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Map Navigation using hand gesture recognition: a case study using MYO Connector on Apple Maps

Mithileysh Sathiyanarayanan[a]*, Tobias Mulling[a]*

[a]School of Computing, Engineering and Mathematics
University of Brighton, UK

Abstract

The effect of user experience on user satisfaction metrics in using MYO armband (hand gesture navigation) to control interactive maps and various other applications is still in a research state. In general, usability can be measured in terms of effectiveness, efficiency and satisfaction based on the metrics-task completion, error counts, task times and satisfaction scores. In this paper, we considered only satisfaction metrics. A simple and widely used System Usability Scale (SUS) questionnaire model is implemented to suggest some guidelines about the use of MYO armband. Another questionnaire, with a focus on ergonomic issues related to the use of the device such as Social Acceptability, Ease of use and ease of learning, Comfort and Stress, attempted do discover characteristics of hand gesture navigation using MYO. The results of this study can be used in a way to support the development of interactive maps using hand gesture navigation.

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Keywords: interactive maps; gesture interaction; MYO armband; human motion; usability.

1. Introduction

The use of interactive maps has been widely used in desktop and mobile platforms. With the development of new devices for interaction through the movement of hands and arms, such as Microsoft Kinect, Leap Motion and MYO (object of this study), a new perspective of interaction in interactive maps becomes absorbed by research in the

* Corresponding author. Tel.: +44 (0) 1273 642598
E-mail address: M.Sathiyanarayanan@brighton.ac.uk
T.Mulling@brighton.ac.uk

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human-computer interaction. Due to the fact that a recent technology, there is now a trend on translating the interactive maps of design patterns for this new perspective of interaction, thus evaluating the effectiveness and user satisfaction to interactive these devices. This research aims to understand how users use the main navigation functions in interactive maps by observing users using Apple Maps Connector software, available for the wearable device, MYO armband. In our paper [11], we have a case study using a wearable device (MYO) considering tht characteristics of hand gesture navigation.

In this paper, we explain how MYO armband works and a case study how this armband can be used as a gesture recognition in map navigation. The rest of the paper is organized as follows. In Section 2 we explain hand gestures recognition and map applications. In Section 3, we explain the method intended to carry out and section 4 illustrates the results. Section 5 concludes our discussions in this paper.

2. Hand Gestures Recognition and Navigation

2.1. Hand Gestures and Map Applications

For the design of a software, to understand what gestures should be used and understood by a system and user preferences is important and according to Pavlovic et al. [2], unintentional movements are characterized by not containing any information that may be read by a system. Therefore, a gesture is so named because it contains information [3]. Figure 1(a) illustrates MYO Armband (black band).

The design of interactive maps shows some conventions related to touch screen gestures [4], as Zoom, panning, Focusing, among other commands. To execute the zoom, commonly put two fingers on the screen (Registration), moves the two fingers in accordance with the desired intention to increase or decrease the screen (Continuation) and finally, withdraw up 2 fingers from the screen when the gesture is completed (Termination). When transporting up these interactions to a navigation using hands and arms, changes are needed in the systems. Pang & Ismail [5] also state that users have preferred to use only one hand while browsing, thus avoiding fatigue and unnecessary effort. In this study we will use the Apple Maps software (Figure 1(b)) together with an application that connects to the Maps, allowing control through hand gestures. Although Pang & Ismail [5] have defined gestures for interacting based on user preferences, this study aims to understand how the navigation occurs with the use of a Wearable device with predefined gestures and commands.

(a) (b)

Figure 1. (a) MYO Armband reading electrical signals from muscles. Source: MYO. (b) Apple Maps. Source: Apple Inc.

2.2. Approach

There are different techniques for detecting the movement of the hands in order to interact at an interface. Bhuiyan & Picking [6] found that the use of gestures to control an interface has been researched since the 80's, from different perspectives such as the use of pens that read traces, gloves that allow interaction in displays, rings that transmit gestures generated by the fingers, to commercial devices such as Nintendo WII and Kinect, that interpret the movement of the hands, etc. The gestural interaction has become popular in most games; the use in specific applications is still in embryonic stages, as the accuracy of the devices is still not ideal and a small amount of users have access to them.

To map and interpret hand gestures, two approaches stand out [7]: the first, based on appearance or visualization, establishes the interpretation of gestures from images that are typically generated from a camera (usually transformed into gray-scale images). As a camera allows the interpretation of gestures in just two dimensions, devices like the Microsoft Kinect and more recently Leap Motion are also equipped with an infrared apparatus, capable of capturing the depth (Z axis) of a gesture. With the data generated it is possible to obtain information about the human skeleton and thus provide feedback to the interactions. This has been one of the approaches most commonly used by researchers and developers.

The second approach corresponds to sensors and the use of physical objects to capture the movement of the hand (rather than images). This approach has been mainly used in the past, especially in gloves that captured the movement of each finger, based on the angle and position of them [6]. Currently, this approach is no longer used again due to use of Wearable devices, due to the low cost sensors and possibilities of access to technology. In this perspective, we will discuss the operation of the MYO, used in this experiment.

2.2.1. MYO

The MYO is an armband equipped with several sensors that can recognize hand gestures and the movement of the arms, placed just below the elbow. It is developed by the company Thalmic Labs, being released in the summer of 2014. It is characterized by using a process called electromyography (EMG); identifying the gesture by moving the arm muscles [8]. Based on the electrical impulses generated by muscles, 8 EMG sensors are responsible to recognize and perform each gesture. Therefore, it is necessary for each user to make a calibration step before using the gadget. This is necessary because each user has a different type of skin, muscle size, etc. From these data, and based on machine learning process, the MYO can recognizes the gestures performed.

In addition to the EMG sensors, the MYO also has a nine-axis inertial measurement unit (IMU), which enables the detection of arm movement. IMU contains a three-axis gyroscope, three-axis accelerometer and a three-axis magnetometer. Another important factor related to gestures reading only images approach is that the MYO has a tactile sensor, responsible for transmitting feedback (three types of intervals - short, medium and long vibrations) to the user as he makes a correct move or want to activate the system. For the connection, the gadget used Bluetooth Low Energy technology, which allows a reasonable way to perform tasks.

2.3. Application Analysis

As already mentioned, this study will be used to control a prototype of Apple Maps application known as MYO connector. In this proposal, commands that were driven from the mouse click on a certain button interface are being substituted by gestures. The creative company MYO, Thalmic Labs, provides a SDK to access different device functions. Due to large amount of data generated by every movement of the arm muscles, the gadget is equipped with a processor responsible for analyzing this data and provide an answer only to already standardized commands; The present device provides only a few commands wave as left, right, and spread fist fingers, and that can be combined with the rotational movement, in addition to vertical and horizontal movements. Some researchers [8] have proposed an increase in the vocabulary of gestures, from the use of current MYO gestures with the design of numbers and letters in the 3D space; however, this practice generates a cognitive burden on users, hindering the implementation of gesture and memorizing the gestures. Soon it is expected that the wearable will support other gestures.

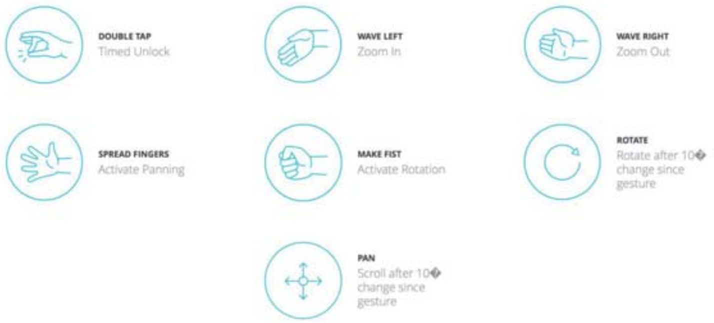


Figure 2. MYO Maps Commands. Source: MYO.

In our study, the MYO app connector allows control and navigation on an interactive map using the gestures described in Figure 2. Note that to activate the MYO you must use the gesture of "double tap"; thus, the device wakes up and starts controlling the Apple Maps.

3. Method

Two questionnaires were used as analytical tools, in order to understand how participants use the Apple Maps software, through a connector app. The first questionnaire addressed in the research presents the results of the SUS model (System Usability Scale), in order to understand the performance of users to the software; Aiming at the comprehension of the ergonomic aspects of gestural interaction through the MYO, a second questionnaire was developed.

In this study, we had 23 participants, pilot (3 participants) and the main study (20 participants), from the University of Brighton, UK which is a multi-cultural hub. We considered only English speakers because of the resources availability but with a mixed gender and a mixed educational background, qualification and experience. The demographic information are given below.

Table 1: Demographics

1. Age = 19 to 32 years	
2. Gender (a) Males = 15 (b) Females = 8	4. Heard about MYO (a) Yes = 2 (b) No = 21
3. Course (a) Computer = 13 (b) Non-computer = 10	5. Heard about controlling maps with hand gestures (a) Yes = 7 (b) No = 16

3.1. SUS Questionnaire

We considered a simple and widely used System Usability Scale (SUS) questionnaire model developed by John Brooke, Digital Equipment Corporation in the 1980s. The SUS model has 10 questions to measure a system usability (or a software under review), where 5 questions are framed in a positive way (odd questions - 1,3,5,7 and

9) and the other 5 questions in a negative way (even questions - 2,4,6,8 and 10). For each question, there is a common 0-4 rating (5-point Likert scale: *Strongly agree = 4* and *Strongly disagree = 0*) and the total score of each participant is multiplied with 2.5 to get the score range between 0-100. Then finally, the average score of all the participants is considered. The total scores are classified as follows: (a) 0-64 - Not Acceptable, (b) 65-84 - Acceptable and (c) 85-100 - Highly Acceptable. We need to consider other factors such as age, experience and feedback from the participants.

3.2. Gesture Questionnaire

A questionnaire related to how gestural interaction occurred during the interaction with the maps application was also designed. For that, users were asked to perform common tasks for navigating interactive maps such as Zoom, panning, Focusing, Among other commands using the predefined commands MYO (spread fingers, wave left, wave right, fist, rotation). The content of the questions was associated with acceptance of the MYO date input device, easy to learn, use, stress and other ergonomics. 20 questions were prepared; for each question, there is a common 0-4 rating (5-point Likert scale: *Strongly agree = 4 and Strongly disagree = 0*). The similarity with the SUS scale questionnaire was intentional so as to maintain a standardization of the questionnaires were filled by the participants.

One of the constraints in this study is that the software used, Apple Maps is not the kind of software designed to be mediated through the MYO device, but suffered an adaptation input on its commands via a connector app.

4. Results and Interpretation

4.1. SUS Results and Analysis

We collected the data based on the SUS questionnaire and the general demographic questions. From the Table 2, the positive questions such as 1,3,5,7 and 9 had achieved high points out of 4 and negative questions such as 2,4,6,8 and 10 had achieved low points out of 4. From the Table 3, the total score of each participant is illustrated. Out of 23 participants, the maximum score achieved is **57.5**, the minimum score achieved is **32.5** and the average score is **49.25.** Based on the SUS model, score **below 64** are not acceptable. So, further investigations were carried out based on the each question asked and the demographic details. The results plotted are shown in Figure 3(a) and (b).

So, to summarise irrespective of the gender and course

- Participants were interested in using MYO in their day-to-day life.
- Participants felt MYO was easy to use but they felt it was unnecessarily complex.
- Participants felt they need support of a technical person to assist them when they use MYO.
- Participants felt there was lot of inconsistency in MYO connector (probably because of latency issues).
- Participants felt confident using MYO but they needed to learn a lot of things before they could get going with it.

Figure 3(a) demonstrates System Usability Scale (SUS) score, overall score (for 10 questions) of each participant. So, the average SUS score of all the participants is 49.25 which is not acceptable as suggested earlier. Figure 3(b) demonstrates average question score of all the twenty three participants. As said earlier, odd questions have high points and the even questions have low points.

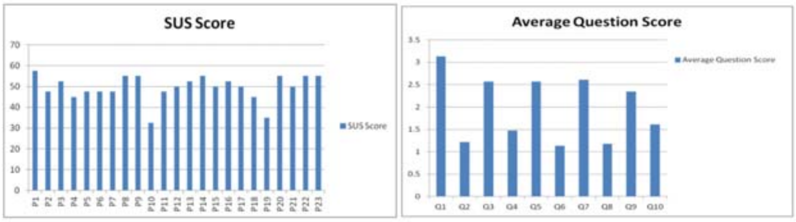
Table 2: Average Points of each Question (Q1 to Q10)

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
3.13	1.21	2.56	1.47	2.56	1.13	2.60	1.17	2.34	1.60

Table 3: Average Score of each participant (P1 to P23)

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
57.5	47.5	52.5	45.0	47.5	47.5	47.5	55.0	55.0	32.5	47.5	50.0

P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23
52.5	55.0	50.0	52.5	50.0	45.0	35.0	55.0	50.0	55.0	55.0



(a) (b)

Figure 3. (a) Bar chart of participants (P1 to P23) overall score. (b) Bar chart of average points for questions (Q1 to Q10) by 23 participants.

4.2. Gesture Results and Analysis

Initially, participants were asked if the MYO device requires prior training to be used. Of the total participants, 20 users (83%) understand that a learning process is necessary to perform the main gestures of the device (which are still very limited). Moreover, 70% of participants believe that the device has a great potential to be exploited in various applications. The following are results on the ergonomic criteria addressed in this study:

- *Social Acceptability:* It is important to understand how the user feels when using a wearable device, which at first seems strange as a kind of extension of the arm. In this sense, the question whether the participants would use the device in their day-to-day life found that most users would not want to utilize the MYO on a daily bases (mode = 1, mean = 1.34, standard deviation = 0.71). On the other hand, when questioning the participants if they feel embarrassed to use the device in public, the general perception is that they do not feel embarrassed to be watched by one (mode = 1, mean = 1.60, standard deviation = 1.11) or more people (mode = 1, mean = 1.11, standard deviation = 1.60) during the interaction in Apple Maps application.

- *Ease of use and learning:* when asked whether the gestures used in the maps application were easy to learn the participants opinionated that they were difficult to learn (mode = 1, mean = 1.78, standard deviation = 0.95). A similar result was found when it was assessed whether the application mediated MYO was easy to use (mode = 1, mean = 1.69, standard deviation = 0.97), demonstrating the difficulty of use. Part of this result, in a negative way, may be linked to the fact that Apple Maps application and its interface are not native to the MYO applications, only adapted to support the interaction of gestures. Another important fact is that, from the observation of the interaction of the participants, it was noticed that the device does not have a precise answer to gestures executed (displays latency) sometimes confusing interpreted gestures and generating frustration in users.

- *Comfort and ability to perform gestures:* the study showed that, despite the problems submitted for the interaction of MYO and Apple Maps, participants felt comfortable not only when using the device but when performing gestures with the same (mode = 5, mean = 4.39, standard deviation = 0.89). On the other hand, when asked if the MYO could improve the ability of participants to perform gestures, most participants stated that the device did not contribute effectively in gestural interaction (mode = 1, mean = 1.26, standard deviation = 0.61). Part of this result may be associated with a possible frustration due to failure of the device already mentioned and the fact that the gestural interaction, from mid-air gestures is not yet widely used in applications other than games.

- *Stress/Effort*: to analyze this criteria, the Likert scale hitherto used was changed to the following classifications: the effort = 1 and stress / painful = 5. Thus participants were asked which the perceived exertion (stress) to perform each of the commands the MYO in Apple Maps application.

  - Wave Left (mode=4, mean=3.73, standard deviation=0.68), used for Zoom In;
  - Wave Right (mode=4, mean=4.04, standard deviation=0.56), Zoom Out;
  - Spread Fingers (mode=4, mean=4.08, standard deviation=0.51), used to activate panning;
  - Fist (mode=4, mean=4.08, standard deviation=0.59), activate rotation;
  - Pan (mode=4, mean=3.95, standard deviation=0.56), to move the map.

Analyzing the results you can see that a major effort is required to run each command in MYO, generating an intense stress when performing each interaction. By observing users during the test, it was revealed that part of the effort was associated with problems in reading sensor of the movement of the muscles (EMG), which sometimes played a gesture the wrong way. The problems related to strength / stress is sanctioned from the general perception of the participants (mode = 4, mean = 3.82, standard deviation = 0.57) to interact with the system.

5. Conclusion and Future Works

System Usability Scale (SUS) is one of the tools to measure user satisfaction. It is a useful, practical quantitative tool for supplementing more reviews and suggestions about software use [10]. That said, SUS ratings are influenced by several factors like user-experience, knowledge about the system, age etc. Other factors could also affect satisfaction ratings such as SUS terminology for non-English speaking users.

Based on the result and observation of users to interact with MYO, one realizes that the wearable device has a potential to be used for controlling interactive maps, but needs improvement in the physical device (MYO) and the software maps (Apple Maps). In relation to gesture recognition, the accuracy of gestures execution should be optimized, because at some interactions the MYO confuses the electrical signals of a gesture to another, thus creating frustration for users and a possible distrust in the system. Furthermore, the execution of actions must be performed with considerable emphasis, leading to an interaction which can lead to fatigue and discomfort to the user. The optimization of MYO gestures reading process by generating a more natural interaction becomes important contribution in order to enhance the user experience using the device [12].

This exploratory study examined how gestural interaction has occurred with potential users of MYO, where it was detected that the device should also evolve in this segment. However, some of the negative reviews may be associated with perception of users on this paradigm of interaction (for not being popular among users), as well as software that need to be designed focusing on not only the interaction from hands and arms, but aligned to navigation and interaction characteristics of each device.

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