Development of Telemedicine Mobile Examination Device

Department of Industrial Systems Engineering and Management

IE3100M Systems Design Project AY2020/21NUS

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Introduction

In recent years, there has been a rising demand for telemedicine. The COVID-19 pandemic has caused further spikes in the demand for telemedicine, which is likely to continue growing even after the pandemic. There is currently a lack of examination devices for telemedicine that doctors can employ for consultations with patients.

The project seeks to develop a prototype examination device to meet this lack and provide doctors with alternatives for examinations during telemedicine consultations.

Problem Description

Despite the growing demand for telemedicine, there are certain limitations present in telemedicine consultations. Doctors may overlook subtle movements which would not be as apparent compared to traditional in-person consultations. These movements could be indicative of early onset of diseases in the patient, which the doctor may not be able to identify. The doctors would also be unable to conduct physical examinations for patients over telemedicine consultations. This leads to a lack of quantifiable examination results that could hinder proper diagnosis.

Benefits

The stakeholders of the project are patients, the Department of Orthopaedic Surgery and NUH. For patients, the proposed solution would allow a timely diagnosis by conducting the examinations. The quantifiable measurements of patients are helpful for doctors to provide a better diagnosis without face-to-face consultation. Once patients and doctors see the benefit of the proposed solution that could resolve current limitations, it would be easier for NUH to further promote telemedicine for orthopaedic surgery and other departments.

Project Objectives

The project aims to develop a prototype smartphone application, to be used for patient examinations in telemedicine consultations. The application should collect examination data via multiple methods and offer insights into spine function. It should also provide quantifiable, accurate measurements, have a simple interface, allow for cloud storage and not require any external sensors to function.

Key Skillsets

Data analysis
- Data cleaning
- Signal processing

Programming
- Matlab to interpret the data
- Python for data pre-processing

Hardware Interface
- Arduino sensor
- Matlab mobile

UI Design
- Figma to create interface

Project Methodology

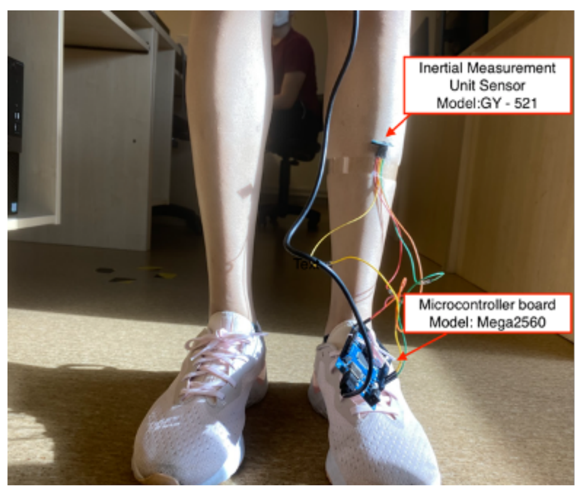
Literature review → Identifying examinations → Data Analysis Methods → Data Collection → Data analysis → Recommendation

Data Collection for Gait Analysis

Procedure: Patients will walk for 10 meters with the phone secured at the ankle at a normal pace to ensure the gait pattern reflects actual walking movement.

Arduino VS Matlab Mobile

Arduino:



Matlab Mobile:

Project Objectives	Arduino	Matlab Mobile
Able to collect required measurements	✓	✓
Easy to set up		✓
Utilizes smartphones sensors only		✓

Matlab Mobile is the preferred method of data collection as it better at meeting the project objectives.

Data Analysis

Data Collection → Lowpass filtering → Graph output → Fast Fourier Transform → Quantifiable Measurements

Quantifiable measurements:

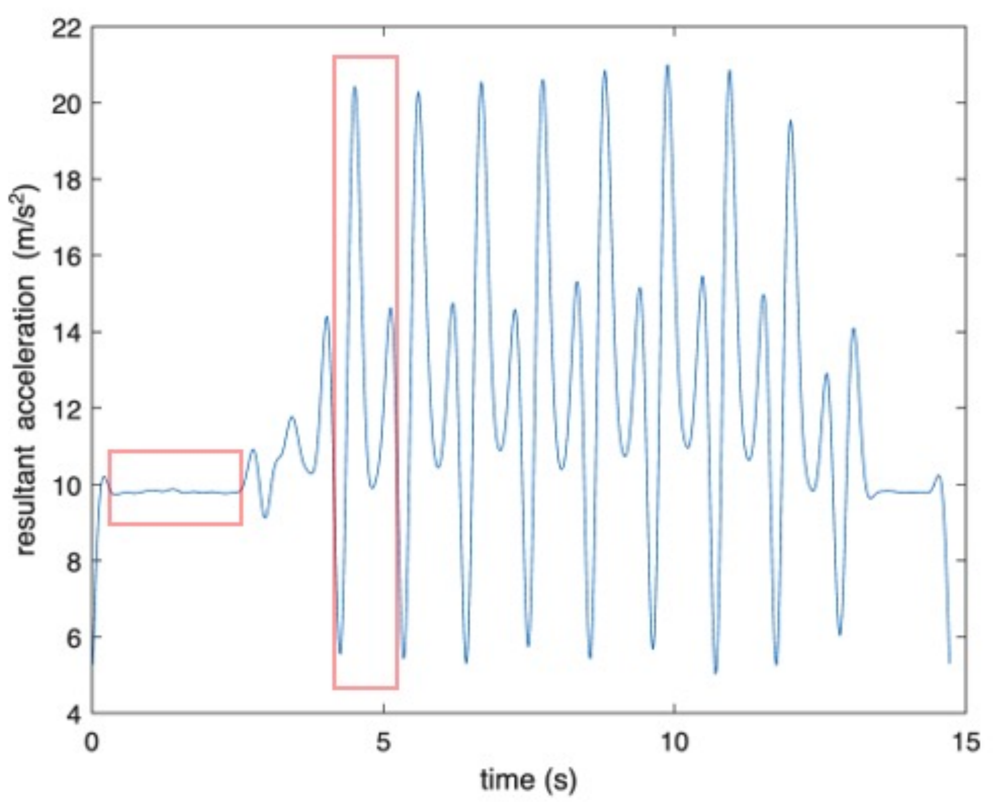
-Walking Frequency

-Stride length

-Total number of steps

Data required:

Acceleration readings in 3-dimensional (3D) space are collected to calculate walking frequency.



The initial graph is relatively stable as there is no movement before the test. The M-shape indicates one complete step, and a series of M-shapes correspond to the actual movement.

Analysis on accuracy of the data collected

The difference in sample means of walking frequency obtained from sensor and Matlab is analysed through hypothesis testing, using a t-distribution at a 5% level of significance.

mean_sensor	1.77791783
standard deviation_sensor	0.11114344
mean_matlab	1.797365
standard deviation_matlab	0.03902194
H0	mean_difference = 0
Ha	mean_difference ¹ 0
Test statistics:	$\frac{(mean_{matlab} - mean_{sensor}) - 0}{\sqrt{variance\_difference}}$ = 0.73832204
P-value	0.23242724 > 0.05

Since the P-value is greater than 5%, there is insufficient evidence to reject the null hypothesis, suggesting that the difference in sample means is insignificant, proving the accuracy of the data collected.

Analysis on accuracy of quantifiable measurements derived

The difference in sample mean and population mean is analysed through hypothesis testing, using a t-distribution at 5% level of significance.

population mean	1.8
population standard deviation	0.11
mean_matlab	1.797365
standard deviation_matlab	0.03902194
H0	mean_difference = 0
Ha	mean_difference ¹ 0
Test statistics:	$\frac{(mean_{matlab} - mean_{sensor}) - 0}{\sqrt{variance\_difference}}$ = -0.10009634
P-value	0.5399448 > 0.05

Since the P-value is greater than 5%, there is insufficient evidence to reject null hypothesis, which suggests the difference in sample mean and population mean is not significantly, proving the accuracy of the quantifiable measurement derived..

Recommendations and Future Developments

- The development of the mobile application CEMS should consider data privacy and sharing, and be able to retrieve sensor data
- Clinical trials should be conducted to test the mobile application and gather large sets of patients' data to improve data analysis through machine learning models.
- A link between quantifiable measurements and the potential disease needs to be established to draw insights from data.