Ministry of Education of Republic of Moldova
Technical University of Moldova
Master's program „Biomedical Engineering"

Co-funded by the Tempus Programme of the European Union

With the support of the project TEMPUS. Biomedical Engineering Education Tempus Initiative in Eastern Neighboring Area (BME-ENA)

BME ENA

Admitted to defending
Chief of department MIB:
prof.univ.dr. Şontea Victor

„16" 01 2018

ELECTROMIOGRAFIC DEVICE FOR REHABILITATION

Master thesis

Student :________________(Gabriel Sarivan)

Supervisor: ________________ (Iavorschi Anatolie)

Chisinau – 2018

ANNOTATION (ENGLISH)

At the master's thesis "Electromyographic device for rehabilitation"

This thesis consists of the list of figures, introduction, three chapters, conclusions, bibliography which consists of 90 titles, 86 basic pages including 61 figures.

Key words: Muscles, atrophy, rehabilitation, EMG, patients, EMG sensor, analysis of EMG signal, virtual keyboard.

Research domain is constituted by the theoretical and practical aspects of collecting of the electromyographic signal as well as methods of interactive rehabilitation.

Thesis scope is constituted in the elaboration of the prototype of an electromyographic device for rehabilitation which will help patients in rehabilitation after different muscular traumas allowing in the same time to monitor the rehabilitation progress.

Methodology of scientific research is based on research of methods to obtain and process the electromyographic signal.

Scientific novelty and originality of results consists in the elaboration of a prototype of a device which combines two important functions monitor of muscular activity in the time of the process of rehabilitation as well as interactivity and motivation of patients to practice rehabilitation exercises after some traumas. The device is composed from several modules. The module for acquisition of the EMG signal transmits the signal to the processing module which transforms the analog signal into a digital one and sends it to the computer for further visualization. The sensor module collects the EMG signal, transforms it by special methods so this sensor could next act as an input to a virtual keyboard.

The theoretical signification is constituted by elaboration of methods of research and analyzing of EMG signal. The first chapter includes the theoretical analysis of the structure and electrical activity as well as methods to study this activity. The second chapter includes methods of elaboration of the device. The third chapter includes the obtained results and the results of simulations / testing.

Practical value of the thesis is constituted by the building of a prototype of the electromyographic device for rehabilitation which participate at the rehabilitation of the muscular activity of the patient and monitoring of rehabilitation progress after the therapy.

ANNOTATION (ROMANIAN)

La teza de master cu tema “Dispozitiv electromiografic pentru reabilitare”

Teza cuprinde lista figurilor, introducerea, trei capitole, concluzii, bibliografia din 90 de titluri, 86 de pagini de baza inclusiv 61 de figuri.

Cuvinte cheie: Muș chi, atrofie, reabilitare, EMG, pacienț i, senzor EMG, prelucrarea semnalului EMG, tastatura virtuala.

Domeniul de cercetare il constituie aspectele teoretice si practice al culegerii semnalului electromiografic precum si metode interactive de reabilitare

Scopul lucrării consta in elaborarea prototipului unui dispozitiv electromiografic pentru reabilitare, care va ajuta la reabilitarea pacienț ilor in urma traumelor musculare, permiț ând urmărirea progresului reabilitational.

Metodologia cercetării ş tiinţ ifice se bazează pe cercetarea metodologiei de obț inere si prelucrare a semnalului electromiografic

Noutatea şi originalitatea ş tiinţ ifica a rezultatelor consta in elaborarea unui prototip al unui dispozitiv care combina doua funcț ii importante – monitorizarea activităț ii musculare in timpul procesului de reabilitare si interactivitatea si motivarea pacientului sa practice exerciț ii de reabilitare după un oarecare traumatism. Dispozitivul propriu zis consta din mai multe module. Modulul de achiziț ionare a semnalului EMG care achiziț ionează semnalul, il transmite modulului de prelucrare a semnalului unde semnalul analogic devine digital si este transmis in continuare la calculator pentru vizualizare. Modulul senzor care achiziț ionează semnalul EMG si il prelucrează după metode speciale pentru ca apoi acest senzor sa poată fi utilizat ca dispozitiv de acț ionare intr-o tastatura virtuala bazata pe un microprocesor.

Semnificația teoretică o constituie elaborarea metodelor de cercetare si prelucrare a semnalului EMG . Primul capitol cuprinde cercetarea teoretica al structurii si activităț ii musculare, si al metodelor de studiere a acesteia. Al doilea capitol cuprinde metodologia elaborării dispozitivului. Al treilea capitol cuprinde rezultatele obț inute si rezultatele simulării / testării.

Valoarea aplicativă a lucrării consta in construirea unui prototip al dispozitivului electromiografic pentru reabilitare care participa nemijlocit la reabilitarea activităț ii musculare al pacientului si monitorizare progresului in urma exerciț iilor de reabilitare.

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INTRODUCTION

Electromyography (EMG) is the subject which deals with the detection, analysis and utilization of electrical signals emanating from skeletal muscles. The field of electromyography is studied in Biomedical Engineering. And prosthesis using electromyography is achieved under Biomechatronics [1]. The electric signal produced during muscle activation, known as the myoelectric signal, is produced from small electrical currents generated by the exchange of ions across the muscle membranes and detected with the help of electrodes. Electromyography is used to evaluate and record the electrical activity produced by muscles of a human body. The instrument from which we obtain the EMG signal is known as electromyograph and the resultant record obtained is known as electromyogram [2].

The human body is a wonder of nature. The functioning of human body is an intriguing and fascinating activity. Motion of the human body is a perfect integration of the brain, nervous system and muscles. It is altogether a well-organized effort of the brain with 28 major muscles to control the trunk and limb joints to produce forces needed to counter gravity and propel the body forward with minimum amount of energy expenditure [3]. The movement of the human body is possible through muscles in coordination with the brain. Whenever the muscles of the body are to be recruited for a certain activity, the brain sends excitation signals through the Central Nervous System (CNS). Muscles are innervated in groups called ‘Motor Units’. A motor unit is the junction point where the motor neuron and the muscle fibers meet. A depiction of the Motor Unit is given in Figure 1. When the motor unit is activated, it produces a ‘Motor Unit Action Potential’ (MUAP) [4]. The activation from the Central Nervous System is repeated continuously for as long as the muscle is required to generate force. This continued activation produces motor unit action potential trains. The trains from concurrently active motor units superimpose to produce the resultant EMG signal. A group of muscles are involved in a certain movement of the human body. The number of muscles recruited depends upon the activity in which the body is involved. E.g. in lifting a small weight such as a tiny pebble, fewer amount of muscles will be involved as compared to lifting a heavy mass like a 6 kg weight, where the muscles employed will be greater. In technical terms, whenever it is required to generate greater force, the excitation from the Central Nervous System increases, more motor units are activated and the firing rate of all the motor units increase resulting in high EMG signal amplitudes [4,5].

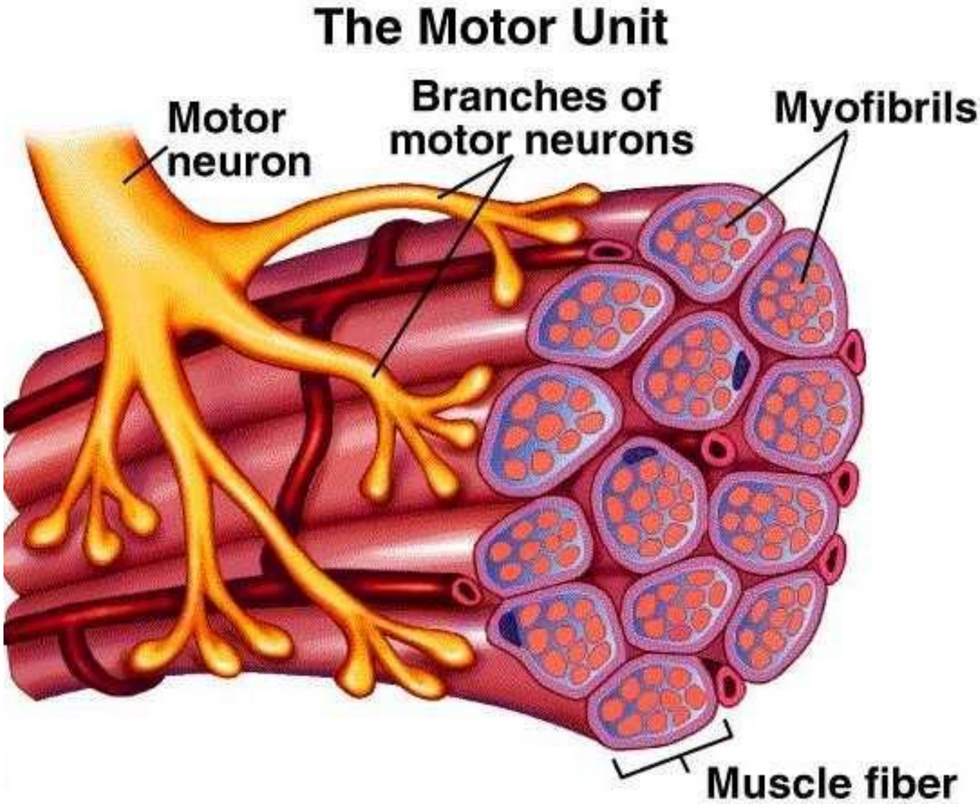

Figure 1: A Motor Unit consists of one motor neuron and all the muscle fibers it stimulates [6]

Electromyography enables us to generate force, create movements and allow us to do countless other functions through which we can interact with the world around us. The electromyograph is a bioelectric signal which has, over the years, developed a vast range of applications. Clinically, electromyography is being used as diagnostic tool for neurological disorders. It is frequently being used for assessment of patients with neuromuscular diseases, low back pain and disorders of motor control [7]. Other than physiological and biomechanical research, EMG has been developed as an evaluation tool in applied research, physiotherapy, rehabilitation, sports medicine and training, biofeedback and ergonomics research.

In the recent past, EMG has also found its use in rehabilitation of patients with amputations in the form of robotic prosthesis. EMG proves to be a valuable tool as it provides a natural way of sensing and classifying different movements of the body. A multi-degree of freedom robotic mechanism can effectively imitate the motion of the human limb. Recent advances in electronics and microcontroller technology have allowed improved control options for robotic mechanisms. One of the most vital advantages of microprocessor technology in robotic prosthetics is the advanced EMG filtering algorithms. Nowadays, control options are even available to those who were not at one time qualified for such prosthetic management.

Unfortunately, people are affected by traumas of different types. It could be a bone fracture or muscle one. The bone fracture is a medical condition in which there is damage in the continuity of the bone. It may be the result of high force impact or stress, or a minimal trauma injury as a result of certain medical conditions that weaken the bones, such as osteoporosis, bone cancer, or osteogenesis imperfecta, where the fracture is then properly termed a pathologic fracture. [8]

Since bone healing is a natural process that will occur most often, fracture treatment aims to ensure the best possible function of the injured part after healing. Bone fractures typically are treated by restoring the fractured pieces of bone to their natural positions (if necessary), and maintaining those positions while the bone heals. Often, aligning the bone, called reduction, in good position and verifying the improved alignment with an X-ray is all that is needed. This process is extremely painful without anesthesia, about as painful as breaking the bone itself. To this end, a fractured limb usually is immobilized with a plaster or fiberglass cast or splint that holds the bones in position and immobilizes the joints above and below the fracture. When the initial post-fracture edema or swelling goes down, the fracture may be placed in a removable brace or orthosis. If being treated with surgery, surgical nails, screws, plates, and wires are used to hold the fractured bone together more directly. Occasionally smaller bones, such as phalanges of the toes and fingers, may be treated without the cast, by buddy wrapping them, which serves a similar function to making a cast. By allowing only limited movement, fixation helps preserve anatomical alignment while enabling callus formation, toward the target of achieving union. Splinting results in the same outcome as casting in children who have a distal radius fracture with little shifting. [9]

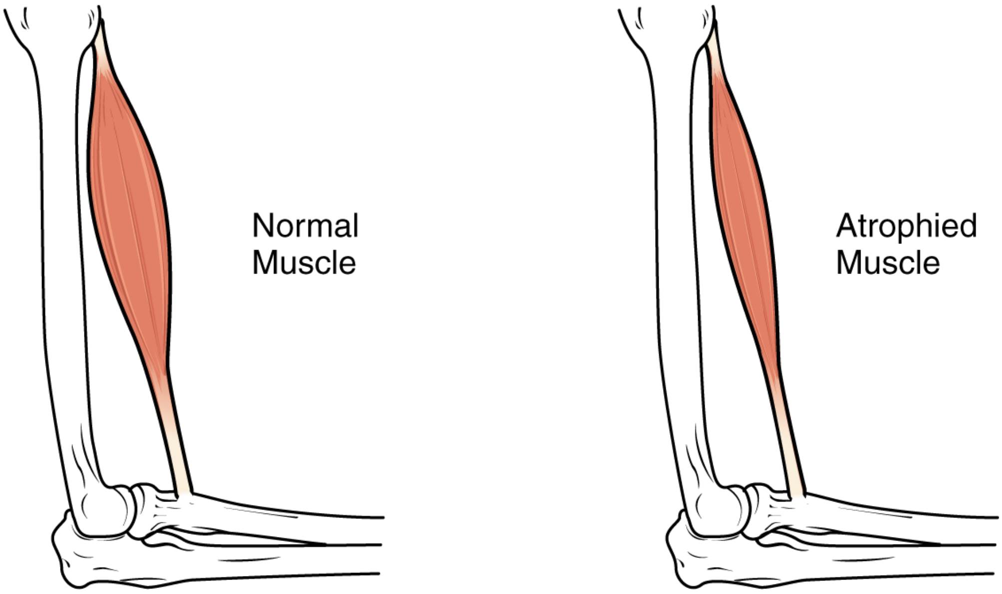

Figure 2: Comparison between normal and atrophied muscle [10]

All the healing needs time. However even after the healing process is over, the danger has not passed. One of the biggest problems is the fact that while being immobilized, the muscle starts to atrophy. So it is important to make a rehabilitation process by making different exercises. The adults understand the importance of it, but children don't. It is hard to motivate them to do something they might consider boring. In my master's thesis, I am proposing a solution for it. Children like to play, to have fun and so on. So to solve this problem, I decided to make a device that will help children in rehabilitation after bone fractures in an interactive and funny way. All children love to play games and with the technological advancement, they love playing computer games. In my thesis, I am proposing a device that will act as an USB keyboard. The contractions of a specific muscle will send an impulse to the microcontroller. When the impulse is high enough, the microcontroller will give the command to the computer as if a taste would be pressed. Following this, the patient will be able to play a computer game by contracting muscles. Within this paper I am planning to make a prototype of the device with only one sensor and action device, however it would be possible to extend the abilities of the device by adding more sensors and using the rehabilitation therapy for multiple muscles at once.

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