AIN SHAMS UNIVERSITY
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Information Science
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DEVELOPING A HYBRID INTELLIGENT TECHNIQUE FOR MOBILE HEALTH APPLICATIONS

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Abstract

Mobile Health in remote medical systems has opened up new opportunities in healthcare systems. It is a steadily growing field in telemedicine and it combines recent developments in artificial intelligence and cloud computing with telemedicine applications.

However, today's Mobile Health research still missing an intelligent remote engine for neuromuscular disorders diagnosis. Moreover, Remote patient monitoring and emergency cases need an intelligent algorithms to alert with better diagnostic decisions and fast response to patient care.

Many neuromuscular disorders that affect the nerves and muscles are hereditary and may cause death. Electromyography (EMG) is the most widely adopted clinical tool used to record and analyze myoelectric signals. EMG detects muscle response during different actions and gives useful identification of the neuromuscular disorders. Early diagnosis of these disorders through EMG signal processing and classification is necessary to help in finding out the best method of treatment of these disorders.

This thesis involves the design of a new hybrid neuromuscular disorders diagnosis system for mobile health applications based on support vector machine and artificial neural networks.

Given a collection of EMG data for normal subjects and Myopathy and Amyotrophic lateral sclerosis (ALS) patients, in this thesis a subset of these objects was used to build the classifiers and compare them to decide which classifier provides the best performance in terms of classification accuracy.

The most important step is to extract appropriate features from the EMG signals. At first the EMG signals were analyzed using discrete wavelet transform and then statistical features like root mean square, mean absolute value, zero crossing, slope sign change and standard deviation were calculated from the processed signal and used as inputs to the both classifiers.

A comparison was made between support vector machine classifiers accuracies with each feature to select the highest accuracy classifier. It was found that support vector machine classifier with radial basis kernel function achieved the best accuracy in classifying amyotrophic lateral sclerosis disorder using root mean square feature with accuracy of 98%.

Another comparison was made between artificial neural network classifiers with the same features. This comparison led to building artificial neural network classifier with 9 hidden neurons using combined five features as inputs to classify myopathy disorder with accuracy of 86.6%.

In this thesis, a mobile health application for ALS neuromuscular disorder diagnosis was developed. The application enables the patient to review his EMG signal. It also notifies the patient and his physician that the application has detected ALS disorder for that patient. The application enables the physician to send recommendations to the patient.

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List of Abbreviations

ALS: Amyotrophic lateral sclerosis

ANN: Artificial Neural Network

AR: Autoregressive

BCU: Body Control Unit

BP: Back Propagation Algorithm

BPNN: Back Propagation Neural Network

CWT: Continuous Wavelet Transform

DTS: Direct Transmission System

DWT: Discrete Wavelet Transform

ECG: Electrocardiography

ELM: Extreme Learning Machine

EMG: Electromyography

FFT: Fast Fourier Transform

FL: Fuzzy Logic

GA: Genetic Algorithm

HCI: Human Computer Interface

HMM: Hidden Markov Model

HOS: Higher Order Statistics

IEMG: Integrated EMG

KNN: K-Nearest Neighborhood

LDA: Linear Discriminate Analysis

LHMM: Layered HMM

LM: Levenberg-Marquardt

LR: Logistic Regression

m-Health: Mobile Health

MAV: Mean Absolute Value

MAVSLP: Mean Absolute Value Slop

MDF: Median Frequency

MLP: Multilayered Perceptron Neural Network

MNF: Mean Frequency

MODWT: Maximal Overlap Discrete Wavelet Transform

MSE: Mean Square Error

MU: Motor Unit

MUAP: Motor Unit Action Potential

MUP: Motor Unit Potential

MUPT: Motor Unit Potential Train

MYO: Myopathy

NN: Neural Network

NOR: Normal

NWPEs: Normalized Wavelet Packets Energies

PCA: Principle Component Analysis

PNN: Probabilistic Neural Network

PSO: Particle Swarm Optimization

QPC: Quadratic Phase Coupling

RBF: Radial Basis Kernel Function

RMS: Root Mean Square

SCG: Scaled Conjugate Gradient Algorithm

SD: Standard Deviation

SEMG: Surface EMG

SMA: Spectral Magnitude Averages

SMLR: Sparse Multinominal Logistic Regression

SNR: Signal to Noise Ratio

SSC: Slope Sign Change

SSI: Simple Square-Integral

STFT: Short-Time Fourier Transform

SVM: Support Vector Machine

TB: Tuberculosis

UEMG: Uterine EMG

VAR: Variance

WAMP: Willison Amplitude

WBAN: Wireless Body Area Network

WF: Wavelet Basis Function

WL: Waveform Length

WNN: Wavelet Neural Network

WPT: Wavelet Packet Transform

WT: Wavelet Transform

ZC: Zero Crossing

Chapter 1

Introduction

Mobile Health (m-Health) application is the integration of mobile computing and health monitoring which is considered as one of the main application areas for pervasive computing. Mobile health is the application of mobile computing technologies for improving communication among patients, physicians, and other health care workers. One of the main goals of using mobile technology in the health sector is to improve the quality of and access to care through treatment support, patient tracking and emergency services. So that, during emergencies, people in affected areas can use m-Health applications to report urgent health needs. Mobile health applications can also help patients manage their treatments when attention from health workers is costly, unavailable, or difficult to obtain regularly. Many m-Health applications have been developed and widely used by health professionals and patients and they played a very important rule in real-time assistive medical diagnosis. The use of those applications is getting more attention in healthcare day by day [1]. An example of such m-Health application was designed for monitoring the body's internal signals for the changes in a user's health that are life-threatening.

1.1 Motivation for the research:

Neuromuscular disorders term refers to all diseases that affect nerves and muscles. Patients with neuromuscular diseases may suffer from increased or decreased tone, loss of muscle bulk, weakness, muscle twitching, cramping, numbness and tingling, and a host of other symptoms. These diseases can also cause difficulty with swallowing and sometimes with breathing [2]. Neuromuscular disorders have six categories: Muscular Dystrophies (MD), Inflammatory Myopathies, Motor Neuron Diseases, Neuromuscular Junction Diseases, Peripheral Nerve Diseases, and other Myopathies [3].

AmyotrophicLateral Sclerosis (ALS, also called Lou Gehrig's disease) is one of motor neuron diseases. ALS is a progressive neurodegenerative disease that affects nerve cells in the brain and the spinal cord. The hallmark of this disease is the selective death of motor neurons in the brain and spinal cord, leading to paralysis of voluntary muscles. Patients with ALS may suffer from muscle weakness, especially involving the arms and legs, speech, swallowing or breathing. Patients in the later stages of the disease may become totally paralyzed [4]. Currently, there are approximately 25,000 patients with ALS in the USA, with a median age of onset of 55 years [5]. On the other hand, one of the most common musculoskeletal diseases is myopathy which causes the weakness of the muscles. Muscle cramps, tautness and spasm are also associated with myopathy. One of the possible ways to investigate the indispensable features of the ALS and myopathy diseases independently in individuals is to analyze the electromyography (EMG) signals that are basically electrical signals originated from the muscles [26].

EMG is a clinical investigation which records and analyzes myoelectric signals [6]. It detects the electrical activity associated with muscle contraction and forms a valuable neurophysiological test for the assessment of neuromuscular disorders [13]. It is the most widely adopted clinical tool in diagnosis of Neuropathy, Muscle Diseases and Motor Neuron Disease. It is a very useful tool for neurology and physical medicine and rehabilitation specialists as it plays a major role in physiological investigations and clinical examinations for either the study of motor control or the diagnosis of neuromuscular disorders like ALS [7]. EMG signal based research is ongoing for the development of simple, robust, user friendly, efficient interfacing devices/systems for the disabled. The advancement can be observed in the area of robotic devices, prosthesis limb, exoskeleton, wearable computer, I/O for virtual reality games and physical exercise equipments [16].

Early detection and diagnosis of neuromuscular disorders by clinical examination and laboratory tests is essential for their management through prenatal diagnosis