شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

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جامعة عين شمس

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قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
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HANAA ALY

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Computer and Systems Engineering Department

Extraction of Electrical Markers for Motor Neuron Disease using Machine Learning Methods

A Thesis submitted in partial fulfillment of the requirements of the degree of
Master of Science in Electrical Engineering
(Computer and Systems Engineering)

By

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Bachelor of Science in Electrical Engineering
(Computer and Systems Engineering)
Faculty of Engineering, Ain Shams University, 2016

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Cairo - 2021

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Date: 21 October 2020

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Amr Yassin Tayea Abdelaal

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Date: 21 October 2020

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Abstract

Motor Neuron Diseases (MNDs) represent a group of fatal neurodegenerative disease that attack the nervous system's motor neurons (MNs). One member of the MNDs' family is Amyotrophic Lateral Sclerosis (ALS) which causes gradual muscle weakness, leading to death, with an average life expectancy 2-5 years from diagnosis. Experimentally, abnormalities were found in spinal MN electrical behavioral long before clinical symptoms manifestation, sparking the idea of developing an approach that could recognize irregular patterns in MN firing with the goal of early ALS diagnosis.

In this thesis, we propose a machine learning approach to discriminate between ALS and normal MN firing, by analyzing MN spiking trains. This approach was tested on two datasets: a simulated dataset generated from a high-fidelity computational model of spinal MNs under normal and ALS conditions, and an experimental dataset recorded from normal and ALS transgenic mice. Our analysis depended on extracting three electrophysiological markers: namely, spiking latency, spike-triggered average signal, and inter-spike interval histogram. Moreover, we developed an approach to infer MN connectivity graphs as another marker. We developed a classification approach that uses the extracted markers as input. Our results demonstrate the ability of our approaches to detect ALS firing from the normal MN firing by reaching classification accuracies of ~99% on simulated data and ~81% on experimental data. These results indicate the utility of using machine learning techniques for the ALS diagnosis from MN activity.

Thesis Summary

Two analysis approaches were performed on simulated and experimental animal data based on the analysis of motoneuron spike train data to recognize the firing activity of ALS disease. In the simulated data, spiking latency, spike-triggered average signal, and inter-spike interval histogram were extracted and classified using a machine learning approach. Moreover, MN connectivity was investigated using a statistical-based method. The results achieved accuracies of ~99% using both extracted features and MN connectivity, showing a premise to be suggested as markers for ALS cellular changes. In the experimental data, a classification approach was proposed, based on the classical method of spike generation and features from the simulated datasets. Additionally, the spike generation method was modified to design a new method of classification. The results obtained achieved accuracies of ~81%. demonstrating the feasibility of discriminating between ALS and control experimental data of ALS progression.

The thesis is organized as follows: Chapter 1 gives an introduction to our research and presents the main research contributions. Chapter 2 discusses the theoretical foundations related to the thesis. Chapter 3 illustrates the analysis methods and results on the simulated datasets, highlighting the extracted markers and the classification results, in addition to analyzing the connectivity between motoneurons. Chapter 4 demonstrates our analysis approach applied to experimental data recoded from mice, presenting the classification accuracy obtained using the proposed approach that utilizes a novel method of spike generation. Chapter 5 concludes the thesis and discusses potential future work.

Keywords: ALS, MND, Neurological Disorder, Machine Learning, Computational Neuroscience, Spike Trains Analysis.

Publications List

A. Y. Abdelaal, M. H. Mousa, M. Gamal, M. I. Khalil, S. M. Elbasiouny, and S. Eldawlatly, “A Classification Approach to Recognize the Firing of Spinal Motoneurons in Amyotrophic Lateral Sclerosis,” Proc. of the 42nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2020), pp. 3680 – 3683, 2020. doi: 10.1109/EMBC44109.2020.9176551. PMID: 33018799.