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# Intelo-Performanzo-Orthotics Performance Evaluation and Rehabilitation Device

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***Abstract*— Health issues due to post-accidents/ diseases are the prevailing problems faced in spite of technical development. Rehabilitation during post- disease involves a cyclical process with specialized training, incorporating a structured and purposeful repletion for improvement that are often constrained by the limited resources of healthcare centers.**

***This paper proposes an assistive orthotics device that meets the needs of patients suffering from partial paralysis and neuromuscular disorders, namely rheumatoid arthritis and myasthenia gravis, and provides an efficient, safer, wearable health monitoring system for updating and monitoring the health status of myopathic patients. The modules include a neuromuscular disorder detection system that diagnoses whether the patients suffer from a specific disorder for further treatment, and the performance improvements are updated to the application that serves as motivation to get rid of the present condition. The feature "telehealth monitoring" updates the results of the performance evaluation along with the detected disorders to the mobile application and is monitored by doctors to keep track of the health status. Recovery duration, basic exercises, and case severity are suggested by the recommendation system. Additionally, the paper proposes a design of a low-profile body-worn antenna with decreased SAR (Specific absorption Rate), ensuring reduced EM radiations. According to existing solutions, orthotic devices are currently used for monitoring general health parameters like ECG, EEG, and heart rate, but there is no specific solution that provides assistance for patients with neuromuscular disorders in getting rid of their disability. The purpose of our device is to evaluate and monitor patients both within and beyond clinical environment. It provides a comprehensive assessment of impairments and also holds potential for involvement in rehabilitation therapies. With the "Intelperformenzo," an orthotic device, patients with disorders are no longer dependent on others.***

***Keywords*— Neuromuscular disorders, Myopathy, Specific absorption rate, Rehabilitation, low-profile antenna.**

## I. INTRODUCTION

Since Rehabilitation during post-disease involves a cyclical process with specialized training, incorporating a structured and purposeful repletion for improvement that are often constrained by the limited resources of healthcare centers. Statistics of Indian Institute of Paralysis states that for every minute one person suffers from paralysis. In India, 90% of the affected people are unable to get proper treatment in time. Neuromuscular and neurodegenerative disorders causes severe damage to skeletal muscles and associated nerve cells of the human body, which may lead to fatal consequences like lifetime physical impairment. Neuromuscular disorders affect the nerves which helps in controlling voluntary muscles and also the nerves that contribute to communicating sensory information back to the brain. Myopathy is a type of neuromuscular disorder that causes muscle weakness due to the dysfunction of muscle fibers. When a neuron is affected, communication between the nervous system and muscles breaks down. Example of neurological disorder is Amyotrophic lateral sclerosis (ALS) which slowly affects the motor neurons. Hence, early detection of these neuromuscular disorders is crucial from a medical point of view[4]. Conventional treatment in intensive therapy is infeasible and expensive due to social and environmental factors. The main aim of our idea is to provide a feasible device for rehabilitation. Our device has the capability to monitor patients within and beyind clinical environments, thus creating a more detailed evaluation of the impairment and allowing the individualization of rehabilitation therapies. The main aim of our project is to provide an efficient, safer, wearable health monitoring system for updating and monitoring the health status of paralyzed patients.

## II. LITERATURE SURVEY

1. Finger Rehabilitation system and orthotic arm based on EMG (2018). Sharlyn Dee et al. This paper proposes a EMG based rehabilitation system of the orthotic arm that helps in extension as well as flexion of fingers and arm for paralyzed patients.[1]
2. EMG Signal Classification for Detecting Neuromuscular Disorders (2021) Tanvir Ahmed et al. This paper proposes a method on detection of neuromuscular disease using ANN by collecting EMG signals from biceps. It classifies the signal detected with neuromuscular disease from a healthy EMG signal . [2]
3. An AI based prediction of stroke using real time EMG signals Jaehak Yu et al. It proposes the

development of a stroke prediction system for pre-detection of stroke using ECG and EMG signal with Artificial Intelligence using Random Forest and Deep learning. [3]

4. Using Deep Feature Extraction from Cross Spectrum Images of EMG Signals to detect Neuromuscular disorders(2020). Sayanjit Singha Roy et al. This paper develops a framework for detection of Neuromuscular Disease by classifying EMG signals using cross-wavelet transform.Extraction of features is done by taking wavelet transforms .[4]
5. The significance of choosing the right muscles for EMG signal analysis during the rehabilitation of upper limb in stroke patients(2017). Costa et al. The suggested approach enables the identification of crucial muscles that play a significant role in specific movements, based on the power and frequency distribution observed in electromyographic signals.[5]
6. An assistive orthotic robotic arm with an electromyography (EMG) sensor that controls forearm movement (2017). Kiran George et al. This paper proposes designing an EMG-based approach for muscle rehabilitation that can help with finger and arm flexion and extension. It is made up of an orthotic arm and finger device that detects when the user tries to contract their forearm or bicep muscles, increasing the amplitude of the EMG signal. This allows the motors to assist with the flexion and extension of the arm and fingers. [6]
7. Using surface EMG signals to regulate the hand and forearm movements of an orthotic arm (2015) Yamik Mangukya et al. In this work, a robotic arm orthotic device that retrains flexion and extension movements of the forearm in stroke patients is proposed. Their own two- degree-of-freedom muscle signals assist them in doing this..[7]
8. Design and comparison of two types of antennas for SAR calculation in wireless applications(2018) Israa H. Ali et al. This paper proposes an idea on the reduction of SAR levels by comparing the SAR level produced in square patch and dipole antenna. It is also compared at three frequency bands according to ICNIRP and IEEE standards.[8]

## III. PROPOSED METHODOLOGY

The surface electromyographic signals (SEMG) are initially acquired using the Myoware sensor SEN-13723. The raw EMG signal is subjected to preprocessing:- amplification, filtration, and the elimination of artifacts. The amplified and filtered signals were processed using the Fast Fourier Transform (FFT) for the frequency domain transformation. Finally, the signal is rectified, and the features are extracted that are used as inputs to the following modules below.

### 3.1 Detection of Neuromuscular Disorders

Neuromuscular disorders (NMD) are diseases related to muscle weakness and it affects the muscular and neural function. Once the patient wears the orthotics device and performs physical activities, the device detects the presence of NMD if present for further treatment and early recovery.

Working process:

Features, namely RMS, Mean, and standard deviation, are extracted from the Healthy and Neuromuscular datasets and fed as inputs to the classifier. The NMD is confirmed whenever there is a deviation from the values in the Healthy dataset beyond the threshold value. On the contrary, it confirms the absence of NMD by evaluating the difference between the features of the user dataset and the healthy dataset, which is evaluated to be near zero.

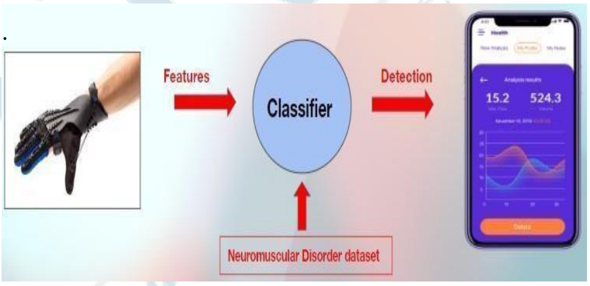


**Fig 1.** Detection of Neuromuscular Disease

### 3.2 Orthotics performance evaluation

The severity of the disorder and improvements in performance are assessed and displayed to users, who are monitored remotely by their doctors and physiotherapists. This module motivates the user with the improvements in performance, making them aware of their present condition, recovery duration, and severity level.

Working process:

Features, namely RMS, mean, and standard deviation extracted from the Healthy and Myopathic datasets are fed as inputs to the classifier. The extracted feature values is fed as input to the classifier, which compares the deviation between the two values and returns the performance of the orthotics device as an output. The improvement in performance can be monitored with this feature, and the time required for recovery can be observed.

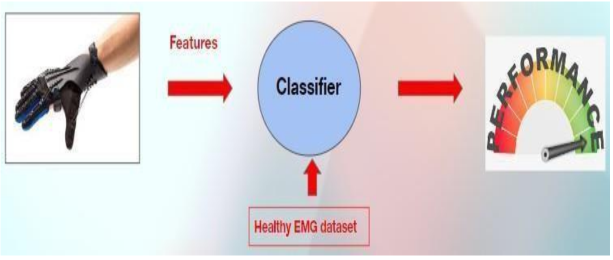


**Fig 2.** Orthotics Performance Evaluation

### 3.3 Tele-health monitoring and Recommendation system

The evaluated results are transmitted to the software application using wireless communication. Antenna with reduced SAR (Specific Absorption Rate) value that is intended for wearable devices is designed for bluetooth communication at the frequency of 3.5 GHz in Ansys HFSS Software[8].The health status and evaluated results are updated to the application, which can be monitored by the respective doctors. Additionally ,depending on the improvements in performance, the doctors may suggest specific exercises and basic exercises with recovery duration are suggested by the recommendation system

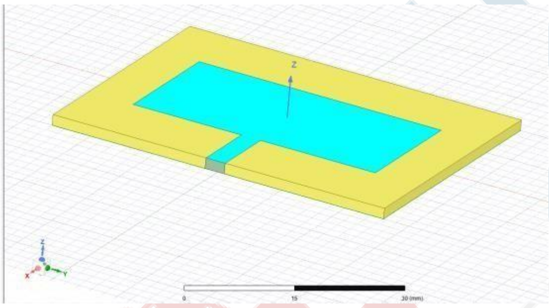

**Fig 3.** Simulation - Microstrip patch antenna in Edge feed

## IV. EXPERIMENTAL RESULTS AND ANALYSIS

This section represents the experimental results of the proposed work. The electromyography (EMG) dataset of healthy and myopathic samples from Physionet[10] is processed using MATLAB. The raw EMG signal from Fig. 4 is processed, and artifacts are removed using bandpass and lowpass filters, as shown in Fig 5. Various parameters of the EMG signal, namely the power spectral density and Fourier coefficient, are calculated and plotted in Fig 6,7. Fig.9 shows the analysis of healthy vs. myopathic EMG signals. The features, namely Root Mean square(RMS), Mean, and

Standard deviation, are extracted and used as inputs to the classifiers built using the random forest Algorithm. The results of the extracted features are shown in Fig.8. The fig

11 shows the VSWR plot where the point falls at 1.14 exactly between 1 and 2. The S parameter plot in Fig. 10 verifies that the antenna operates at 3.5 GHz with more than 25 dB of impedance. Finally, the gain plot in Fig. 12 shows the gain of the designed low-profile antenna.

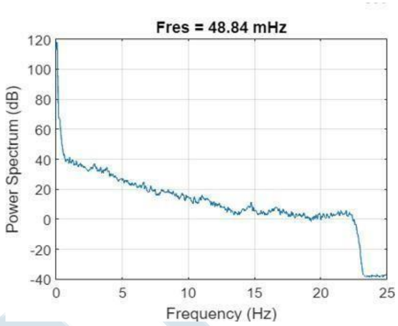


**Fig 4.** Raw emg signal po

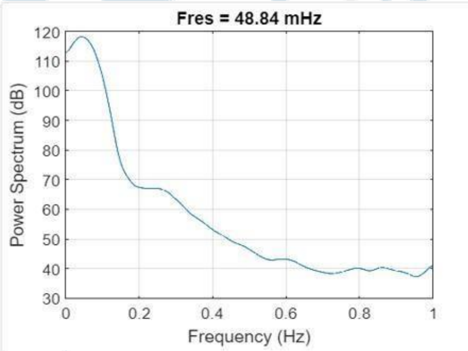


**Fig 5.** Elimination of Artifacts(Noise)

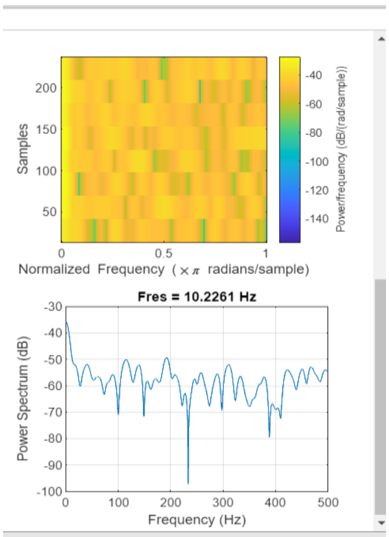


**Fig 6.** Power spectrum

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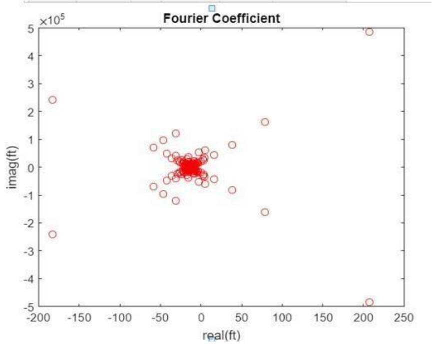


**Fig 7.** Fourier transform

```
Command Window
New to MATLAB? See resources for Getting Started.
>> disp("RMS of Healthy EMG - "+RMS);
RMS of Healthy EMG - 7.3411
>> disp("Mean of Healthy EMG - "+MEAN);
Mean of Healthy EMG - 6.3576
>> disp("Std Deviation of Healthy EMG - "+STD_D);
Std Deviation of Healthy EMG - 3.6705
>> disp("RMS of Myopathic EMG - "+RMS_myo);
RMS of Myopathic EMG - 15.9364
>> disp("Mean of Myopathic EMG - "+MEAN_myo);
Mean of Myopathic EMG - 13.7998
>> disp("Std devaition of Myopathic EMG - "+STD_D_myo);
Std devaition of Myopathic EMG - 7.9709
```

**Fig 8.** Extracted features- RMS, Meam,STD

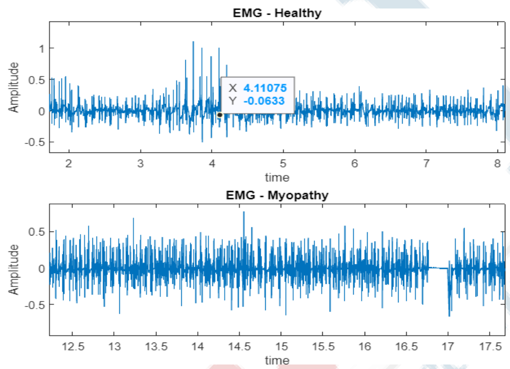


**Fig 9.** EMG - Healthy vs Myopathic

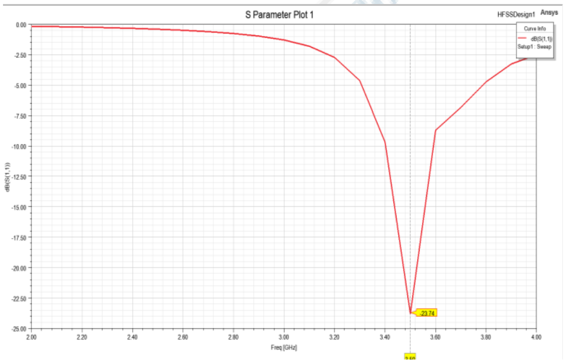


**Fig 10.** S parameter plot - 3.5 GHz

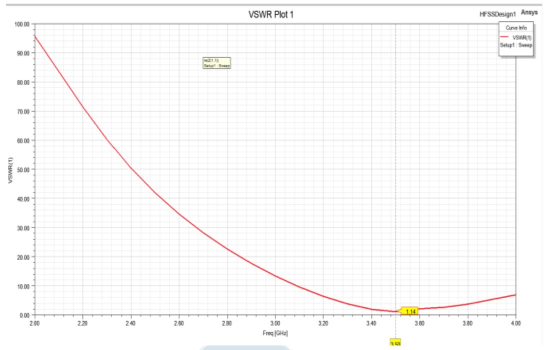


**Fig 11.** VSWR plot (1.14)

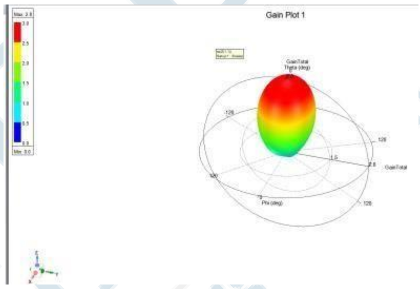


**Fig 12.** Gain plot (dB)

| | | |
|---|---|---|
| 1 | Substrate | Teflon (2.1) |
| 2 | Substrate width | 40 |
| 3 | Substrate length | 52 |
| 4 | Substrate height | 1.6 |
| 5 | Patch width | 19.3 |
| 6 | Patch length | 38 |
| 7 | Feedline length | 13 |
| 8 | Feedline width | 3 |

**Fig 13.** Antenna design specifications

## V. CONCLUSION AND FUTURE SCOPE

This paper proposes a safe, efficient, and lightweight health monitoring-smart orthotic device that enables patients to regain their independence in movement, making them self-standing and self-sufficient**.** Our proposed system comprises four features: neuromuscular disorder detection,

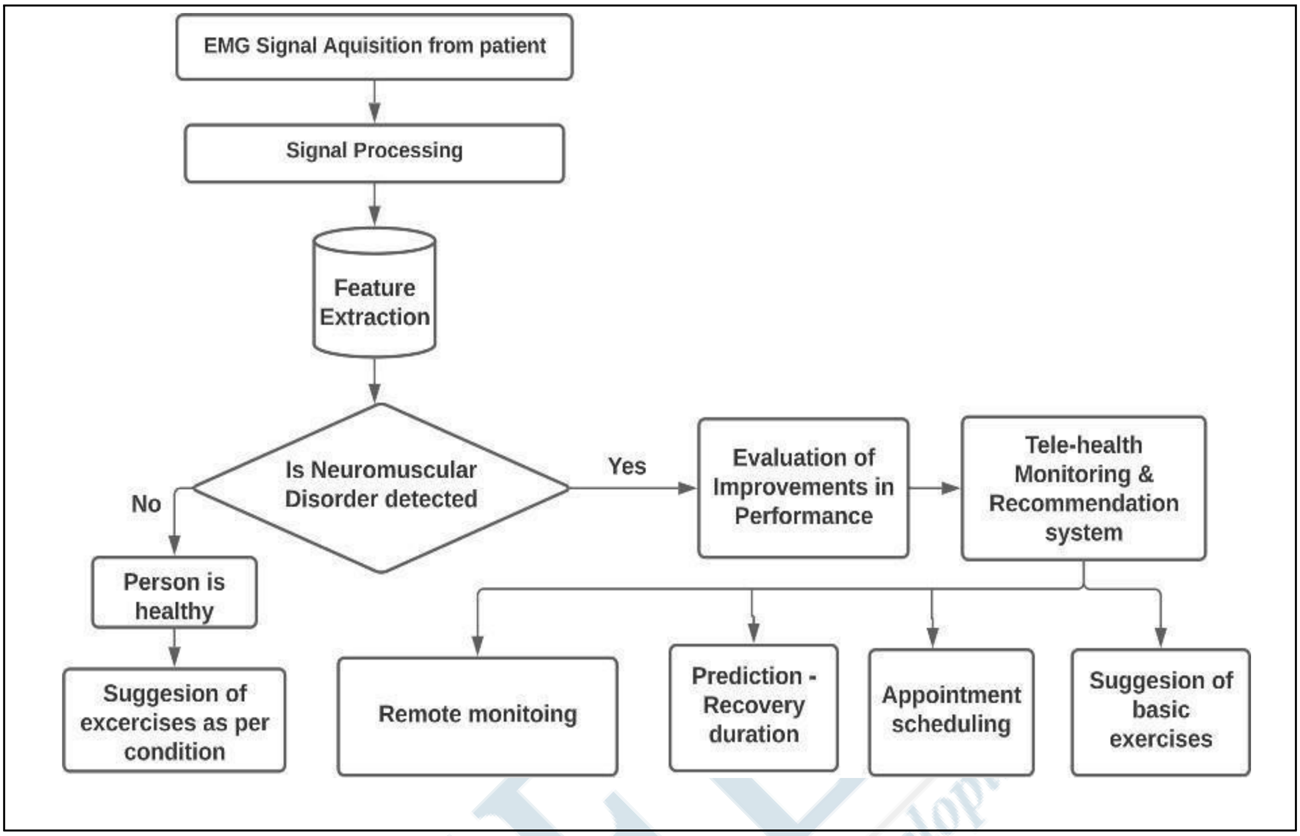


**Fig 14.** Flowchart

orthotic performance evaluation, telehealth monitoring, and a recommendation system. Early diagnosis of NMDs is an added advantage so that treatment can be planned accordingly. The results of the performance evaluation and the statistics are uploaded to a software application. Hence, this feature helps doctors and physiotherapists track the patient's improvements. This reduces the dependence on rehabilitation centers and physiotherapists, as there is an evaluation of the patient's improvements that acts as motivation to get rid of the disability. In response to the results obtained, recommendations for mild exercise, food intake, recovery duration, appointment scheduling, and severity level are notified through the application. Additionally, this wearable device offers a low-profile antenna with a reduced SAR rate, resulting in less radiation. This device not only evaluates performance but is also a ray of hope for a speedy recovery for a community of people. Our future plans include medicine intake reminders, exercise suggestions, urinary incontinence detection, correction of movement and posture disorders, and rehabilitation of muscular dystrophy.

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