ASME 2017 International Design Engineering Technical Conferences and
10th Frontiers in Biomedical Devices Conference
IDETC 2017
August 6-9, 2017, Cleveland, Ohio, USA

DRAFT DETC2017-68313

MONITORING REHABILITATION PARAMETERS IN STROKE PATIENTS

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INTRODUCTION

This research presents the development and testing of a system for monitoring functional parameters in stroke patients undergoing rehabilitation. Benefits of real-time automated monitoring will improve measurement consistency and accuracy, reduce consultant time, earlier discharge, less hospital beds required and delivery of controlled, repetitive training.

The system uses three devices: (1) the Myo gesture control armband (Thalmic Labs) to detect EMG signals, angles and acceleration; (2) the Arm Motion Monitoring and Recovery Improvement Toolkit (AMMRIT) (custom built) arm exoskeleton to monitor the whole arm angles and (3) the Kinect Sensor (Microsoft) to detect facial expressions.

Stroke is the second most common cause of death and the leading cause of disability in Europe. The incidence rate is approximately 16 per 10,000 per year in the UK. One of the most effective treatments following stroke is physiotherapy which can help the patient relearn how to move the limbs. Quantifying the progress of functional recovery is technically complex because of the multi-joined structure of the arm. Currently there is no single portable system available that can provide objective measurement and analysis to monitor functional recovery for Early Supported Discharge (ESD).

We developed the AMMRIT which can guide as well as assess the arm's functional recovery of patients. In this research we combine the device with Myo armband and Kinect sensor to monitor a wide range of functional parameters to accurately assess the rehabilitation progression.

METHODS

Our system uses the Myo Armband (Fig. 1), which is worn just below the elbow. The Myo device detects electrical or electromyography (EMG) signals from the user's skin, produced by muscle contractions in the forearm during arm movements and hand gestures. In addition to the EMG sensors, Myo also has a highly sensitive nine-axis IMU containing three-axis gyroscope, three-axis accelerometer, three-axis magnetometer. Myo contains eight banded segments each containing three electrical sensors. We experimentally determined where the eights sensors are positioned upon the key forearm superficial & intermediate muscles (Table 1).

Fig. 1. Myo Armband uses 8 sensors on various muscles.

Sensor	Name of the muscle
1	Flexor Carpi Ulnaris
2	Extensor Carpi Ulnaris / Flexor Carpi Ulnaris
3	Extensor Carpi Ulnaris
4	Extensor Carpi Ulnaris / Extensor Digitorum
5	Extensor Carpi Radialis Brevis / Radialis Longus
6	Flexor Carpi Radialis / Pronator Teres
7	Palmaris Longus / Flexor Carpi Ulnaris
8	Flexor Carpi Ulnaris

Table 1. The eight forearm muscles monitored by Myo.

Variation between users of the Myo device can affect the muscle positions (Table 1), the type of gesture recognized, and the type of EMG signals detected. For this reason, it is advised not to rely entirely on the EMG raw data for defining the gestures, but to also combine with other sensors.

THE AMMRIT CUSTOM MADE ARM EXOSKELETON

We developed the Arm Motion Monitoring and Recovery Improvement Toolkit (AMMRIT), which can directly attach to the arm to monitor the motion during physiotherapy (Fig. 2). The AMMRIT has a real-time data collection using digital encoders that can transmit wirelessly to a laptop.

The AMMRIT measures the range of movement, velocity and acceleration at the shoulder (3 DOF) and elbow joints. The position and accelerometer sensors are so accurate that they enable our predictive modelling software to anticipate the intentions or attempts made by the patient to move their arm.

The data-driven software could be coupled with motor actuation in an active exoskeleton or electrical stimulation of the muscles, facilitating independent training assistance.

MYO ARMBAND INTERFACE

Custom made software integrating all three devices was developed in C++, using Microsoft Visual Studio, the Myo SDK and gnuplot 5.0. The software accesses the raw data created by the Myo armband sensors and converts into an appropriate scale to allow recovery monitoring in rehabilitation. To avoid delay when plotting the graphs, temporary files are created which contain only the most recent recordings so that the graphs can be plotted in real-time.

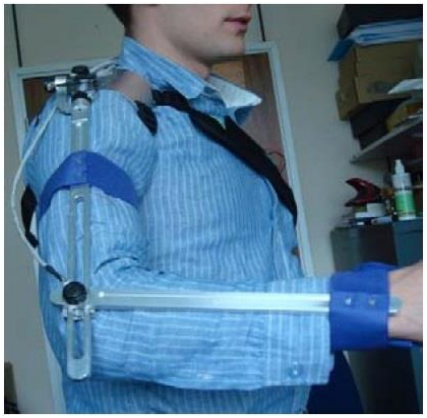

Fig. 2. AMMRIT custom made arm exoskeleton.

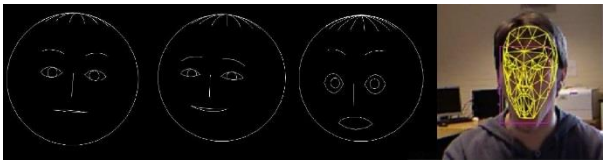

Fig. 3. Detection of facial expression.

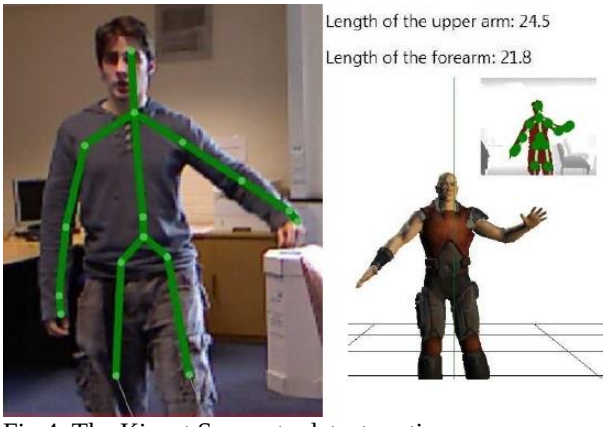

Fig.4. The Kinect Sensor to detect motion.

MONITORING USING KINECT SENSOR

The system detects facial expression to identify the patient's mood during physiotherapy (Fig. 3). Our system also uses the Kinect sensor to show direct visuals of physiotherapy motion (Fig. 4). It also guides the users giving verbal command of the routines to be followed by patients and motivational encouragement prompting if they fall short of the desired target. This can monitor and guide performance of training.

RESULTS

The integrated system utilizes these capabilities to monitor a variety of important parameters, and produces real-time graphs. The graphs can display the EMG data (Fig. 5), acceleration, joint angles, facial expression and motion data for shoulder and elbow (Fig. 6).

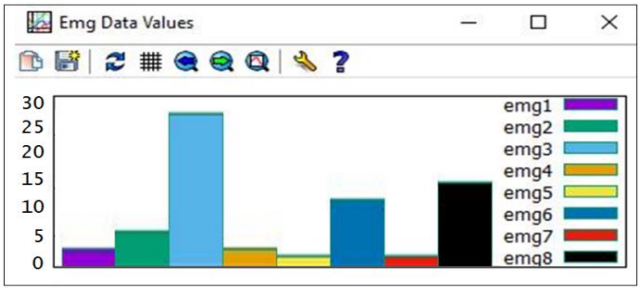

Fig.5. EMG data during rehabilitation training.

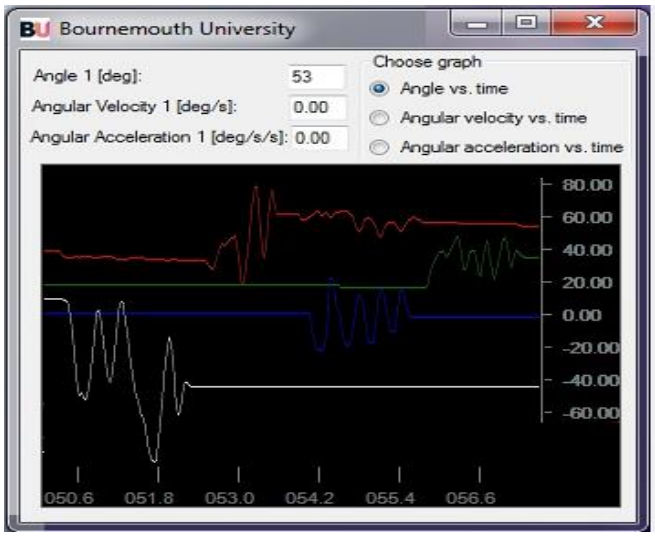

Fig. 6. Motion data for shoulder and elbow during training.

INTERPRETATION

We are in the process of applying for ethical approval to conduct a pilot trial on stroke patients. The trial will evaluate the usefulness of real-time monitoring of rehabilitation and the improvement in patient movement over time, with an improved user-interface and customized design of the system. Data will be analysed to assess reproducibility of this device to quantify recovery of upper arm function. As a secondary outcome, this will be correlated with functional recovery and ability to perform activities of daily living.

REFERENCES

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[2] Leuenberger K, et al. "A method to qualitatively assess arm use in stroke survivors in the home environment." Medical & biological engineering & computing (2016).