

LITERATURE SURVEY

Detecting Parkinson's Disease using Machine Learning

I. PARKINSON'S DISEASE:

Parkinson disease is a neurodegenerative disorder that mostly presents in later life with generalized slowing of movements and at least one other symptom of resting tremor or rigidity.

Other associated features are a loss of smell, sleep dysfunction, mood disorders, excess salivation, constipation and excessive periodic limb movements in sleep (REM behaviour disorder).

Causes:

- Loss of Dopaminergic neurons in the substantia nigra and the presence of Lewy bodies.
 - Symptoms appears in old age (age above 60)
- Genetic cause
 - Symptoms appears in young age itself
 - Autosomal dominant disorder
- Multiple medications at higher doses (Reversible)
 - Drug Induced Parkinsonism (DIP)

Early Symptoms:

- Tremor is the first symptom
 - ☐ Tremor can be the initial symptoms for many other neurological disorders such as multiple sclerosis, stroke.

Progressive Symptoms:

These symptoms appears at later stages of the disease. At this stage approximately 50-80 % of the dopaminergic neurons are degenerated.

- Bradykinesia (Slowness of movement)
 - ☐ Key diagnostic criterion. In some cases it may be a initial symptom and tremor may never develop
- Rigidity
- Postural instability

Diagnosis:

- History of family is analyzed
- Clinical Examination is performed

If both are not sufficient to confirm that a patient is suffered from Parkinson's disease to rule out other neurological disorders DAT-SPECT and MRI scans (Imaging based scans) are performed

Treatment and Management:**Pharmacologically:**

- Levodopa (Combined with Carbidopa, which decreases side effects and improves Central Nerves System (CNS) bioavailability.
- Dopamine Agonist (Pramipexole, Ropinirole)
- Selegiline (Used to treat early disease provide mild symptom relief)

Most antiparkinsonian medications provide good symptom control for 3 to 6 years. After this period, the disease progresses and is often unresponsive to medications

Depression, carer fatigue, constipation, REM sleep disorder paranoia and Psychosis can be side effects due to medications or can be a part of the disease

- Management of DIP involves identifying and discontinuing the contributing medications, which usually resolves the symptoms.

Physical therapy program:

- They can be taught to improve their balance and gait, improve their stability and maintain active life

References:

- [1] George DeMaagd and Ashok Philip: Parkinson's Disease and Its Management: 2015 Aug; 40(8): 504-510, 532. [PMC]
- [2] Saman Zafar, Sridhara S. Yaddanapudi: Parkinson's Disease , 2021 Aug; StatPearls. [NIB]

II. SPIRAL DRAWINGS FOR DETECTION OF PARKINSON'S DISEASE

Since Parkinson's disease is a motor disorder, it affects various motor functions in the body including coordination, speech, walking and handwriting. Tremors in the limbs are the earliest symptoms of Parkinson's disease, as mentioned earlier. Therefore, observing the handwriting of those at a risk of developing Parkinson's disease may prove beneficial in the early detection of the disease. Slight tremors that are not visibly detectable can be detected through having the patient undertake handwriting tasks and applying statistical techniques to analyze their performance.

However, handwriting samples are dependent on demographic features and the literacy of the patient, meaning handwriting analysis may not be scalable in terms of reaching all patients. Instead, the following tasks were given to patients in [1] to be performed on a digital tablet:

- Static Spiral Test (SST): The patient traces over an Archimedean spiral with 3 winds that is displayed on the screen of the digital tablet. The results of this test help in detecting tremors in the upper limb.
- Dynamic Spiral Test (DST): The patient traces over an Archimedean spiral that blinks on the screen of the digital tablet. This test requires the patient to remember the spiral design and trace the same, testing spatial memory and motor skills at the same time. This test incorporates the non-motor functions of the body that are affected by Parkinson's disease, thus increasing probability of detection.
- Stability around Centre Point (STCP): The patient draws a circle around a red point without touching the screen of the tablet. This tests the in-air stability of their hand, apart from the on-surface stability.

The above tests were reproduced by Kamble et al. in [2] and are said to be scientific tests for motor sensitivity. Since these tests are guided Archimedean spiral tests, they demonstrate better accuracy in the classification of healthy subjects and patients, since all images can be compared against a standard Archimedean spiral, and deviation from the standard spiral can be deterministically established in terms of r , θ .

The data that can be extracted from the afore-mentioned tests include:

- Pressure and stroke features [3]

- Severity and shape of the spiral, kinematic irregularities – second order smoothness and first order zero crossing, tightness and variability of spiral width [4]
- Entropy, signal energy and empirical mode decomposition of the handwriting signals [5]

These features of the drawings are shown to bear strong correlation with the Unified Parkinson's Disease Rating Scale (UPDRS-III). Apart from these statistical measures, there have been machine learning and deep learning techniques such as Logistic Regression, C-Support Vector Classification (SVC), K-nearest neighbour, Random Forest Classifier [2] and Convolutional Neural Networks [6] have been applied to the purpose, showing significant results.

References:

- [1] Impedovo D, Pirlo G and Vessio G, "Dynamic Handwriting Analysis for Supporting Earlier Parkinson's Disease Diagnosis" in *Information*, 2018, 9(10):247, doi: 10.3390/INFO9100247.
- [2] Megha Kamble, Prashant Shrivastava and Megha Jain, "Digitized spiral drawing classification for Parkinson's disease diagnosis" in *Measurement: Sensors*, vol. 16, 100047, 2021, doi: 10.1016/J.MEASEN.2021.100047.
- [3] Peter Drotár, Jiří Mekyska, Irena Rektorová, Lucia Masarová, Zdeněk Smékal and Marcos Faundez-Zanuy, "Evaluation of handwriting kinematics and pressure for differential diagnosis of Parkinson's disease" in *Artificial Intelligence in Medicine*, vol. 67, pp. 39–46, 2016, doi: 10.1016/J.ARTMED.2016.01.004.
- [4] San Luciano M, Wang C, Ortega RA, Yu Q, Boschung S, Soto-Valencia J, Bressman SB, Lipton RB, Pullman S and Saunders-Pullman R, "Digitized Spiral Drawing: A Possible Biomarker for Early Parkinson's Disease" in *PLoS One*, 11(10):e0162799, Oct. 2016, doi: 10.1371/JOURNAL.PONE.0162799.
- [5] P. Drotár, J. Mekyska, I. Rektorová, L. Masarová, Z. Smékal and M. Faundez-Zanuy, "Decision Support Framework for Parkinson's Disease Based on Novel Handwriting Markers," in *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 23, no. 3, pp. 508-516, May 2015, doi: 10.1109/TNSRE.2014.2359997.
- [6] Gil-Martín, Manuel, Juan Manuel Montero, and Rubén San-Segundo, "Parkinson's Disease Detection from Drawing Movements Using Convolutional Neural Networks" in *Electronics*, vol. 8, pp: 907, 2019, doi: 10.3390/electronics8080907.