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Monitoring frozen shoulder exercises to support clinical decision on treatment process using smartphone

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Abstract

Continuously performing rehabilitation exercises are important for frozen shoulder patients to recover and increase their range of motion (ROM). Every time patients go to see their medical practitioner, they will be assigned home program rehabilitation exercises and the results of the ROM measurements will be measured on their return to their practitioner's clinic. At present, there are many kinds of technology that can detect movements. Many researchers have studied and used them to develop applications to facilitate tele-rehabilitation. This study aims to develop an application that supports a medical practitioners' decision making process. This application animates the exercise pattern of the patient and it is developed on Android and Web platforms. The web-based treatment process manages the patient's details, assigned tasks, and medical practitioners' profiles. The Android application part provides three exercise types: flexion, abduction, and horizontal flexion. These are useful for the patient in performing frozen shoulder tele-rehabilitation. We performed a preliminary study with five participants. The participants were assigned three exercise types according to the target angles set by the medical practitioner. When the subjects reached the target angle, an audio biofeedback was provided. In the experiment, the subjects needed to exercise in the time period set by the medical practitioners in order to track the shoulder rehabilitation progress. The preliminary results found that our application can possibly help medical practitioners in the treatment process and tele-rehabilitation tracking. In the future our application can be applied to other parts of the body and possibly modified to apply to stroke rehabilitation tracking.

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Keywords: Clinical decision support; frozen shoulder rehabilitation; range of motion animation; smartphone-based application.

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1. Introduction

Shoulder joints are important because these joints have the most frequent movements when compared with other joints in the body. The movement of the shoulder joints occurs in response to other related movements of other parts of the body and environment. Shoulder can cause the loss of normal movement, physical disability, and difficulty in working or enjoying activities in daily life. In frozen shoulder treatment, the patients need to exercise continually every day until they can move their shoulder in a range of motions and until the shoulder is back to a normal state. In a traditional treatment process, the patients have to travel from home to hospital to do the exercises with their medical practitioners present. To do this, the patients and their families incur a loss of valuable time by visiting hospitals or clinics. Therefore, by taking advantage of useful and available technologies and tools that are already quite familiar to everyone such as smartphones to perform exercise from home is rather challenging and interesting, and many researchers are presently studying this opportunity. A smartphone is a device that many people now own without great expense as the price continues to decrease. Sensor technology in a smartphone is enables it to collect many kinds of data, as in this study, we could collect movements of the shoulders and shoulder angles, which are useful for the visualization that helps support the medical practitioner's decision making and improve the treatment process.

Nowadays, many researchers study and develop technology related to rehabilitation such as tele-rehabilitation from home via mobile devices. Important sensors used in smartphone-based rehabilitation are accelerometer sensor, gyroscope sensor, and geo-magnetic sensor. These sensors complementarily work to accurately measure degrees of movement. Therefore, as tools and technologies are reliable and ready to use in tele-rehabilitation, we are interested to use the sensors data received from a smartphone when a patient performs the prescribed exercises to track the patient's status and provide a more suitable and effective treatment for the patient.

The impetus for this study is to provide a tool for medical practitioner to track patients' status and assess the exercise results. The practitioner is able to manage the activities via the web application console which presents exercise results in the form of 3D model animation and graphs. The main objective is to improve the monitoring features of an existing web application to support the medical practitioner to determine suitable activity exercises in the frozen shoulder treatment process.

2. Literature review

Ongvisatepaiboon el al.[1] developed the iJoint application based on an Android smartphone. The study aimed to test the accuracy of gyroscope, accelerometer and magnetometer sensors that were embedded in the smartphone to measure a shoulder's range of motion. The experiment compared accuracy of sensors in different brands and models having these three types of sensors. The phones were Samsung Google Nexus S, Samsung Galaxy Note 1, and Sony Xperia Z Ultra. The experiment found that these sensors could work together to measure a shoulder's range of motion and provide sufficient reliability to be used in a tele-rehabilitation exercise from home.

Patanapanich et al.[2] developed a Self-Physical Rehabilitation System using Microsoft Kinect to detect body movements. They simulated the correct therapy exercises with Unity software and showed the patient as a model of a stick figure displayed on the screen. The patient could exercise by following the correct examples simultaneously in real time. They tested the correctness and reliability of the application by comparing the effectiveness of exercise results that used the system's features against the results of exercises without the features. The result showed that the provided rehabilitation exercises could help the patient exercise with more accuracy than ones without it.

Ferreira[3] considered the rehabilitation of a paralysis patient was difficult when transferring patient from home to hospital, and physical burden for the patient's family when the appointment date came. For this reason, they studied and developed Smartphone Based Tele-Rehabilitation, which helped patients do exercises from home. Orientation sensors and gyroscope sensors work together complementarily with a Kalman filter to obtain the accurate angle data from a smartphone. There were two parts of the application. The client side focused on forearm rehabilitation, and the server side used the Java3D API and simulation technique to simulate a 3D model of the patients exercise. A driving game and party balloon game to help the patient enjoy the exercise were also included on the server side.

Aung et al.[4] studied the upper arm rehabilitation system by developing the application framework called ARIS. This application combined multi-technology to work and support rehabilitation, by combining received live video