MYO Armband for Physiotherapy Healthcare: A Case Study Using Gesture Recognition Application

Mithileysh Sathiyanarayanan
University of Brighton, UK
Email: M.Sathiyanarayanan@brighton.ac.uk

Sharanya Rajan
Fortis Hospital, Bangalore
Email: Sharu.rajan043@gmail.com

***Abstract*—As there is a need for innovative and new medical technologies in the healthcare, we identified Thalmic's "MYO Armband", which is used for gaming systems and controlling applications in mobiles and computers. We can exploit this development in the field of medicine and healthcare to improve public health care system. So, we spotted "MYO diagnostics", a computer-based application developed by Thalmic labs to understand Electromyography (EMG) lines (graphs), bits of vector data, and electrical signals of our complicated biology inside our arm. The human gestures will allow to gather huge amount of data and series of EMG lines which can be analysed to detect medical abnormalities and hand movements. This application has powerful algorithms which are translated into commands to recognise human hand gestures. The effect of doctors experience on user satisfaction metrics in using MYO armband can be measured in terms of effectiveness, efficiency and satisfaction which are based on the metrics-task completion, error counts, task times and satisfaction scores. In this paper, we considered only satisfaction metrics using a widely used System Usability Scale (SUS) questionnaire model to study the usability on the twenty-four medical students of the Brighton and Sussex Medical School. This helps in providing guidelines about the use of MYO armband for physiotherapy analysis by the doctors and patients. Another questionnaire with a focus on ergonomic (human factors) issues related to the use of the device such as social acceptability, ease of use and ease of learning, comfort and stress, attempted to discover characteristics of hand gestures using MYO. The results of this study can be used in a way to support the development of interactive physiotherapy analysis by individuals using MYO and hand gesture applications at their home for self-examination. Also, the relationship and correlation between the signals received will lead to a better understanding of the whole myocardium system and assist doctors in early diagnosis.**

***Index Terms*—MYO armband; gesture interaction; human gestures; human-computer interaction; usability; physiotherapy; healthcare.**

I. INTRODUCTION

The field of interactive systems has grown tremendously in the last decade as many research contributions have demonstrated its relevance and impact in the field of manufacturing, planetary exploration, medicine, healthcare, military, and consumer products. After successful prototype versions of medical interactive systems, there is a strong need for using these systems in the medical and health care field. Many countries are engaged in developing various types of interactive systems, including medical robots and provides funds for research and development. Also, India is providing massive funding opportunities in evolving technology and enterpreunureal mindset in the market, which means - the startups will revolutionize the future of innovations in our country and benefit the healthcare systems.

People developing these systems need a strong passion for designing systems, robotics and artificial intelligence. The utilization of interactive systems technology is effectively and generally utilized with the end goal of proficiency. The automated innovation in interactive systems not just explores outside activities, but also applied more into sciences that includes the space, defence, and underwater systems. The on-going advancement of this sort of innovation is acknowledged and has a great welcome in almost all the fields now.

The birth of human interactive systems idea will help in the medical industry that will make full use of the innovative ideas. Different varieties, built, styles, and mobility are created yearly, more specifically the human inspired or humanoid robots that can act and think like humans and act like humans. The on-going development of this kind of invention is appreciated and somewhat inspired the medical and health care field. With the possibility of computer intervention, it is expected that the thrust of getting better in medicinal care will be on a high. The success will rely on how efficient the interactive systems are in the health care field and how useful it is for the patients. To understand the success of any new technological systems to be used in the healthcare field,"doctors' satisfaction metrics" will play an important role.

In this paper, we identified a gesture interactive system (physical device) called "MYO Armband" and a computer-based application (software) called "MYO Diagnostics" which can be used to understand Electromyography (EMG) lines (graphs), bits of vector data, and electrical signals of our complicated biology inside our arm. This application has powerful algorithms which are translated into commands to recognise human hand gestures. The human gestures will allow to gather huge amount of data and series of EMG lines which can be analysed to detect medical abnormalities and hand movements. So, the main aim of the paper is to understand "doctors' satisfaction metrics" of using MYO armband on the patients using a widely used System Usability Scale (SUS) questionnaire model on the twenty-four medical students of the Brighton and Sussex Medical School. This helps in providing guidelines about the use of MYO armband for physiotherapy treatment by the doctors. Another questionnaire, with a focus on ergonomic issues related to the use of the device such

978-1-4673-9622-6/16/$31.00 ©2016 IEEE

as social acceptability, ease of use and ease of learning, comfort and stress, attempted to discover characteristics of hand gestures using MYO as considered in [1], [2]. The results of this study can be used in a way to support the development of interactive physiotherapy treatment using MYO and hand gesture applications.

The rest of the paper is organised as follows. In the Section II, we explain the MYO armband and MYO diagnostics which are used for general applications. Section III describes the methodology of the conducted user study (two studies). Section IV discusses the results from the two studies. At the end of this paper, conclusions and future works are discussed in the Section V.

II. MYO Armband and MYO Diagnostics

The MYO armband is a device developed by the company Thalmic Labs which can be worn on the arm (placed just below the elbow) to interact with the systems. The MYO is equipped with several sensors that can recognize hand gestures and the movement of the arms. It is characterized by using a process called electromyography (EMG); identifying the gesture by moving the arm muscles [3]. 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 which will help the MYO recognize the gestures performed [1], [2].

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. One must make sure, the Bluetooth adapter is plugged in and have a look at the Bluetooth signal (and its strength), get a reading from each of the eight EMG sensor pods in the armband, check out the motion control of the IMU, test your gesture recognition, play with haptic feedback, and so on [1], [2].

Pavlovic et al. [4] says, to understand what gestures should be used and understood by a system, user preferences is important. Fig. II (a) illustrates MYO Armband (black band) and (b) illustrates the internal and external units in the MYO Armband.

The design of interactive MYO Diagnostics shows some conventions related to touch screen gestures [4], as zooming, panning, focusing, rotating, waving and among other commands. In this study, we will use the MYO controls as showed in the Fig. 2, where an application that connects to the MYO diagnostics, allowing control through hand gestures. The previous results on Apple map navigation is in [1], [2].

The main task is to perform the hand gestures and to visualize the graphs of three axis (gyroscope, accelerometer and orientation). The lines can be straight or curvy or irregular. The presence, size, and shape of the wave form (the action potential) produced on the application provide information about the ability of the muscle to respond to nervous stimulation. Each muscle fiber that contracts produces an action potential. The size of the muscle fiber affects the rate (how frequently an action potential occurs) and the size (the amplitude) of the action potential [1], [2].

Although Pang and Ismail [5] have defined gestures for interacting based on user preferences, this study aims to understand how the reading of signals occur with the use of a wearable device with predefined gestures and commands. This paper aims to understand how users (doctors and patients) use the main gesture commands in interactive MYO Arm diagnostics using a wearable device. This will help us exploit more interactive features that will allow to gather huge amount of data and series of EMG lines which can be analysed to detect medical abnormalities and hand movements of patients. Also, support the development of interactive physiotherapy analysis by using the device and the applications at home.

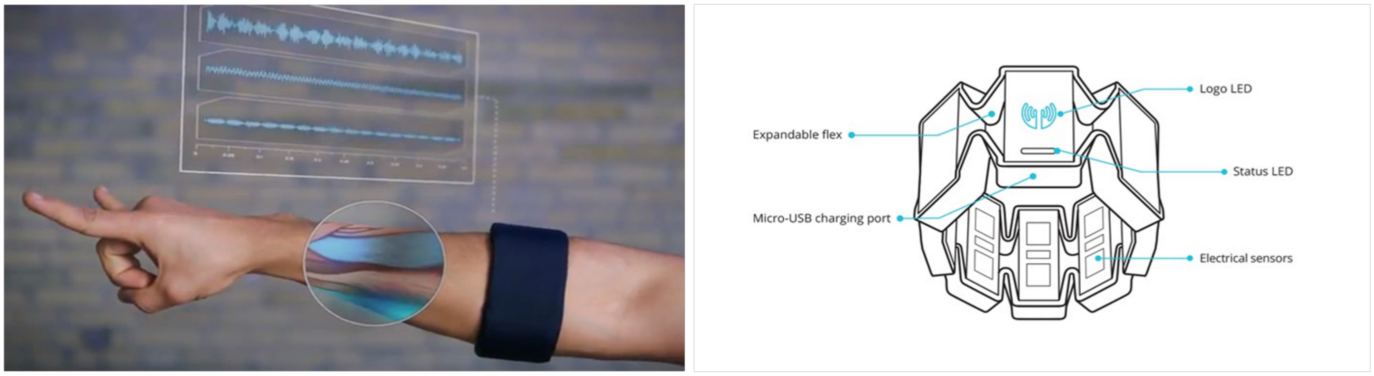
III. Study Method

In this study, we used MYO Armband (physical device) and MYO Diagnostics (computer application) to understand Doctors' satisfaction metrics, so that they can motivate their patients to use it for self-examination at home. The study had 24 participants, medical students (we eliminated one participant due to error in the results) from the Brighton and Sussex Medical School, UK which is a multi-cultural hub and the demographic information are given below. In order to come up with guidelines and solutions, we designed two types of questionnaires:

1) The first type of questionnaire is based on the SUS model (System Usability Scale), in order to understand the performance of doctors to the MYO Diagnostics;
2) The second type of questionnaires aimed at the comprehension of the ergonomic aspects of gestural interaction through the MYO Armband.

The screenshot of our MYO Armband is shown in the Fig. 3. The screenshot of the MYO Diagnostics application, before and after the gesture movements are shown in the Fig. 4 and Fig. 5 respectively.

Study 1: The SUS model questionnaire has 10 questions to measure a system usability (or a software under review), where odd questions are framed in a positive form and the other even questions in a negative form. For each question to be rated between 0 and 4 (5-point Likert scale, where 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



(a) (b)

Fig. 1. (a) MYO Armband reading electrical signals from muscles. (b) Internal and external units in the MYO Armband. Source: MYO

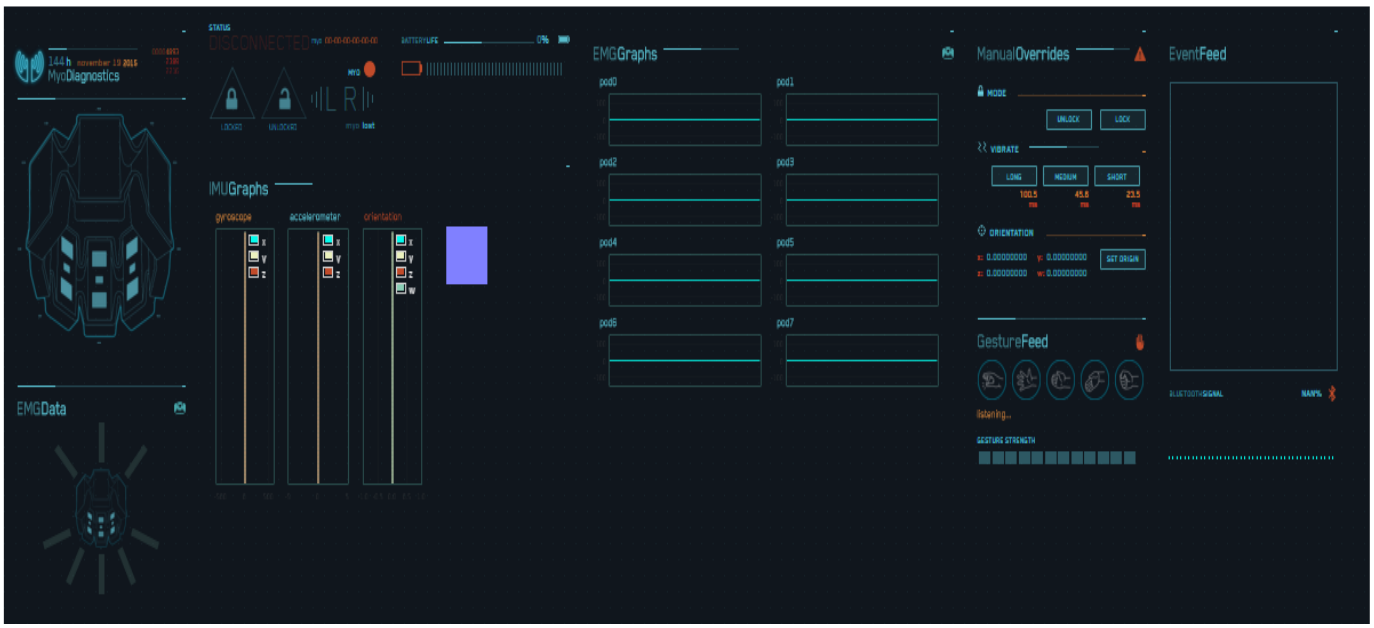


Fig. 4. Screenshot of the MYO Diagnostics application: before the gesture movements. Source: MYO

other factors such as age, experience and feedback from the participants.

Study 2: The gestural interaction questionnaire had 20 questions which was associated with acceptance of the MYO - input device, easy to learn, use, stress and other ergonomics. For that, users were asked to perform common tasks for gestures such as zooming, panning, focusing, rotating and waving (spread fingers, wave left, wave right, fist, rotation). Again, each question to be rated between 0 and 4 (5-point Likert scale, where Strongly agree = 4 and Strongly disagree = 0).

The results of both the studies are explained in the next section.

IV. Study Results

A. Study 1 Results

From the SUS questionnaire data collected, the positive questions (such as 1,3,5,7 and 9) achieved high values out of 4 and negative questions (such as 2,4,6,8 and 10) achieved low values out of 4. From the Table 3, the total score of each participant is illustrated. Out of 23 participants, the maximum score achieved is 76.22, the minimum score achieved is 65.12 and the average score is 69.21. Based on the SUS model, score above 64 are *acceptable*. So, further investigations were carried out based on the each question asked and the demographic details. The results plotted are shown in Fig. 6(a) and (b) . So, to summarise irrespective of the gender:

- Medical students were interested in using MYO in their day-to-day life and happy to suggest to the patients in

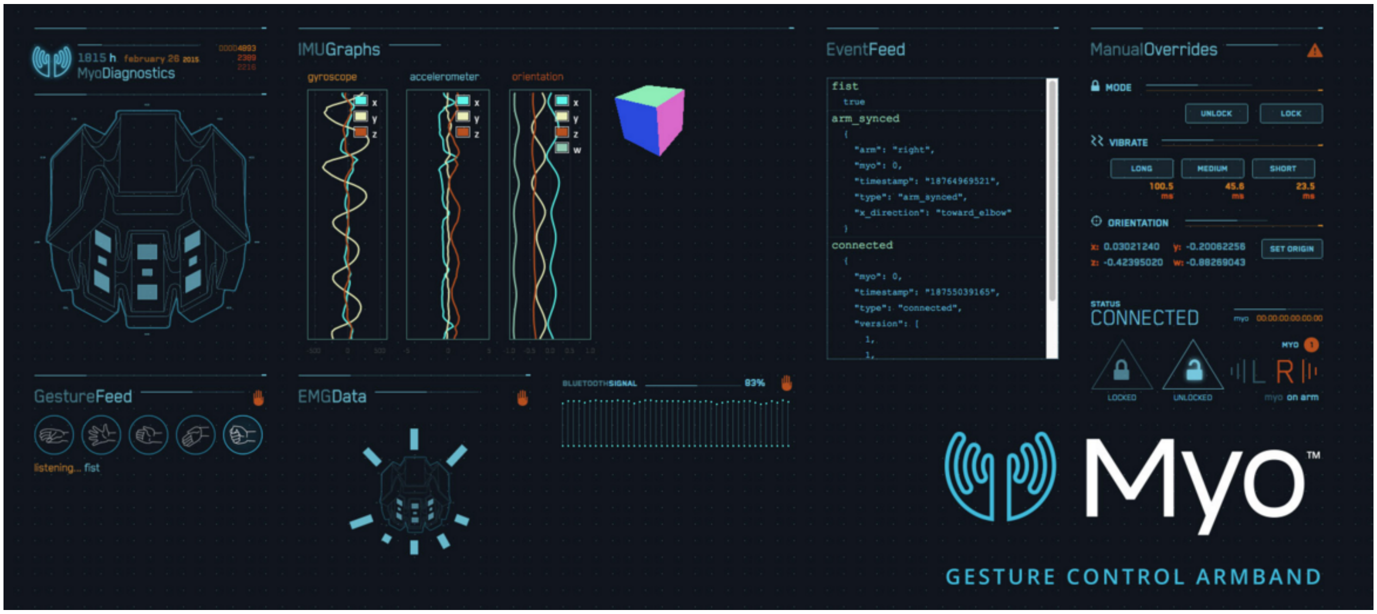


Fig. 5. Screenshot of the MYO Diagnostics application: after the gesture movements. Source: MYO

future.
- Medical students felt MYO was easy to use but they felt it was unnecessarily complex.
- Medical students felt they don't need support of a technical person to assist them when they use MYO.
- Medical students felt there was lot of inconsistency in MYO connector (probably because of latency issues).
- Medical students felt confident using MYO but they needed to learn a lot of things before they could get going with it.

Fig 6(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 69.21 which is *acceptable* as suggested earlier in the SUS description. Fig 6(b) demonstrates average question score of all the twenty three participants. As described earlier, odd questions have high values and the even questions have low values.

B. Study 2 Results

From the data collected, most of the participants felt a proper training at the start was required in order to perform the main gestures and to visualize the graphs of three axis (gyroscope, accelerometer and orientation). Questions were asked on the axis lines: (a) Is the line straight or curvy or irregular?

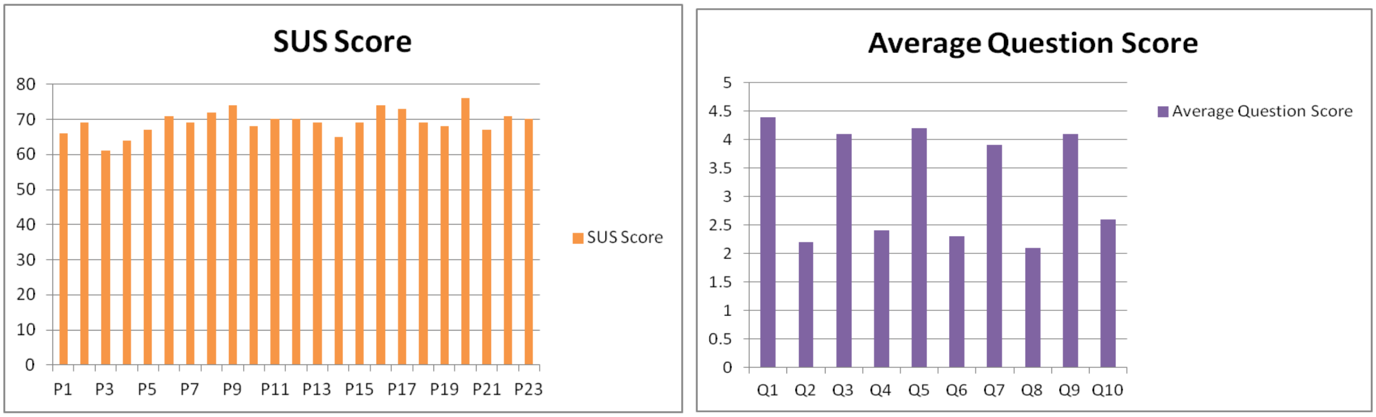
The following are results on the ergonomic criteria addressed in this study:

- Social Acceptability: We were interested to know how the user feels when using MYO Armband to analyse his/her own movements. So, the question was asked "would you like to use the MYO in your day to-day life and will you recommend to your patients in the future?". The results were positive, the participants supported the use of MYO (mode = 4, median = 4, standard deviation = 0.54).
- Ease of use and learning: We were interested to know if the application was easy to learn using MYO. So, the question was asked "Is the gestures used in the application easy to learn?". The participants opinionated that they were not very difficult to learn (mode = 4, median = 4, standard deviation = 0.55). We also noticed that the device does not have a precise answer to gestures executed (displays latency) sometimes confusing interpreted gestures and generating frustration in users.
- Comfortableness: Participants felt comfortable not only when using the device but when performing gestures with the same (mode = 5, median = 5, standard deviation = 0.67).
- Stress/Effort: to analyze this criteria, the Likert scale was changed to the following classifications: the effort = 1 and stress / painful = 5. Thus participants felt some effort is needed to perform the gesture commands.

By observing users during the test, we understand that the effort was associated with problems in reading sensor of the movement of the muscles (EMG), which indicated a gesture the wrong way. Improving the sensor reading and adding more interesting reading features in the application will improve the results.

V. Conclusion and Future Works

In order to come up with guidelines and solutions for using the MYO Armband (physical device) and the MYO Diagnostics (software application), we designed two types of questionnaires for the twenty four participants (medical students):



(a) (b)

Fig. 6. (a) Bar chart of participants (P1 to P23) overall score. (b) Bar chart of average values for questions (Q1 to Q10) by 23 participants.

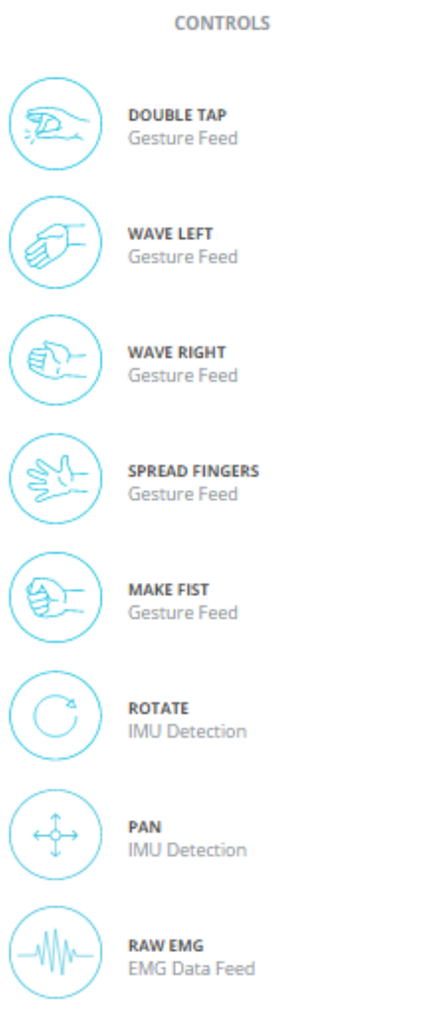


Fig. 2. MYO Armband Controls for the MYO Diagnostics. Source: MYO

Fig. 3. MYO Armband used in the case study

1) The SUS model (System Usability Scale) to understand the performance of the doctors using the MYO Diagnostics
2) The comprehension of the ergonomic aspects of gestural interaction using the MYO Armband.

Based on our observation of using the MYO Armband and the Diagnostics application, we understand the participants have accepted the use of the device for their day-to-day life and for their patients (SUS results). Ergonomic issues related to the use of the device such as social acceptability, ease of use and ease of learning, comfort and stress, attempted to discover positive characteristics of hand gestures using the device. So, based on the positive results, we propose that the wearable device MYO has a potential to be used for understanding one's arm movements during the physiotherapy stage. The users can visualize the graphs displayed in the application (gyroscope, accelerometer and orientation). The lines can be straight or curvy or irregular. Their presence, size, and shape of the wave form produced in the application provide information about the ability of the muscle to respond to nervous stimulation.

Each muscle fiber that contracts produces an action potential. The size of the muscle fiber affects the rate (how frequently an action potential occurs) and the size (the amplitude) of the action potential.

With respect to the gesture recognition, the accuracy of gestures execution should be optimized because of consistent delays (latency issues) which frustrates and discomforts the users. Also, the software application needs to be improved in terms of response from the sensors, more focus is needed on the interaction characteristics. Adding more features considering the physiotherapy treatment will attract more doctors and the patients to use the system at their home. Finally, MYO Armband in the market is not very expensive and the application (MYO Diagnostics) is free of cost.

Our future aim is to improve the device accuracy and the sensing precision along with the improvement of the software features which will have more user interactions from the physiotherapy treatment point of view along with some interesting visualization [6], [7], [8]. We also aim to analyze the different signals received and find the correlation between them which can possibly lead to a better understanding of the whole myocardium system and assist doctors in early diagnosis. Also, our long term goal is to develop a prototype Interactive Medical Robot (IMR) for physiotherapy which will be beneficial for researchers and practitioners in the medical field. Finally, we are eager to work with the MYO to improve the healthcare system - https://www.myo.com/smartglasses/.

References

[1] T. Mulling and M. Sathiyanarayanan, "Characteristics of hand gesture navigation: a case study using a wearable device (myo)," in *Proceedings of the 2015 British HCI Conference*. ACM, 2015, pp. 283–284.

[2] M. Sathiyanarayanan and T. Mulling, "Map navigation using hand gesture recognition: A case study using myo connector on apple maps," *Procedia Computer Science*, vol. 58, pp. 50–57, 2015.

[3] Z. Lu, X. Chen, Q. Li, X. Zhang, and P. Zhou, "A hand gesture recognition framework and wearable gesture-based interaction prototype for mobile devices," *Human-Machine Systems, IEEE Transactions on*, vol. 44, no. 2, pp. 293–299, 2014.

[4] V. Pavlovic, R. Sharma, T. S. Huang *et al.*, "Visual interpretation of hand gestures for human-computer interaction: A review," *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, vol. 19, no. 7, pp. 677–695, 1997.

[5] Y. Pang and N. Ismail, "Users preferences for map navigation gestures," vol. 9, no. 1, pp. 77–83, 2015.

[6] M. Sathiyanarayanan and N. Burlutskiy, "Design and evaluation of euler diagram and treemap for social network visualisation," in *Communication Systems and Networks (COMSNETS), 2015 7th International Conference on*, Jan 2015, pp. 1–6.

[7] M. Sathiyanarayanan and T. Mulling, "Wellformedness properties in euler diagrams: An eye tracking study for visualisation evaluation," in *Human Factors in Computer Systems (IHC), 2015 14th Brazilian Symposium on*, Nov 2015.

[8] M. Sathiyanarayanan and T. Mulling, "An eye tracking study on the wellmatchedness principles in euler diagrams," *Journal of Usability Studies*, 2015.