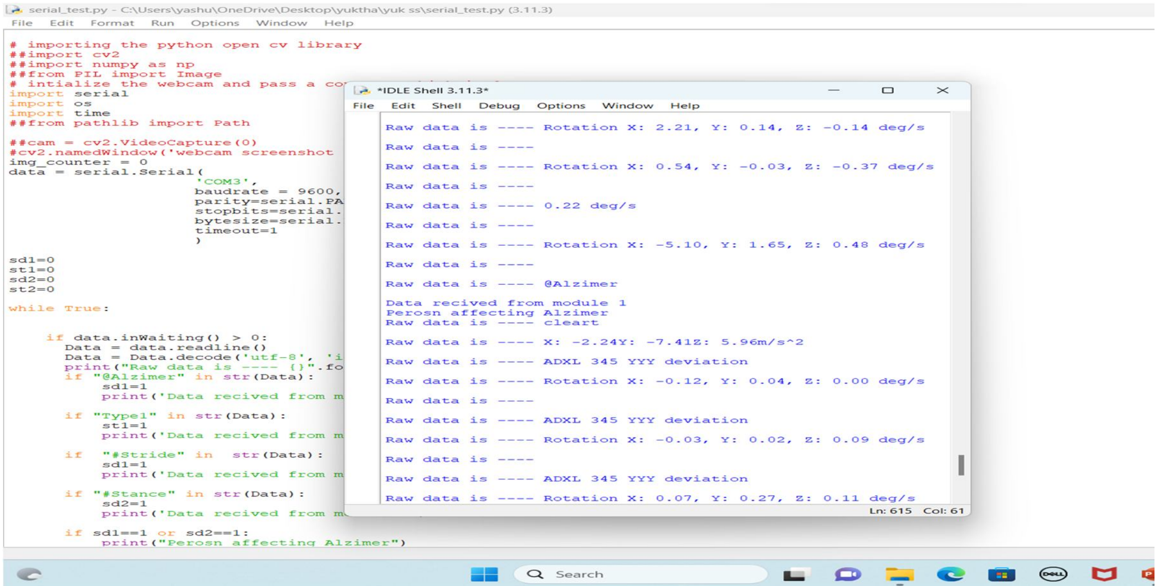


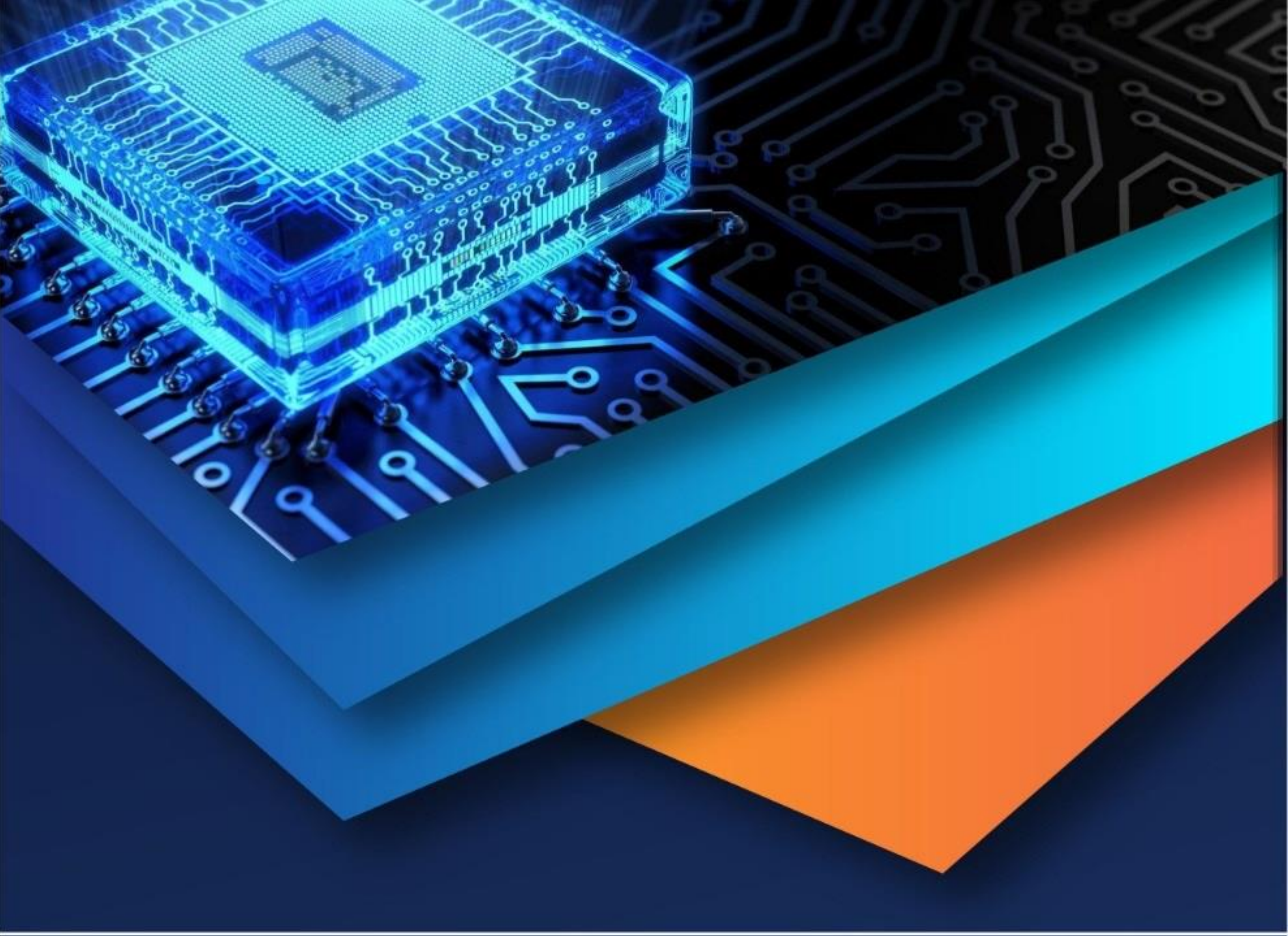
Fig 6 : predicted disease is displayed on the serial monitor

V. CONCLUSION

In this project, the fundamental issues of gait analysis, for supporting the diagnosis or the progression of neurodegenerative diseases have been explored. To date, a large number of gait parameters have been measured by using various technologies and modelled by applying several methodologies in order to better understand impaired gait due to different neurodegenerative conditions. However, the majority of investigations based on studies in clinic environments,small populations suffering from neurological disorders, pre-defined and limited gait protocols. Free-living gait assessment is the new study direction where the scientific communities are goingto focus their efforts as it reflects real-life settings, where habitual and insightful gait data can be captured on observed subjects. This system will enable researchers to translate biomechanics, rehabilitation, and sports performance research that rely on kinematics into real-world solutions. The system's accuracy meets clinical standards for several common use cases in biomechanics and rehabilitation research. We have also documented and openly shared all hardware and software to allow other researchers to use the system in a wide range of new applications that leverage the biomechanics software tools included wearable and real-time joint kinematics will allow research to test biofeedback for gait retraining or sports performance outside of the lab, and the low cost could enable large-scale and longitudinal collection of free-living biomechanics data. The accessibility of this technology could also reduce the financial and technological barriers to perform state-of- theart quantitative biomechanical analysis in low-income or developing countries with limited access to laboratory equipment, offering tools to improve musculoskeletal health on a global scale.

REFERENCES

[1] D. Impedovo and G. Pirlo, ‘‘Dynamic handwriting analysis for the assessment of neurodegenerative diseases: A pattern recognition perspective,’’ IEEE Rev. Biomed. Eng., vol. 12, pp. 209–220, 2019.
[2] C. De Stefano, F. Fontanella, D. Impedovo, G. Pirlo, and A. Scotto di Freca, ‘‘Handwriting analysis to support neurodegenerative diseases diagnosis: A review,’’ Pattern Recognit. Lett.,vol. 121, pp. 37–45, Apr. 2019.
[3] K. Ubul, G. Tursun, A. Aysa, D. Impedovo, G. Pirlo, and T. Yibulayin, ‘‘Script identification of multi-script documents: A survey,’’ IEEE Access, vol. 5, pp. 6546–6559, 2017.
[4] D. Impedovo, G. Pirlo, F. M. Mangini, D. Barbuzzi, A. Rollo, A. Balestrucci, S. Impedovo, L. Sarcinella, C. O'Reilly, and R. Plamondon, ‘‘Writing generation model for health care neuromuscular system investigation,’’ in Computational Intelligence Methods for Bioinformaticsand Biostatistics (Lecture Notes in Computer Science), vol. 8452. Cham, Switzerland: Springer, 2014, pp. 137–148.
[5] D. Impedovo, ‘‘Velocity-based signal features for the assessment of parkinsonian handwriting,’’ IEEE Signal Process. Lett., vol. 26, no. 4, pp. 632–636, Apr. 2019.
[6] D. Vincenzo, D. Impedovo, and G. Pirlo, ‘‘Real-time neurodegenerative disease videoclassification with severity prediction,’’ in Proc. Int. Conf. Image Anal. Process., Cham, Switzerland: Springer, 2019, pp. 618–628.
[7] S. Chen, J. Lach, B. Lo, and G.-Z. Yang, ‘‘Toward pervasive gait analysis with wearable sensors: A systematic review,’’ IEEE J. Biomed. Health Informat., vol. 20, no. 6, pp. 1521–1537,Nov. 2016.



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