**MS insight:** An Intelligent Diagnostic Assistant Harnessing AI for Early Detection and Comprehensive Management of Multiple Sclerosis.

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**Abstract**

Detection and classification of diseases frequently relies on manual assessment by specialists across various medical fields. Consequently, the diagnostic process and monitoring of disease progression tend to be meticulous yet time-consuming. However, certain diseases, such as multiple sclerosis (MS), present formidable hurdles due to the imperative of timely diagnosis. Delayed detection of MS can lead to grave repercussions for patients, underscoring the need for innovative solutions to aid in early detection. The objective of this paper is to propose a mobile phone-based system designed to facilitate the early and accurate diagnosis of MS. Leveraging advancements in technology, our system aims to empower healthcare professionals, including newly graduated doctors, with tools to detect MS efficiently and reliably. By providing accessible and user-friendly diagnostic capabilities on a mobile platform, our system seeks to enhance the sensitivity and speed of MS diagnosis, thereby improving patient outcomes and quality of care. Through the integration of cutting-edge algorithms and medical knowledge, our proposed system represents a promising step towards addressing the diagnostic challenges associated with MS

# **Motivation and significance/Introduction**

# **1.1 The Problem**

Multiple sclerosis (MS) is a potentially disabling disease of the brain and spinal cord (central nervous system).

In MS, the immune system attacks the protective sheath (myelin) that covers nerve fibers and causes communication problems between your brain and the rest of your body. Eventually, the disease can cause permanent damage or deterioration of the nerve fibers.

Signs and symptoms of MS vary widely between patients and depend on the location and severity of nerve fiber damage in the central nervous system. Some people with severe MS may lose the ability to walk independently or ambulate at all. Other individuals may experience long periods of remission without any new symptoms depending on the type of MS they have.

Multiple sclerosis is an acquired inflammatory and neurodegenerative immuno-mediated disorder of the central nervous system, characterized by inflammation, demyelination and primary or secondary axonal degeneration. It clinically manifests with signs of multiple neurological dysfunctions (e.g. visual and sensory disturbances, limb weakness, gait problems and bladder and bowel symptoms) followed by recovery or by an increasing disability because of irreversible functional disability over time. However, more specific symptoms can be detected, such as fatigue, which is experienced by nearly 80% patients as interfering with their quality of life and productivity, regardless of the degree of disability and course status [1].

Immunoprophylactic therapies have not yet proven to be highly efficacious in modifying the disease course and are often associated with side effects further worsening patients’ quality of life and productivity. The disease shows heterogeneity with respect to its pathogenesis, clinical manifestations, prognosis and, most interestingly, with respect to its pathology. The etiology of MS is unknown. It is a complex multifactorial disorder, in which environmental factors are hypothesized to interact with genetically susceptible individuals. Pediatric MS and late-onset MS (i.e. clinical onset over the fifth decade) are rare.

Multiple sclerosis (MS) is the most common idiopathic inflammatory disease of the central nervous system [2]

The distinction between MS and other benign or fulminant inflammatory demyelinating disorders is based on quantitative, rather than qualitative, differences in chronicity and severity.

Primary progressive MS may differ from relapsing-remitting MS in MRI lesion frequency, immunogenetic profile, responsiveness to immunosuppressive treatment, and histology.

In 60% of patients, MS begins as a relapsing-remitting disease and evolves secondarily into a progressive neurological illness. Life expectancy is not substantially altered in patients with MS, particularly in the early years of the illness.

The rate of suicide has been reported to be increased sevenfold in MS patients. Up to 40% of patients with attacks severe enough to render them no ambulatory may not recover. At 15 years from MS onset, 50% of patients are disabled to the point at which they at least require a cane to walk a half block. Early age at onset, female sex, relapsing-remitting course at onset, and perhaps optic neuritis or sensory symptoms at onset and relatively few attacks in the first two years are associated with a favorable course.

Despite significant refinement in multiple sclerosis (MS) diagnosis in recent decades, no specific disease biomarker exists, as a result of which, confirming the diagnosis is not always a straightforward process. MS has heterogeneous clinical and imaging manifestations, which not only differ between patients, but also vary in individual patients over time [3].

Misdiagnosis remains a problem with significant clinical and psychosocial implications for both patients as well as health care providers. Although the problem of MS misdiagnosis is known, true incidence and prevalence is not.

One study conducted in four academic MS centers revealed over 50% of patients carried a misdiagnosis for at least 3 years, 70% had received disease-modifying therapy (DMTs), and 31% experienced unnecessary morbidity as a direct result.

A wide range of conditions can be mistaken for MS, including migraine, cerebral small vessel disease, fibromyalgia, functional neurological disorders, and neuromyelitis Optica spectrum disorders, along with uncommon inflammatory, infectious, and metabolic conditions.

Initial reports of MS misdiagnosis began at the end of the 1980s. Interestingly, if MRI had been available, diagnostic error would have been prevented in most cases. However, when MRI became widely used, overestimations of radiological findings started to be reported.

The problem of delayed diagnosis in Multiple Sclerosis (MS) is multifaceted, presenting significant challenges in the healthcare landscape. One key aspect is the complex nature of MS itself, characterized by a wide range of symptoms and varying progression among individuals. This complexity poses a challenge for healthcare professionals, particularly those less experienced in neurology, making early and accurate diagnosis a formidable task so MS diagnosis often involves a prolonged process, including multiple tests and consultations, leading to delays in initiating appropriate treatment.

Early symptom onset further complicates the diagnostic process, as symptoms may be subtle and overlap with conditions like Clinically Isolated Syndrome (CIS). Distinguishing between MS and CIS is crucial for timely and targeted interventions, yet the current diagnostic reliance on MRI imaging, while valuable, may not always provide a conclusive diagnosis, especially in the disease's early stages.

The limited availability of resources and tools for early MS diagnosis exacerbates the problem. The scarcity of effective diagnostic technologies, particularly those leveraging artificial intelligence, contributes to missed opportunities for early intervention and disease management. Additionally, accessibility to specialized healthcare, essential for accurate MS diagnosis, is constrained in certain geographic areas, impacting patients' ability to obtain timely and accurate diagnoses.

Educational and training gaps further hinder the diagnostic process. Less experienced healthcare professionals may lack the necessary knowledge to recognize the nuanced symptoms of MS, highlighting the need for comprehensive solutions that bridge these gaps and facilitate accurate diagnoses even among providers without extensive neurology experience.

Statistics on MS: It is estimated that there are approximately 2.8 million people worldwide living with multiple sclerosis.

The number of multiple sclerosis patients in Egypt has reached 60,000, one of the largest countries in the Middle East with several patients.

MS is commonly attributed to high familial risks, decreasing with relatedness, which indicates a large genetic component involved in the disease etiology. The relative risks estimated were lower than usually reported, with a sibling relative risk of 7.1 and no significant differences between the sexes. The heritability was estimated to be 64% and the environmental 36% with a non-significant shared environmental component of 1% [4].

MS is a disease more common in women than men, and an increase in the women-to-men ratio has been reported in several countries. However, a report from Sweden did not show this increase in women. An increase among women compared to men was identified, and when comparing against the previous study, an inclusion bias, presumably caused by a higher mortality rate among the oldest men, was identified.

## **The available tools and gaps found**

In the literature survey focused on Multiple Sclerosis (MS) solutions, the existing landscape primarily consists of applications that aim to support individuals living with MS. These applications commonly offer services such as tracking and managing MS symptoms and treatments, creating connections, and providing support within the MS community, and offering simple guidelines to improve the quality of life for those affected by the condition .

While these applications play a valuable role in supporting individuals already diagnosed with MS, the notable gap lies in the lack of solutions specifically designed for early diagnosis prediction using artificial intelligence (AI). The current solutions tend to focus on managing and alleviating symptoms rather than predicting or diagnosing the condition at its early stages.

The literature review highlights a need for innovative tools that can provide more proactive and predictive healthcare solutions, especially in the context of MS. By incorporating AI into the diagnostic process, there is an opportunity to revolutionize the way MS is identified, particularly during the early onset of symptoms. This shift could significantly impact the timeliness and accuracy of diagnoses, potentially leading to more effective interventions and improved outcomes for individuals with MS.

The absence of AI-driven diagnostic prediction tools in the current solutions emphasizes the potential for the proposed system, which aims to fill the identified gap by utilizing AI to assist in the early and accurate diagnosis of MS, thereby addressing a critical need in the healthcare sector.

## **Solution**

1- MS insight is a comprehensive, patient-focused app that offers an innovative approach to MS diagnosis and management.

2- It leverages advanced artificial intelligence and machine learning algorithms to provide accurate and efficient diagnosis results, providing them with treatment recommendations.

3- The diagnostic test results obtained through our app assist healthcare professionals in confirming their diagnosis

4- Our app provides a diagnosis within minutes, enabling early intervention and improved patient outcomes. It's a game-changer in the world of healthcare.

# **Related Work**

Initially ,MS diagnosis is complex because its signs and symptoms are widespread, having a similarity with the symptoms of other neurological diseases [5] . In the present study evaluate utility of machine learning

techniques to diagnosis MS and provide long-term predictions of the degree of disability in MS patients based on clinical data and RNFL thickness

measurements acquired by OCT [6]. Studies have shown that RNFL thickness, measured by OCT, is a useful parameter to distinguish MS patients from

healthy controls, Rothman et al. [7] evaluated the capability of OCT data to predict the disability status 10 years later in 172 MS patients, applying linear regression models . Garcia-Martin et al. [8] used an artificial neural network

(ANN) in combination with OCT data to diagnose MS. Zhao et al. [9] evaluated the utility of SVM and logistic regression to predict the progression of MS- associated disability using brain MRI data acquired over 5 years. Yperman et al. [10] analysed random forest and logistic regression to predict disability

progression after 2 years using EP time series. Arani et al. [11] used rule-

based, fuzzy logic (FL), and artificial neural network (ANN) to diagnosis MS. Seccia et al. [12] reviewed studies that used computer-aided diagnosis (CAD) using clinical data alone or in conjunction with other forms of data to build

prognostic models for MS . Ion-Margineanu et al. [13] utilized three classifiers, LDA, RF, and SVM with radial base function (SVM-RBF), to classify patients into one of the four MS subtypes. Ettema et al. [14] examined the effectiveness of an electronic nose (eNose) in detecting MS based on exhaled breath

analysis.Sharifmousavi and Borhani [15] provide a simple and efficient method for detection of MS using vitamin D3, vitamin B12, and selenium

levels. Similarly, Wang et al. [16] aimed to find a method of detecting the early phases of MS. They used 676 MRI slices holding plaques of 38 patients and 880 MRI scans of 34 healthy people. Wang et al[16] introduced a six-layer stochastic pooling CNN to detect MS with multiple-way data augmentation.

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