Parkinson's Disease: Diagnosis And Management Using Artificial Intelligence

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***Abstract*— Artificial intelligence (AI) has found numerous applications in computer-aided diagnostics, monitoring and management of parkinsonism. Parkinson's disease (PD) is the second most frequent neurodegenerative disorder that affects parts of the brain responsible for the motor functions. Old assessments of PD symptoms are conducted by questionaries and clinical assessments which have many limitations. To overcome these limitations, AI is used to detect PD and track its progression from nocturnal breathing signals, raw speech recordings in patients, radio frequency (RF) based wireless monitoring, Video assessments, closed loop detection, finger-tapping, wearable sensors and smartphone apps. The management of parkinsonism can be done by using digital biomarkers for speech and voice impairments, hypomimia (facial dynamics), gait impairment and by using home-based telemedicine systems.**

Index Terms*— *assessments, computer based, hypomimia, parkinsonism

I. INTRODUCTION

Originally used by John McCarthy in 1956, the term describes capacity to carry out tasks that are comparable to those carried out by humans. In other words, AI mimics human behavior through computer programs that emulate human thought processes (Milana C, 2021 May;30)Since the 1980s, computers have likely been used for a variety of purposes, including data collection, retail pharmacy management, clinical research, drug storage, pharmacy education, clinical pharmacy, and much more. Among the technologies that can enhance and revolutionize diagnostics, medicines, care delivery, regenerative treatment, and precision medicine models are genomics, biometrics, tissue engineering, and the vaccine industry. AI's capacity to handle enormous amounts of data from several sources makes it possible to oversee the drug development process through all of its phases. (Deopujari S, 2019 Dec) Additionally, it is useful for identifying novel therapeutic targets and forecasting the possible toxicity and adverse effects of medications in studies. (Blanco-Gonzalez A & 16(6):891., 2023 Jun 18)

Using a variety of approaches, several industries are working to advance in order to satisfy the needs and expectations of their clients. One important sector that is essential to preserving lives is the pharmaceutical business. In order to solve global healthcare concerns and respond to medical catastrophes, like the previous pandemic, it is predicated on ongoing innovation and the adoption of new technology (Krikorian G, 2021 Jun).

II. PARKINSONISM

With a variety of origins and clinical manifestations, Parkinson's disease is a recognizable clinical illness. Parkinson's disease is a rapidly expanding neurological disease; aside from an infectious etiology, its increasing global incidence closely mirrors many of the traits commonly seen during a pandemic. While 90 genetic risk variants together account for 16–36% of the heritable risk of non-monogenic Parkinson's disease, 3–5% of Parkinson's disease in most populations is caused by genetic factors connected to known Parkinson's disease genes, indicating monogenic Parkinson's disease. (Bloem BR, 2021 Jun 12)

Causes of Parkinson's Disease: Genetical causes:
Common routes to Parkinson's disease development include free radical damage, mitochondrial myopathy, abnormal protein buildup, and protein phosphorylation. (Wood-Kaczmar A, 2006 Nov 1)

Non-genetical causes:
Various studies have stated that exposure to pesticides leads to elevated risk. Additional hazards mentioned includes living in a rural area and

working in specific professions. While dietary fat and milk consumption, excessive calorie intake, and head trauma may raise risk, cigarette smoking, coffee/caffeine use, and Non-Steroidal Anti-Inflammatory drug (NSAID) use all seem to reduce risk of Parkinson's disease (PD).PD most likely has a complex etiology. (Chade AR, 2006)

III. CLASSIFICATION

The most frequent primary cause of parkinsonism is Parkinson's disease. It can be further separated into familial (hereditary) and sporadic (most prevalent) PD. Parkinsonism can be classified into two major groups: primary and secondary.

1) Primary parkinsonism: Parkinson's disease and atypical parkinsonian illnesses are examples of primary parkinsonian disorders. A neurologist trained in movement disorders can assist in accurately diagnosing and coordinating care, but both can be misdiagnosed.

2)Secondary parkinsonism: This category of parkinsonism encompasses neurological conditions frequently brought on by chemicals, drugs, or brain tumors. Depending on the condition, symptoms might occasionally disappear with treatment and resemble those of Parkinson's disease. Levodopa does not alleviate symptoms, in contrast to Parkinson's disease. (S, 2016 Oct)

IV. PHARMACOLOGICAL TREATMENT

dopaminergic ones do following vesicle storage.
The first carbidopa/levodopa combo brand available on the pharmaceutical market was called Sinemet. The Food and Drug Administration (FDA) recently approved two drugs for Parkinson's disease (PD): rytary and duopa. A new drug called Xadago (safinamide) has been licensed for Parkinson's disease patients who do not respond well to levodopa or carbidogopa.

A class of substances known as dopamine agonists attaches themselves to dopaminergic postsynaptic receptors and produces the same signal as dopamine. Pergolide , pramipexole dihydrochloride, ropinirole hydrochloride, rotigotine, and apomorphine hydrochloride are all members of this category. · There are also PD drugs that are MAOB inhibitors, such as rasagiline and selegiline. (Emamzadeh FN, 2018 Aug 30)

V. DIAGNOSIS

A. Description

Artificial intelligence (AI) technologies are gaining popularity in medical diagnostics due to their capacity to process vast volumes of data and produce precise statistical predictions.This article provides a full assessment of several machine learning and deep learning-based AI techniques used to diagnose Parkinson's disease, as well as its impact on opening up additional research areas. (Saravanan S, A systematic review of artificial intelligence (AI) based approaches for the diagnosis of Parkinson's disease, 2022;oct)

1.VOICE ASSESSMENT:

A non-invasive, dependable, user-friendly, and reasonably priced technique for identifying Parkinson's disease is acoustic analysis of voice. (Sharma RK, 2016 Feb 1)
Method:Their voice signals were recorded and processed. The relevant features were then extracted. Different classifiers were provided features so they could determine whether or not the participants had the condition. (Sharma RK, 2016 Feb 1)
Result:The use of speech analysis to enhance the diagnosis and evaluation of Parkinson's disease (PD), with a focus on studies that suggest methods for automatically detecting PD or determining its severity. (.Moro-Velazquez L, 2021 Apr 1)

2.WEARABLE SENSORS:

This relies on clinical criteria, primarily bradykinesia, along with rigidity, tremor, and supportive features. (. Sigcha L, 2023 Nov 1) By offering spatiotemporal characteristics to analyse the stage of Parkinson's disease, wearable sensor systems facilitate gait analysis.Advances in sensor and battery technology enable continuous, objective monitoring of movement in daily life. This review highlights wearable devices used to assess motor symptoms in PD. (Ossig C, 2016 Jan)

3. NOCTURNAL BREATHING PATTERNS:

Nocturnal breathing data was used to develop an artificial intelligence (AI) model that can diagnose and monitor the progression of Parkinson's disease (PD). (Yang Y, 2022 Oct) The technology obtains one night's worth of breathing signals from a person wearing a breathing belt on their chest or abdomen. An alternate method for gathering breathing signals without the need for wearable technology is to send out a low-power radio signal and see how it reflects off the patient. A key feature of this model's

architecture is its capacity to learn the auxiliary task of predicting an individual's quantitative electroencephalogram from nocturnal breathing. This helps to understand the model's output and avoids overfitting. Our approach is to create a digital biomarker for diagnosis and progression that is objective, undetectable, affordable, and repeatable. (V, 2022)

4.VIDEO ASSESSMENT:

Video-based eye tracking and machine learning were utilised to create a simple, non-invasive test that detects Parkinson's disease and stages of cognitive failure. (Donald C Brien) Video assessments can also help evaluate patients in the absence of their regular dopaminergic medication, which is useful in the assessment process for treatments like deep brain stimulation (DBS) surgery, where a "off" and "on" medication assessment is required as standard practice. Avoiding the need to travel to a clinic or hospital while "off medication" can be much more pleasant for patients, minimise the amount of time they spend in a suboptimal state, and save money on transport costs and parking fees.

There have been several attempts to produce an automated grading of the disease severity utilising video records and Artificial Intelligence (AI)/Machine Learning approaches. This may help clinicians discover and diagnose diseases. Given the growing interest in using a) video-based/remote assessments to assess PD severity and b) AI-based PD rating, the purpose of this review is to discuss the major issues that must be addressed as part of the potential role of video assessment and analysis in future PD patient management, in the context of the growing use of Digital Health Technologies in PD. (Sibley KG, 2021 Jan 1)

5.HANDWRITING OF PATIENT:

Handwriting can be evaluated while assessing Parkinson's disease. Handwriting demonstrates cognitive planning, coordination, and execution abilities. To diagnose the disease and its severity, handwriting issues might be regarded an important component, and alterations in writing can be considered a significant biomarker. (Ranjan N, 2022 Mar)The Hand Parkinson's Disease dataset from Botucatu School of Medicine contains photographs from a handwriting evaluation, used for PD hand drawing analysis. Subjects complete forms with guided templates like circles and spirals, which are digitized for further analysis. Additionally, the PaHaW dataset, created by Drotár et al., collects dynamic handwriting data from 37 PD patients and 38 healthy controls using a Wacom Intuos tablet. The dataset includes eight pre-filled templates, with handwriting signals captured at 200 samples/ second, recording x- and y-coordinates, pen tip, and time stamps.In datasets like the Hand PD dataset, Parkinson's disease symptoms such as reduced movement amplitude, slow and rigid motions, and erratic changes in spiral shapes affect handwriting analysis. While templates aid in standardization, they can influence handwriting patterns, potentially leading to diagnostic errors. (Li Z, 2022 Jun 1)

6.FINGER TAPPING TECHNIQUE:

A new device, consisting of an accelerometer and a touch sensor, was created to determine objective parameters for the finger tapping (FT) test in Parkinson's disease (PD) patients. (Yokoe M, 2009 Jul 1) The finger-tapping (FT) test is an informative measure of upper-extremity motor skills that is used in the neurological assessment of Parkinson's disease patients. As a result, this study tested the motor abilities of Parkinson's disease patients utilising a computer-based method that measures FT performance. (BARUT BO, 2012 Dec 1)

VI. MANAGEMENT

1. *DIGITAL BIOMARKERS FOR SPEECH AND VOICE IMPAIRMENT:*

Voice dysfunction may be an early indicator of motor impairment in Parkinson's disease, according to new research (Darley FL, 1969 Jun) (Fagherazzi G, 2021 Apr 16) (Voice changes in Parkinson's disease: What are they telling us?. , 2020 Feb 1) . These symptoms, which include a decrease in prosody, phonological abnormalities, and articulation difficulties, are referred to as hypokinetic disartria. The majority of authors have thus far concentrated on using speech and voice data to identify PD in moderate to advanced stages of the illness (Fröhlich H, 2022 Feb 28) .Digital biomarkers (DMs) have been extracted as handcrafted features in previous research, such as repeated words or vowels. Either asking participants to read a text, analyzing their free speech, or having them do a more specialized task, like diadochokinetic (DDK) exercises, were the methods used to get this data (K, 2008 Apr 1) . The DDK tasks require the production of quick syllabic sequences with consonant-vowel combinations (/pa/-/ta/-/ka/, /ba/-/da/-/ga/, …).

2.*DIGITAL BIOMARKERS FOR HYPOMIMIA:*

People with Parkinson's disease (PD) often have hypomimia (reduced facial dynamics, sometimes called facial bradykinesia), which is a major clinical symptom and a secondary indicator of the disease in its early stages, in addition to voice and speech problems (Chade AR, 2006) (Bologna M, 2013 Jun 1) . The primary pathophysiology and clinical characteristics of face bradykinesia in Parkinson's disease are outlined by Bologna et al. Reduced emotive and spontaneous facial expressions are characteristics of facial bradykinesia in Parkinson's disease, according to clinical observations (Bologna M, 2013 Jun 1) . The primary mechanism underlying facial bradykinesia in Parkinson's disease (PD) is basal ganglia dysfunction, which results in abnormalities of spontaneous, emotional, and voluntary facial movements. Given the correlations between voice and face movement, the Lee Silverman Voice Treatment's (LSVT) ability to improve diminished facial expressivity was investigated (Dumer AI, 2014 Mar) .

3.DIGITAL BIOMARKERS FOR GAIT IMPAIRMENT:

In order to analyze the severity of Parkinson's disease, gait evaluation modalities include muscular activity, kinetic data (from force plates or pressure sensors), and kinematic data gait abnormalities that arise in other conditions, the majority of published research has focused on Parkinson's disease (Chen S, 2016 Sep 22). A substantial amount of studies has shown that there are systematic changes in characteristics such gait speed, stride length, cadence, and double support time (.Zanardi AP, 2021 Jan 12) .It has been proposed that gait metrics measured by wearable digital technology, such as inertial measurement units worn on body segments such the foot, pelvis, lower back, or wrist, could be utilized as digital biomarkers (Rehman RZ, 2020 Jan 22) .

4.HOME BASED TELEMEDICINE SYSTEMS:

The technique of diagnosing and treating a specific condition remotely through the use of communication equipment and artificial intelligence (AI) applications is known as home-based telemedicine. Three separate tiers make up the hierarchical tiered structure used by telemedicine systems: Specialty centers, city/district hospitals, and rural/remote centers.The device facilitates high-quality, real-time audio-video communication between patients at home and doctors, nurses, and sometimes a multidisciplinary team (Rehman RZ, 2020 Jan 22).The feasibility of telemedicine for levodopa-carbidopa intestinal gel (LCIG) home titration and optimization was examined in a study by Willows et al., which also evaluated nurse, doctor, and patient satisfaction (Willows T, 2017 Jan 1).technical incidents were documented and subjected to additional analysis in order to evaluate both technical viability and procedural constraints.

VII. CONCLUSION

AI is revolutionizing the approach to Parkinson's disease by enabling earlier and more accurate diagnosis, personalized and proactive symptom management, and faster, cost-effective research for potential treatments. Through advanced data analysis, wearable technology, and predictive models, AI empowers healthcare providers to tailor care more precisely, improving the quality of life for patients and providing insights into disease progression. As AI technology advances, it holds even greater potential to transform the field of neurology, making Parkinson's disease more manageable and potentially bringing us closer to a cure.

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