COMP4801 Final Year Project

FYP15027 Interim Report

Internet of Thing Application

TOUCH3

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Abstract

Robots play a significant role in human development. Human usually remotely manipulate robots to finish different dangerous and inaccessible tasks. However, the remote-control system with physical buttons is not appropriate in certain situations, such as doctors in operating room and astronauts in space. And this project is to provide a gesture-control system to solve this problem. This paper describes the design, implementation and evaluation of TOUCH3, a web application that interconnect MYO armband and robots. With TOUCH3, users are able to use hand gestures to manipulate robots and monitor the connecting devices. This paper introduces the four main functionalities of TOUCH3. Also, it discusses the major problem in this project, the limited amount of hand gestures provided by MYO armband. The solution, combining hand gestures with arm motions, will be mentioned to solve this major problem. Currently, connection functionality was completed. All in all, the final product of TOUCH3 will provide an unexpected touch-free experience to user in robot control, which may contributes to the future robot development.

Acknowledgement

This project is a final year project for computer science student. And it consumed huge amount of work and research. However, this project would not have been possible without a support of many individuals and organizations. Therefore I would like to extend my sincere gratitude to all of them.

Thank you Dr. Lau Vincent for his supervision and his valuable advises. Also, thank you the Department of Computer Science, the University of Hong Kong for providing different items and financial support. Finally, thank you everyone's opinion and suggestions for making TOUCH3 better.

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1. Introduction

Most of the current remote-control systems are using physical buttons to control different electric devices. This project is trying to make a change on robot control. Instead of using remote-control systems with physical buttons, an advanced technology, MYO armband is used. MYO armband is a remote with a gesture-control system. It has a powerful sensor, called electromyography sensor [1]. This sensor is able to read the electrical signals from muscles. Therefore, MYO armband can detect users' hand gestures after recognizing the electrical signals in forearm. This project is to make use of MYO armband and to develop a web application, TOUCH3.

TOUCH3 aims to connect MYO armband and robot and manipulate a robot by gesture-control system, so as to achieve a touch-free experience for users and be suitable for scenarios where touch is not preferred. For example, doctors interact with different medical devices by MYO armband in operating room, and astronauts complete their dangerous mission with MYO armband assistance.

In this interim report, the project progress, interim results and problems are reported and evaluated, so the quality of the final product can be ensured and meet the requirements.

2. Motivation

Human make use of robots to complete different dangerous and inaccessible tasks though remote-control system, but most of the remote control systems use many physical buttons or many commands to perform a simple task. Therefore, the development of robot is facing a bottleneck due to the complex and inconvenient control system. So MYO armband has been developed to solve this problem, and this project is to develop a web application TOUCH3. The purpose of TOUCH3 is to provide a touch-less control for user to control the robot in different scenarios. And there are two example showing gesture-control system is significantly useful.

First, doctors in operating room are required to locate the affected part by controlling the diagnostic imagery. Due to avoiding any infection, they cannot touch anything with their hands, so doctors need nurses to help and more manpower is needed to complete the surgery. With the help of MYO armband, doctors will be able to navigate the diagnostic imagery by gestures [2]. In addition, they can also interact with other medical devices without nurses' help, so nurses can focus on other duties. As a result, the efficiency and the success rate of surgery will be increased.

Apart from medical purpose, astronauts can also complete their mission with the gesture control system. Under zero gravity state and wearing space suit, using remote with physical buttons is not user-friendly to them, and reduces the working efficiency. So gesture control system is significantly useful in this case. Astronauts can easily control different devices by a simple hand gesture, so they can work faster and reduce the time of exposure to space. As a result, the risk of the mission will be reduced and the safety of astronauts will be secured.

Hence, using gesture control system to remotely control different devices is especially useful under certain scenarios. And this project is to show the great potential of MYO armband by developing a web application, TOUCH3, which can use MYO armband to manipulate robot.

3. Objectives

This project aims to remotely control robots by MYO armband, and aims to develop a user-friendly web application, TOUCH3, which allows users to monitor robot and define customer gestures. It provides four functionalities:

1. To interconnect MYO armband and robots
2. To map hand gestures to robot's motions
3. To customize user gestures
4. To present the information to the users in a proper manner

First, TOUCH3 is required to connect MYO armband with robot. Since MYO armband and robot support the Bluetooth Smart (Bluetooth 4.0 Low Energy),

they are able to communicate with smart devices with Bluetooth radio. Applying BLE technology, TOUCH3 can exchange information between MYO armband and robot. As a result, TOUCH3 acts as a platform. It is able to handle the data input from MYO armband and data output to robot, so it can accommodate interconnection and intercommunication with MYO armband and robots.

Second, TOUCH3 is to map hand gestures to robot's motions. An ARM Cortex M4 processor in MYO armband provides a strong processing power to recognize muscle activities and sends detected gestures to smart devices. Therefore, TOUCH3 can read the gestures recognizing by MYO armband and then sends commands to robot, so as to control the robot's motion.

Third, this project would like to develop a functionality, which allows users to define their gestures with certain robot's motion. Since MYO armband contains two types of sensors, TOUCH3 can make use of them to detect hand gestures. Firstly, MYO armband has eight medical grade stainless electromyography (EMG) sensors, thus is can monitor the electrical signal in forearm muscle. Secondly, it contains a highly sensitive nine-axis inertial measurement unit, which are able to detect the forearm motion in any direction. With the powerful sensors, MYO armband is able to recognize numerous gestures, and provides lots of gestures for user. So TOUCH3 allows users to customize their own gestures, and map to certain robot's motion.

Fourth, TOUCH3 should be able present different information to users with a proper manner. Therefore, a concise and user-friendly user interface will be developed and implemented in website. Also, MYO armband contains vibration motor. It is able to produce several types of vibration. TOUCH3 makes use of this feature, and provides haptic feedback to users. Therefore, users are not necessary to hold their smart devices all the time during controlling robot.

The goal for this project is to develop a web application, TOUCH3, which is able to have above four functionalities with a user-friendly user interface. As a result, users are able to remotely control robot with MYO armband. Also, robot can

perform a sequence of complicated actions by a simple gesture, so as to enhance the efficiency of gesture control system and to perform a smooth robot's motion.

4. Previous Work

MYO armband has an application store. It likes the Apple app store and the Google market. The application store is open to public. There are generally two types of application, one is for remote control, and one is for entertainment.

In the MYO market, there are some applications make the MYO armband to replace the remote control. For example, a PowerPoint connector can connect the MYO armband with the PowerPoint, so users are able to use hand gestures to switch the slideshow. Also, there are other connectors, which are able to connect the MYO armband with different music players. Therefore, users can enjoy the convenience brought by gesture control.

Apart from connection application, there are also some applications for entertainment. For example, users play Fruit Ninja or Minecraft with MYO armband, so they do not need any mouse or touch screen to control, instead, they can enjoy touch-less gaming experience. Also, there are some applications, which connect MYO armband with the toys, so MYO armband will acts as a controller to manipulate the toys.

And the product of this project TOUCH3 is a connector, but also is a controller. It has a fundamental functionality as similar as the previous works. However, it also aims to enhance the efficiency of gesture control and to perform a smooth robot's control. For example, the robot can perform a sequence of complicated actions by a simple gesture. This feature is not provided by previous works, therefore, this project would like to achieve this goal and contribute to the future robot development.

5. Deliverables

Deliverables of phase one (inception)

1. Detail Project Plan

2. Project Website
3. User Interface of TOUCH3

Phase one was completed. All deliverables of phase one was finished. The detail project plan and a project web page were uploaded to the project website, http://i.cs.hku.hk/fyp/2015/fyp15027, also they were submitted to supervisor, Dr. Lau Vincent. The prototype of user interface was designed and a user experience assessment was conducted.

Deliverables of phase two (elaboration)

1. Implementation of Four Functionalities
2. Detailed Interim Report
3. Modification of UI Design

Phase two is in progress. The progress will be discussed in the later part. After phase two, TOUCH3 will be released with the modified UI design. It is able to detect the hand gestures and the self-defined hand gestures. An interim report will also be provided to assess the progress and the achievement.

Deliverables of phase three (construction)

1. Implementation of Beta Version Application
2. Final Report

After phase three, a beta version application will be released. It is able to control the robot by gesture control. The project objectives and progress will be evaluated our objectives and a final report will be provided.

6. Approach and Methodology

This project is to develop a web application with four functionalities to control robots by MYO gesture-control system. To elaborate on the system design, a use-case diagram is showing below.

Use-Case

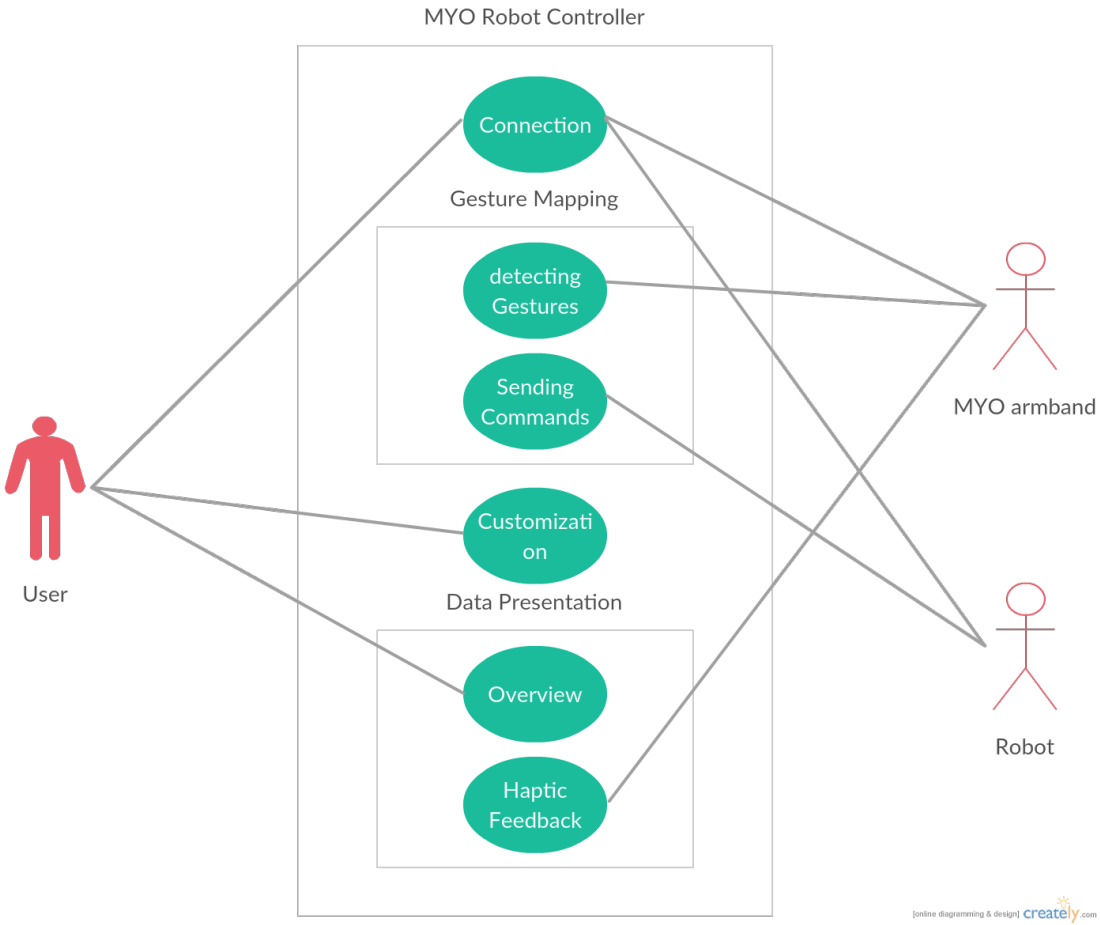

Figure 1: TOUCH3 Use-Case Diagram

Figure 1 is the use-case diagram for TOUCH3. There are one primary actor on left hand side, and two secondary actors on right hand side. In the middle, it is TOUCH3 with the four functionalities. This use-case diagram can explain the interaction between functionalities and actors.

The primary actor for TOUCH3 is the user. The user is interested in controlling robot by MYO armband, so they would like to perform three functions. They want to connect certain MYO armband with certain robot, so the BLE technology is applied to interconnect these devices. In this project, BLE supports TOUCH3 acting as a sender or receiver of data while connecting with different devices. With the software development kit (SDK) of MYO armband and robot, TOUCH3 forms a platform to handle the communication of two devices. Also, the user would like to define the gestures to certain robot's motion, so TOUCH3 is developed this functionality with a Node.js library, MYO.js. Finally, the user is

able to interact with the UI mentioned before, to monitor the robot and MYO armband.

The secondary actors in this use case are MYO armband with a BLE radio is able to send the detected gestures to smart devices. And also TOUCH3 is able to order the vibration motor in MYO armband, so as to give a haptic feedback to the user. Robot also contains a BLE device, thus it is able to receive the commands from TOUCH3, and performs certain motion.

7. Progress

User Interface Design

After phase one, a prototype of user interface was designed. Figure 2 shows the prototype. There are three tabs. First, the connection tab is used to select the connection of MYO armband and robot. Second, the gestures tab is used to display the gestures with certain robot's motions. Third, the setting tab is for users to modify the gesture control and haptic feedback.

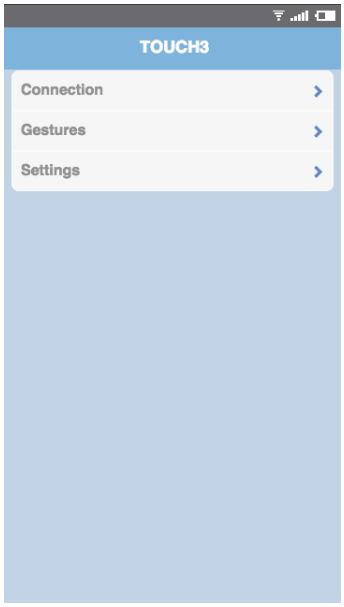

Figure 2: TOUCH3 UI Prototype

Also, a user experience assessment was conducted to collect the user opinion. The prototype was tested by six engineering students, after reading the project plan and visiting the project website. Most of them mentioned about the style of UI is too concise and unattractive, since the application lacks in animation and does not have any icon. Although it provides the necessary functionalities, it is plain. However, they said the website design is concise but also fashionable, they suggested applying the style of website into the mobile application.

After analyzing the user opinion, the UI design was modified. Also, since the application was developed as a web application instead of mobile application (the reason will be discussed in the problem encountered part), the UI design was re-designed with user opinion, similar style of the project website was applied.

Figure 3: Modified TOUCH3 UI Design

Figure 3 shows the modified UI design of TOUCH3. It is a one-page web application developed on Node.js. It has four tabs and a text box. First, the Status tab shows the information of connected MYO armband. Second, the Calibration tab is to modify the gesture control setting. Third, the Log tab is to show the detected hand gestures in word. Fourth, the Pairing tab is to connect the MYO armband and robot. This UI design bases on the user opinion, and another user experience assessment will be conducted to collect user new opinion.

Implementation of Four Functionalities

Based on the system design shown as figure 1, the four functionalities are implemented in the web application.

A. To interconnect MYO armband and robots

TOUCH3 now is able to connect with MYO armband through BLE. It can accurately identify MYO armband even there are different devices with BLE, user can select a specific one MYO armband to connect with TOUCH3. TOUCH3 can receive the information and data input from MYO armband. Under the BLE environment, MYO armband can be connected within 10 meters. Although the maximum theoretical range is about 100 meters, it may be affected due to the power output of the devices. But 10-meter-range is long enough for manipulating the robot and fulfill the requirement in this project. To increase the range, the power consumption of MYO armband and the connected device will be increased, and the manipulation time will be reduced.

B. To map hand gestures to robot's motions

This functionality is not implemented yet. In phase two, 26 hand gestures can be detected. Since MYO armband only provides 5 pre-set hand gestures, TOUCH3 needs more hand gestures to fully control the robot. So 21 self-defined hand gestures are created.

Table 1: Detected Gestures in TOUCH3

Pre-set Hand Gestures	Self-Defined Hand Gestures						
Double Tap							
Fingers Spread							
Fist	Fist Up	Fist Down	Fist Right	Fist Left	Fist Clockwise	Fist Anticlockwise	Fist Punch
Wave In	Wave In Up	Wave In Down	Wave In Right	Wave In Left	Wave In Clockwise	Wave In Anticlockwise	Wave In Punch
Wave Out	Wave Out Up	Wave Out Down	Wave Out Right	Wave Out Left	Wave Out Clockwise	Wave Out Anticlockwise	Wave Out Punch

Table 1 shows all gestures detected in TOUCH3. The self-defined hand gestures are combining the five pre-set hand gestures with arm motions. Since MYO

armband is not only an electromyography sensor, it also includes gyroscope, accelerometer and magnetometer. By calculating the input data, TOUCH3 can get the angle of roll, pitch, yaw and the acceleration of three axes. Making use of these data, TOUCH3 is able to determine the arm motion and the arm position. For example, it can determine whether arm rising up or putting down, placing right or left, rolling clockwise or anticlockwise and also detect the punch action. Therefore, combining these data with three pre-set hand gestures, 21 self-defined hand gestures are created.

C. To customize user gestures

This functionality is not implemented yet. And the implementation will start when the connection functionality and the mapping functionality are completed. Since TOUCH3 defined 26 hand gestures, users can customize the gestures mapping to certain command by themselves. This part does not need too much time to complete the implementation, and the main problem is solved (will be discussed in problem encountered part).

D. To present the information to the users in a proper manner

TOUCH3 now is able to present the information of MYO armband, for example, the battery and the synchronization status of MYO armband. The modified UI design was implemented into TOUCH3, so the layout of TOUCH3 is concise and user-friendly. However, the functionality of haptic feedback is not implemented yet, and it will be implement after the completion of customization functionality.

Table 2: Progress of Four Functionalities

Functionality	Subtask	Status
A. To interconnect MYO armband and robots	MYO armband	Completed
	Robot	In progress
B. To map hand gestures to robot's motions	Self-defined gestures	Completed
	mapping	In progress
C. To customize user gestures	NA	In progress
D. To present the information to the users in a proper manner	UI design	Completed
	Haptic feedback	In progress

To summary, table 2 shows the progress of the four functionalities. There are three functionalities completed 50%, and one is in progress. The next task is to connect the robot with TOUCH3, and then will implement the mapping functionality. Finally, the customization functionality and haptic feedback will be also completed.

8. Problems Encountered

In this project, there is a big challenge. The current MYO armband applications are mainly using five pre-set hand gestures to control different devices. But this project aims to develop a web application, which is able to fully and smoothly control the robot. In general, it requires numerous hand gestures to perform different kinds of robot's motions, but MYO armband can only recognize the five pre-set hand gestures. Therefore, TOUCH3 needs more hand gestures, and self-defined hand gestures are required. There are two solutions to solve this problem, they are capture the EMG data of self-defined hand gestures and combining the five pre-set hand gestures with arm motion.

The first solution, capturing the EMG data of self-defined hand gestures is not a good solution. To recognize more gestures, the data of electrical signals from muscles in forearm have to be collected and analyzed. It requires to collect a large amount of EMG data from different people. Also, the EMG data from different people have a slightly difference. This slightly difference affects the accuracy and the efficiency of recognition of self-defined hand gestures. Since the

cost is greater than the result, it is not a good approach to create more self-defined hand gestures.

The second solution, combining the five pre-set hand gestures with arm motion is better than the first one. Since MYO armband also includes gyroscope, accelerometer and magnetometer, TOUCH3 can make use of their input data to detect the arm motion. By calculating the data input from three sensors, TOUCH3 can get the roll angle, pitch angle, yaw angle and the acceleration. This information is used to determine the arm motion and arm position. Therefore, TOUCH3 defined 21 self-defined hand gestures and can detect totally 26 hand gestures.

As a result, the limited amount of hand gestures can be solved by combining the five pre-set hand gestures with arm motion. And TOUCH3 applied this method to increase the number of hand gesture. With the MYO armband firmware updating from Thalmic Lab, more and more hand gestures will be added, so users can make use of them to have a better manipulation of robot.

Apart from the limited amount of hand gestures, the running environment is also a problem in this project. The original designed platform is Android environment, however, the accuracy and the efficiency of detecting hand gestures are unsatisfactory. Therefore, a web application, TOUCH3 is developed, instead of a mobile application. And there are two reasons for which changing running environment.

First, the support of developing an Android mobile application from Thalmic Lab is insufficiency. Although the mobile application can connect with MYO armband easily, the connection of MYO armband is without any synchronization and calibration. Therefore, the recognition of hand gestures and the performance are poor. However, the support in PC version is better. Users have to synchronize their MYO armband before they using it. Also, the MYO armband will keep track on the muscle signal and learn from it, so after a time of warming up, the recognition of hand gestures is significantly great. Moreover, users can calibrate

if the performance is not good enough, so users can have their own calibration profile to improve the accuracy. As a result, the overall recognition performance in PC is better than in smartphone.

Second, there are many open source libraries in Node.js. These libraries are very useful in this project. For example, the calculation of acceleration, the angle of roll, pitch and yaw are used from the open source libraries. Also, there is a developing MYO.js for developer to work with MYO armband. Therefore, developing a web application for TOUCH3 is better.

Last but not least, there is a small problem of eliminate the noise hand gesture. For example, TOUCH3 usually mistakes fist for double tap. Since these two gestures require similar muscles to contract, the producing electrical signals are similar, so MYO armband cannot recognize correctly. Also, MYO armband is very sensitive to the electrical signals from muscles, so some small hand movement may be detected as a hand gesture. Therefore, the threshold for the hand gestures should be increased to reduce the noise hand gestures.

9. Conclusion

MYO armband is a high potential smart device. Making use of it, user can achieve a touch free experience and apply in different dangerous and inaccessible situation. This project is trying to combine MYO armband with robot, the main vision is to provide an unexpected user experience in robot control.

The development of TOUCH3 is in progress, and the progress is satisfied. The table 3 shows the current status and the working schedule. All of the tasks were completed on time. And now, the connection of MYO armband and the creation of self-defined hand gestures are completed. The remaining functionalities will be completed on 29th February, 2015. However, there is a major difficulty in this project. Since the MYO armband can only detect five pre-set hand gestures, the number of hand gesture is not enough for the requirement. The solution is to combine the pre-set hand gestures with arm motion, so the number of hand

gesture can be increased, and provide more gestures for users to manipulate the robot.

Table 3: Schedule of TOUCH3 Development

Tasks		Due Date	Status
Inception	Project Plan	10/4/15	Done
	Project Website		
System Design	Review Preliminary	10/11/15	
	Develop UI Prototype	10/18/2015	
	Review UI Prototype	10/21/2015	
	Review System Architecture	10/25/2015	
Elaboration	Implement UI	11/4/15	
	Develop Connection of MYO armband Functionality	12/31/2015	
	Combine pre-set hand gestures with arm motion	1/4/16	
	Release Demo application	1/9/16	
	Interim Report	1/20/2016	
	Website Maintaining	1/20/2016	
Construction	Develop Connection of Robot Functionality	1/31/2016	In progress
	Develop Remaining Functionalities	2/29/2016	In planning
	Debugging	3/31/2016	
Testing	Release Bate-version application	4/4/16	
	Testing	4/10/16	
Documentation	Project Documents	4/13/2016	
	Final Report	4/15/2016	
Deployment	Final Checking	4/17/2016	
	Release final application	4/17/2016	

All in all, the objective of this project is to remotely control robot by MYO armband. After phase three, a beta version of TOUCH3 will be released, and this objective will be achieved. So this project will focus on the remaining functionalities. Hopefully, the final product of TOUCH3 will be powerful and may contribute to the future robot development.

10. List of Figures

11. List of Tables

13. Reference

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