Development of a Clinically Viable Wearable Sensor to Record and Report Exercise Based Movements

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BMEN 4899 - Spring 2015

Project Overview

Problem statement:
- Patient Accountability – Physical therapists (PTs) do not know if the patient has been exercising the prescribed amount.
- Incorrect Form – Patients that exercise at home may not have the correct form, which may lead to further injury.
- Visiting Frequency – Visits to the PT office are often expensive and time consuming to the patients.
- Reassessment as a Time Cost – PTs go through a lengthy re-evaluation of the patient’s physical state each visit.

Project Definition/Approach:
This wearable device will track and stream the movement data of the rehabilitation exercise to a mobile application that will record and report the data to the patient and the physical therapist.

Current Scope:
We will concentrate on Knee Osteoarthritis rehabilitation exercises for this project.

Final Design: Hardware

Wrap:
The wrap is made out of Neoprene and will easily conform to the thigh and the ankle in any orientation. The waterproof pocket will keep the MPU 9150 in place and prevent any damage due to moisture (sweat).

Chip Platform - MPU 9150:
The InvenSense MPU 9150 has a 3-axis gyroscope, 3-axis accelerometer, and 3-axis magnetometer. A rechargeable battery, charged via micro USB, powers the device.

The Bluetooth Low Energy (BLE) module connects to a mobile device through an application to stream and display the data.

Algorithm:
Rithmio’s algorithm can record and recognize movement patterns. With this algorithm, form will be defined by three metrics:
- Speed – time of repetition
- Range of Motion – distance moved by the patient in main plane of motion
- Path efficiency – distance moved by patient in planes of least motion

The patient will record the prescribed exercises under PT supervision. This ensures proper form serving as a baseline.

Final Design: Software

User Interface:
The user interface (UI) and user experience (UX) is designed to be simple and easy to navigate for both the patient and the PT. A mock up of the patient UI and the PT UI were designed with FluidUI software. These mock ups help establish the flow of the application in order to create a simple, intuitive UX.

With the metrics derived from the algorithm and the data, total form is assessed with red (bad), yellow (good), and green (great) indicators (sample screens in Analysis).

Accountability is assured with constant reports that are sent back to the PT.

Analysis

Testing:
1) User directs participants in training of the mobile application with exercises.
2) Patients perform exercises in 3 sets of 8 repetitions each.
3) User records the number of performed exercises before the mobile application counts to 8 repetitions.

The number of total performed exercises are displayed below.

Conclusion

This wearable sensor system shows promise to achieve and deliver accountability, assessment of form, and accessibility to the field of Physical Therapy. Rithmio plans to take our growth in this project to finish application development before going to market as well as look into developing a motion tracking visualization for PTs. Our project expands the possible applications of Rithmio’s algorithm.

Further work includes a research study collaboration between Rithmio and UTSW to test the system in a clinical environment.

Acknowledgements

Industry Mentors:
Rithmio: Adam Tilton, Jen Quinlan, Rachit Shah, Christian Nam, Kamil Chmielewski
UTSW: Dr. Robert Dimeff, Dr. Ross Querry

Faculty Mentor: Dr. Robert Gregg
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Fig. 5 FluidUI user interface flow chart. This flow depicts the navigation and preliminary screen designs for the patient user interface.

Fig. 7 Preliminary Patient UI that displays information about the 3 metrics. Speed, Range of Motion, and Path Efficiency

Fig. 8 The graph displays the data of an experiment to determine the sensitivity of the algorithm to the form of knee osteoarthritis exercises.

Fig. 9 The graph displays information about the 3 metrics for the form of knee osteoarthritis exercises.

Fig. 1. The Neoprene leg wrap with waterproof pocket, closed and secured with a simple button enclosure.

Fig. 2. The InvenSense MPU 9150 with all components labeled. A small battery pack is located on the back of the chip.

Fig. 3. The 3D printed case and switch extender models from SOLIDWORKS. The imprinted figures help with user orientation.

Fig. 4. Rithmio’s basic features of the gesture tracking algorithm.

Fig. 6. A mock up of the patient UI and the PT UI were designed with FluidUI software.