AALBORG UNIVERSITET
STUDENTERRAPPORT

System til facilitering af motivation hos KOL-patienter

P6 Bachelorprojekt - Foråret 2017

Gruppe 17gr6407

Abstract

Chronic obstructive pulmonary disease (COPD) is among the leading causes of death worldwide and patients suffering from the disease slowly deteriorate as it progresses. Studies have shown that physical exercise is beneficial to patients suffering from COPD, however some patients are unable or unwilling to leave their homes in order to exercise. This project aims to answer the question of how to motivate COPD patients to exercise and thus improving their general state of health. As an answer to this question a system has been developed which can motivate COPD patients to exercise from home, while still allowing healthcare personnel to monitor their activity. The system is developed mainly using object-oriented programming and the development process is described using unified modeling language. The system is split into three main components; a hardwaremodule for measuring the crankarms revolutions on an exercise bike, a front-end application that displays distance and other information about the training session, and a back-end system with a database and a user interface for healthcare personnel to monitor the patients activiy.

Forord

Dette projekt er udarbejdet af gruppe 6407, i forbindelse med 6. semester af sundhedsteknologiuddannelsen på Aalborg Universitet. Projektet er udarbejdet fra 1. februar til den 30. maj 2017. Rapporten er udarbejdet med udgangspunkt i en problemstilling, som søges løst igennem udvikling af et system ved brug af objektorienteret programmering, for at opfylde semesterbeskrivelsens tema "Design af sundhedsteknologiske systemer".

Projektet omhandler udviklingen af en træningsapplikation til patienter med Kronisk Obstruktiv Lungesygdom (KOL), og designes med henblik på at forøge patienternes aktivitetsniveau, for derved at øge livskvaliteten. Dette gøres eftersom KOL-patienter har mulighed for at forøge deres funktionsevne ved daglig træning, da aktiviteten resulterer i færre komplikationer relateret til patienternes sygdom.

Der rettes tak til projektvejlederen Lars Pilegaard Thomsen for vejledning og konstruktiv kritik igennem projektperioden.

Koden fra projektet kan findes på:
https://github.com/SebastianMnk/17gr6407-Projektkode

Indhold

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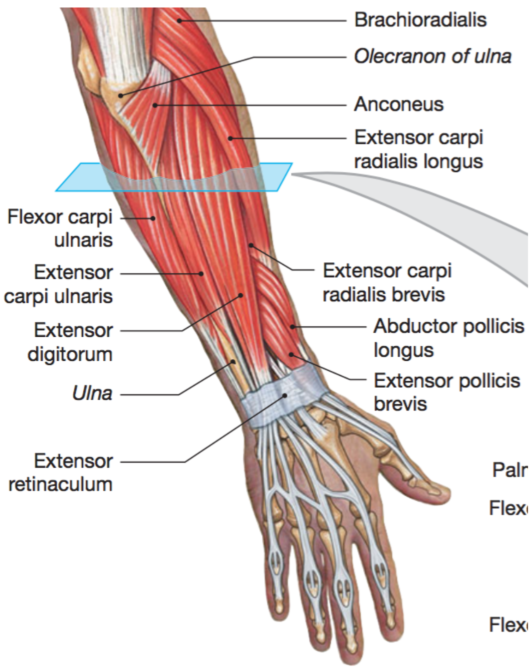
Del I

Postanalysis

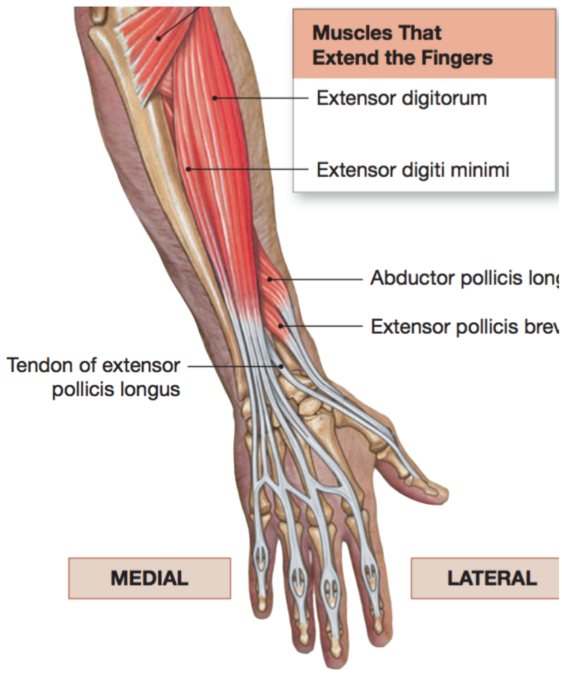
0.1 Anatomy of the lower arm

In this paper/project there will be a focus on the lower arm only, since the MYOBAND will only be used to measure EMG signals from this part of the body. The anatomy of the lower human arm will briefly be described in this section along with a description of relation between lower arm muscles and hand movements for selected gestures.

The lower human arm is designed to give humans a manoeuvrability and dexterity with which we can coordinate and execute complicated and precise hand and finger movements with ease. This skill is achieved through the use of several muscles which intertwine and make synergies to perform all the different gestures our hands are able to make [**jiang2009**] [**avella2006**]. The lower arm contains around 20 individual muscles separated in an outer, middle and inner layer. These muscles are used to rotate the forearm and hand, flex and extend the hand at the wrist as well as adduction and abduction, of both the wrist and fingers. The muscles control extension and flexion of the fingers at each separate joint and the movements of the thumb.



(a) Clockwise 4Q operation. *Posterior view of the outer muscle layer.* [**martini**]



(b) Counterclockwise 4Q operation. *Posterior view of the middle muscle layer.* [**martini**]

Figur 1: Muscles and muscle layers of the forearm.

The aim for this paper/project is to translate pronation and supination of the wrist along with extension and flexion fingers via EMG signals to control a robotic arm. Therefore, only selected muscles will be relevant to further investigate. Muscles involved with pronation of the wrist includes the pronator quadratus and pronator teres muscles. The pronator quadratus muscle is located near the wrist and is fixated on the distal portions of both ulna and radius, from where is forms a wide band across the gab of the two bones. The pronator teres is located near the elbow, where it originates from the medial distal part of humerus and the medial lateral part of ulna, to reach across the anterior part of the forearm and fixate to the midlateral surface of radius. There is only one muscle involved in the process of supination of the forearm, the supinator. The supinator muscle sits opposite the pronator teres muscle near the elbow, where it originates from the lateral distal part of humerus and the lateral proximal part of ulna and fixate on the anterolateral surface of radius. These three are the only muscles responsible for pronation and supination of the forearm. Therein exists a problem in detecting viable EMG signals to properly detect pronation and supination gestures, since the muscles involved does not extend through the forearm as most other muscles in the forearm.

Extension and flexion of the fingers include most of the muscles in the lower arm. Most of these muscles extend throughout the whole forearm as most of them originates from the lateral surfaces of humerus or the proximal portions of ulna and radius, and extends towards the wrist and fingers to fixate on the metacarpal bones in the wrist and through tendons fixate on the different phalanges bones of the fingers and thumb. See 2 and 3 for a detailed overview of each muscles origin, insertion and action it performs.

ACTION AT THE HAND					
Flexors	**Flexor carpi radialis**	Medial epicondyle of humerus	Bases of second and third metacarpal bones	Flexion and abduction at wrist	Median nerve (C_6–C_7)
	Flexor carpi ulnaris	Medial epicondyle of humerus; adjacent medial surface of olecranon and anteromedial portion of ulna	Pisiform, hamate, and base of fifth metacarpal bone	Flexion and adduction at wrist	Ulnar nerve (C_8–T_1)
	Palmaris longus	Medial epicondyle of humerus	Palmar aponeurosis and flexor retinaculum	Flexion at wrist	Median nerve (C_6–C_7)
Extensors	**Extensor carpi radialis longus**	Lateral supracondylar ridge of humerus	Base of second metacarpal bone	Extension and abduction at wrist	Radial nerve (C_6–C_7)
	Extensor carpi radialis brevis	Lateral epicondyle of humerus	Base of third metacarpal bone	Extension and abduction at wrist	Radial nerve (C_6–C_7)
	Extensor carpi ulnaris	Lateral epicondyle of humerus; adjacent dorsal surface of ulna	Base of fifth metacarpal bone	Extension and adduction at wrist	Deep radial nerve (C_6–C_8)

Figur 2: Table of the muscles in the forearm involved with movements of the wrist. [**martini**]

Muscle	Origin	Insertion	Action	Innervation
Abductor pollicis longus	Proximal dorsal surfaces of ulna and radius	Lateral margin of first metacarpal bone	Abduction at joints of thumb and wrist	Deep radial nerve (C_6–C_7)
Extensor digitorum	Lateral epicondyle of humerus	Posterior surfaces of the phalanges, fingers 2–5	Extension at finger joints and wrist	Deep radial nerve (C_6–C_8)
Extensor pollicis brevis	Shaft of radius distal to origin of adductor pollicis longus	Base of proximal phalanx of thumb	Extension at joints of thumb; abduction at wrist	Deep radial nerve (C_6–C_7)
Extensor pollicis longus	Posterior and lateral surfaces of ulna and interosseous membrane	Base of distal phalanx of thumb	Extension at joints of thumb; abduction at wrist	Deep radial nerve (C_6–C_8)
Extensor indicis	Posterior surface of ulna and interosseous membrane	Posterior surface of phalanges of index finger (2), with tendon of extensor digitorum	Extension and adduction at joints of index finger	Deep radial nerve (C_6–C_8)
Extensor digiti minimi	Via extensor tendon to lateral epicondyle of humerus and from intermuscular septa	Posterior surface of proximal phalanx of little finger (5)	Extension at joints of little finger	Deep radial nerve (C_6–C_8)
Flexor digitorum superficialis	Medial epicondyle of humerus; adjacent anterior surfaces of ulna and radius	Midlateral surfaces of middle phalanges of fingers 2–5	Flexion at proximal interphalangeal, metacarpophalangeal, and wrist joints	Median nerve (C_7–T_1)
Flexor digitorum profundus	Medial and posterior surfaces of ulna, medial surface of coronoid process, and interosseus membrane	Bases of distal phalanges of fingers 2–5	Flexion at distal interphalangeal joints and, to a lesser degree, proximal interphalangeal joints and wrist	Palmar interosseous nerve, from median nerve, and ulnar nerve (C_8–T_1)
Flexor pollicis longus	Anterior shaft of radius, interosseous membrane	Base of distal phalanx of thumb	Flexion at joints of thumb	Median nerve (C_8–T_1)

Figur 3: Tabel of muscles in the forearm involved with movements of the wrist and fingers. [**martini**]

0.2 Some stuff and such stuff and other stuff too

The following section will contain an explanation of the two main components when acquiring EMG signals, including different electrode designs and the most common preprocessing methods used in EMG acquisition.

0.2.1 Electrode function and selection

When performing EMG the electrodes act as a transducer by converting the differences in ion distribution on the skin surface caused by ion exchange under muscle activity, into an electric current. Electrodes used to aquire EMG signals comes both with and without gel covered surfaces, where the the Myo Band employs dry electrodes. Using dry electrodes will often be more practical in use, while the gel covered electrodes will aquire more exact readings of the signals

The most commonly used electrodes for EMG are made of disposable silver-impregnated plastic, and in order to keep the electric potential on the skin surface stable and reduce impedance between the surfaces, they are often covered in a silver chloride gel. Using dry electrodes will result in a higher surface impedance, which means that the signal contains more noise compared to a gel covered electrode. [Surface Electromyography (book)]

0.2.2 Preprocessing of EMG

In order to achieve a higher signal to noise ratio (SNR) it is common practice to implement some preprocessing methods, including input impedance, differential amplification and filtering. The raw EMG signals has to be preprocessed due to them sensible to noise elements from the surroundings, since the range of the signal is in the order of millivolts to microvolts.[Surface Electromyography (book)]

Input impedance is determined by a simple rule in order to avoid defeating the common mode rejection of the EMG amplifier. The rule states that the input impedance of the EMG amplifier has to be between 10 and 100 times higher than the impedance of the skin-electrode interface. [Surface Electromygraphy (book)]

Differential amplification is used in EMG in order to amplify the original signal and remove common signals from two or more electrodes, in order to avoid common noise from more electrodes in the amplified signal. The amplifier has a build in gain as well, which determines the final strength of the signal, and both of these features are implemented in order to avoid the SNR. [Surface Electromyography (book)]

Basic filtering should be implemented in order to avoid electrical noise (50 or 60 Hz). This filter would be implemented as a notch filter, in order to reject the electrical noise and achieve a higher SNR. Furthermore the filtering should include a bandpass filter with a bandwith chosen depending on where the EMG is performed. This is done in order to make sure the final signal doesn't contain irrelevant high and low frequencies. [Surface Electromyography (book)] /sectionMyoBand arm

Myo band arm is a gesture interactive system developed by Thalmic Labs capable of identifying the movement of hands and arms in order to interact and control different electronic devices.

The main components of the Myo armband illustrated in the figure are: The logo LED gives information about the sync state. The LED is solid when you perform the Sync Gesture successfully and the Myo armband is synced to your arm. The LED pulses when the armband is not synced. The status LED shows the state of the Myo armband. When it lights up in blue once the Myo armband is connected to a device. The USB charging port allows to charge the Myo armband battery. The systems counts with sizing clips which allow for a tighter grip, more appropriated for smaller arms.

This wearable physical device (arm band positioned in the upper forearm) counts with eight medical grade stainless steel electromyogram (EMG) sensors, responsible of recognizing and performing each gesture. In addition, it has nine axis inertial measurement unit (IMU) which enable the detection of arm movement. IMU includes a three axis gyroscope, a three axis accelerometer and a three axis magnetometer. It is equipped with an ARM Cortex-M4 microprocessor of low consumption.

It offers five pre-defined gestures as showed in the figure. (figure) Furthremore, it provides haptic feedback through short, medium or long vibrations to correct moves or activate the system.

The Myo armband is capable of pulling sEMG data at a sample rate of 200Hz while the remaining data (accelerometer, gyroscope and magnetometer) is pulled at a sample rate of 50HZ. The recorded signals can be sent to other devices using Bluetooth 4.0

Myo band arm supplies two kinds of data: Spatial data, provides information about the orientation and movement of the user's arm. There are two types of spatial data: Orientation Acceleration Gestural data gives information about the user's position of their hands.

/

0.3 What do we measure with EMG?

The electric potential detected with an electromyography is an action potential causing the muscle to contract. Certain mechanisms are involved for this to happen. The motor unit of the muscle needs to be activated alongside with its associated alpha motor system, which is the lower motor neuron, its axon, and the muscle fibers the motor unit innervates. The muscle fiber is an excitable cell with a resting potential of between -90mV and -70mV. A threshold of approximately -55mV needs to be reached for an action potential to be generated. The sarcolemma, the membrane covering the muscle fibers, has sodium and potassium ion channels that maintains the resting potential, depolarize the muscle fiber if the threshold is exceeded or repolarize the muscle fiber.

The lower motor axon is branching out so that it can attach to the muscle fiber at the motor end-plate and create neuromuscular synapses. The action potential traveling down the axon reaches the synapses and releases ACh. ACh raises the permeability of the cell membrane where sodium ions influx and causes the membrane to depolarize. Calcium ions are released and binds with troponin and exposes the active sites on the thin filaments which allows the muscle to contract. The action potential travels along the whole muscle fiber through t-tubuluses. This happens in both directions from the motor end-plate to the tendentious attachment. When the peak of the depolarization of about 30mV is reached a rapid efflux of potassium ions causes the muscle fiber to repolarize and reach its resting potential again.

Depending on the force that needs to be applied for a given task more or less motor units are activated and therefore more or less muscle fibers are contracted. The bigger the force the more motor units are activated. Furthermore, the number muscle fibers per motor unit varies between muscles in the human anatomy. The finer the movement the higher the innervation, e.g. the extraocular muscle has the highest innervation of 3:1 and the gastrocnemius muscles has one of 2000:1.

(Something about how the innervation is in certain muscles of the forearm)