Controlling a Robot Using a Wearable Device (MYO)

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***Abstract* - There is a huge demand for military robots in almost all the countries which comes under the field of human-computer interaction and artificial intelligence. There are many different ways of operating a robot: self controlled, automatic controlled etc. Also, gesture controlled operation mode is on the rise. This acted as our motivation to develop a gesture controlled robot using MYO armband. The word 'MYO' has created a buzz in the technological world by its astonishing features and its utility in various fields. Its introduction as a armband that can wrap around our arm to control robots with our movements and gestures has opened new wide doors of its experimentation with robotics. This independently working gesture recognition system does not rely on any external sensors (motion capturing system) as it has its sensors embedded in itself which recognizes the gesture commands and acts accordingly. This armband can be worn by soldiers to operate robots to fight against enemies. This work in progress paper illustrates an existing robot designed by us, which can be controlled by hand gestures using a wearable device called as MYO. We would like to investigate more on this and implement, such that the robot can be interfaced with a MYO armband for a successful control.**

***Index Terms* - Unmanned Ground Vehicle, Robot, Artificial Intelligence, Human-Computer Interaction.**

I. INTRODUCTION

In real world robotic systems, communication exist between humans and computer based systems/communication systems. Hand gesture is one of the imperative methods of communication for people to control the systems, which we call as gesture controlled. There is an active research being carried out in hand gesture recognition systems because of its applications for human computer interaction and virtual environments. We initially developed a prototype command controlled robot, automatic controlled robot and gesture controlled robot using gloves. In situations which do not permit the Unmanned Ground Vehicle (UGV) to be operated with base station assistance (manual and auto control), an alternative to tackle such problem is to provide gesture control mode for soldiers to maneuver UGV. The introduction of MYO[1] as a armband that can wrap around our arm to control robots with our movements and gestures has opened new wide doors of its experimentation with robotics.

The MYO experience begins with the MYO Connect. In addition to mediating software access to the MYO armband and providing basic control over some applications, MYO Connect helps you set up and explore the MYO armband's capabilities. MYO Connect aids in controlling your presentations by changing the slides with your gestures, adjusting the volume of your computer or manipulating any features of any applications, with MYO nothing seems difficult or cumbersome. Though multitasking using MYO is still under consideration.

In this paper we explain how MYO armband works and the design of the unmanned ground vehicle which will be controlled by hand gestures using MYO armband which forms the creativity and novelty in this research. The rest of the paper is organized as follows. In Section 2 we explain the concept of gesture control mode for operating UGV. In Section 3, we explain the results. Section 4 concludes our discussions in this paper.

II. MYO ARMBAND AND NAVIGATION

For the design of a software, to understand what gestures should be used and understood by a system and user preferences is important [1]; this is relevant because we are constantly running movements with our hands, to express/communicate different situations and emotions. In order to classify gestures and identify them - posterior allowing reading - it is important to understand the structure of a gesture and its taxonomy. 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].

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 [4]. 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. Other components of MYO includes a lithium rechargeable battery, an ARM processor, Bluetooth 4.0 LE, a micro USB port for charging, and best among all is the wireless compatibility with PCs, Macs, iOS and Android [4].

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

[1] https://www.thalmic.com/myo/ [Accessed on 16th July 2015].

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 [4].

MYO has the potential to offer gesture controls where things like a Kinect sensor wouldn’t work. Its working is really simple as the task consists of programming the gestures into the device and defining them as per our requirements, then wrapping the device around one’s hand and using our defined gestures to witness the desired effect. The armband can be turned on and off by enabling or disabling respectively. MYO very well replaces keyboard while playing any video games as in when you desire to fire a gun, you may make gesture using your fingers. In order to increase the degrees of freedom you can allow another MYO to grip your second hand. A perfect synchronization among motion sensors and muscle activity sensors enables to track different gestures. MYO is worn on the forearm and it works by using a biosensor to pick up minute electrical impulses in the user's arm muscles. This helps users in wirelessly controlling and interacting with computers and other digital gadgets using simple, intuitive movements such as moving their wrist, tapping their fingers together or making a fist. MYO gives you the 10-foot experience of controlling your computer and digital tech. The more advanced user would be using MYO for their smart home with connected devices and light bulbs. MYO is also working with Bluetooth beacons to control specific devices in each room, and it's featured in the Logitech booth at CES 2015, to show how MYO can be used to control any existing home theatre as shown in Figure 1.

Figure 1. MYO Armband

The figure 2(b) gives you a glimpse of the physical structure of the MYO. The eight segments of expandable casing enclose the MYO armband’s components and are connected using stretchable material that allows them to expand and contract relative to each other, so that the MYO armband can comfortably fit each user's unique physiology . The electrical sensors measure electrical signals travelling across the user's arm, which the MYO armband translates into poses and gestures. The USB charging port allows you to charge the MYO armband's internal battery using a USB power adapter or a conventional USB port on a computer. The logo LED shows the sync state of the MYO armband. It pulses when the MYO armband is not synced. The LED becomes solid when you perform the Sync Gesture successfully and the MYO armband is synced to your arm. The status LED shows the current state of the MYO armband. It lights up in blue once the MYO armband is connected to a device. The MYO armband is connected to a device (e.g. a computer, tablet, or Smartphone) using Bluetooth 4.0 Low Energy [4].

The software development kit (SDK) takes care of all of the low level details related to Bluetooth connections and data transmission. At its core, the MYO armband provides spatial data and gestural data to an application. Spatial data informs the application about the orientation and movement of the user's arm. The SDK provides data to the application in the form of events. There are three categories of events. Spatial events (corresponding to spatial data from a MYO armband), gestural events (corresponding to gestural data using a MYO armband) and auxiliary events. Generally, spatial events occur regularly at some fixed rate, whereas gestural events occur irregularly. For example, a pose event will occur whenever the MYO armband has detected that the wearer has changed their hand's configuration to one of the detected poses. An orientation event, on the other hand, will occur regularly at the rate at which the MYO armband updates its internal measurement of the orientation. Auxiliary events typically occur infrequently and correspond to situations such as the MYO armband becoming disconnected or connected. While the SDK will generally maintain a connection with the MYO armband once it is established, it will inform the application when the MYO armband is disconnected. This might happen, for example, when the MYO armband is moved out of range of the device it has been connected to. All types of events identify the MYO armband from which they occurred and provide a time detail at which the event occurred. For example, one pose represents the hand making a fist, while another represents the hand being at rest with an open palm.

The MYO armband provides information about which arm it is being worn on and which way it is oriented with the positive x axis facing either the wrist or elbow. This is determined by a Sync Gesture performed upon putting it on. The MYO armband similarly detects when it has been removed from the arm. An application can provide feedback to the wearer of the MYO armband by issuing a vibration command. This causes the MYO armband to vibrate in a way that is both audible and sensed through touch.

(a) (b)

Figure 2. (a) MYO Armband reading electrical signals from muscles. Source: MYO. (b) Structure of MYO Armband. Source: MYO.

III. PROPOSED GESTURE CONTROLLED MODE

The aim of this proposed gesture control mode is to enable gesture functioning of the unmanned ground vehicle (UGV) using MYO without base station assistance. To accomplish this operation, hand gesture commands need to be acquired using inertial measurement unit (IMU) and then be transferred wirelessly using Zigbee technology. Other than MYO concept in robotics, rest are from the literature [5, 6, 7, 8]. Sathiyanarayanan et al., [9, 10] successfully built a robot which could be controlled by hand gestures using hand gloves. In this paper, the hand gloves are replaced by MYO armband and the efficiency will be tested for practical implications.

The main tasks of the gesture control mode are:

- The hardware components should be connected and tested completely: Arduino Microcontroller, Servo Motor, Dc Motor, Inertial Measurement Unit, Zigbee Radio Modem, 78xx Ic's, Electromagnetic Compass Module, GPS Receiver System, H-Bridge, Lithium Polymer Battery, Ftdi Chip, Webcam, 2x Relay Board, IR Sensors, Nickel-Cadmium Battery.
- Gesture control mode is implemented when situations do not permit the UGV to be operated with base station assistance (manual and auto control).
- UGV is capable of travelling from one point to another using hand gestures commands from users.
- Hand gesture commands are acquired using inertial measurement unit and transferred wirelessly using Zigbee technology.
- For these tasks to be performed, hand gesture commands need to be acquired completely using inertial measurement unit and transferred wirelessly using Zigbee technology.

The proposed gesture control mode is quite straightforward to design theoretically but implementing practically is a challenging one. In this paper, we describe only the theoretical design and the implementation will be the future work.

The two sides of the proposed gesture control mode are as follows:

1. MYOARM SIDE (MYOARM Controller Side)
   - The user wraps the MYO armband around his arms, calibrates the MYO and starts moving his hand for the robot to move according to his desire.
   - First, MYO provides H-level (horizontal) and V-level (vertical) values based on the inclination along x and y axis of the ground.
   - We have assumed a range of 30 degrees along both the positive and negative directions.
   - Values are serially monitored and transmitted by Arduino and Zigbee respectively.

2. UGV SIDE (Robot Side)
   - UGV monitors serial input for the received characters and makes the subsequent decisions.
   - The following functions are executed in response to the character sent [up(), down(), left(), right(), halt()]. We have provided Clockwise and anticlockwise pin assignment for forward and reverse movement of the UGV.
   - Dedicated PWM signal pin for 80 - 120 degrees range of servo turn is maintained and H - Bridge Enable control is being utilized for braking.

At the Unmanned Ground Vehicle (UGV) side, from user, UGV obtains the complete information to move along which direction. So basically, navigation signals are controlled by the user using hand gestures. The gesture control mode is based on the

Figure 3. The flow chart of gesture control mode for operating UGV is shown in the Figure 4. The range and characteristics of using MYO are given in the Figure 5.

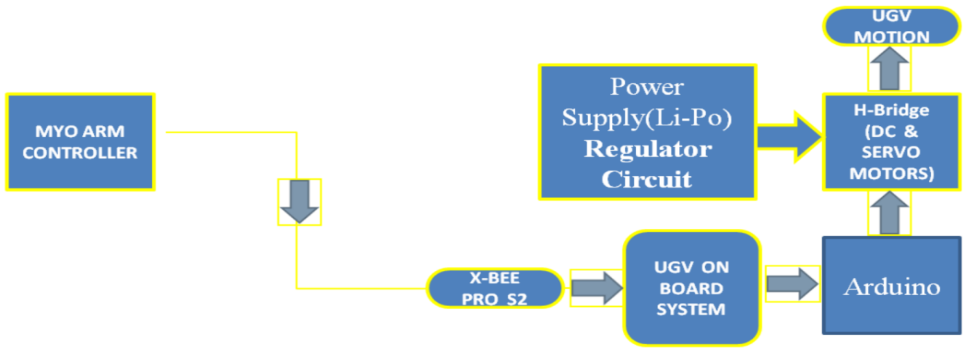

Figure 3. Block Diagram for controlling a robot using MYO Armband

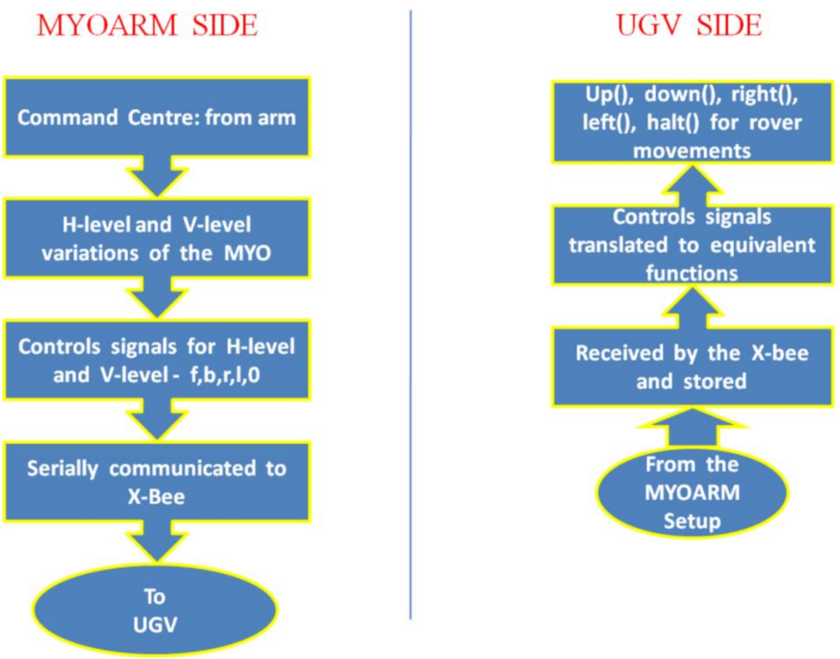

Figure 4. Flow Chart of the Gesture Controlled Robot

Range	Character sent	Objective
V-level > 30	F	Forward
V-level < -30	B	Reverse
H-level > 30	R	Right
H-level < -30	L	Left
-30<= V-level >=30 -30<= H-level >=30	0	Stop

Figure 5. Range and Characteristics of using MYO Armband

IV. RESULTS

Result 1: We designed and developed a robot capable of performing hand gestures using Aurduino and Zigbee [9, 10] as shown in Figure 6.

Result 2: We measured usability in terms of satisfaction metrics for using MYO armband (hand gesture navigation) to control Apple Maps and various other applications [11, 12]. A simple and widely used System Usability Scale (SUS) questionnaire model was implemented to suggest some guidelines about the use of MYO armband. The user-feedback and observations found during our testing have led us to offer some practical insights to designers and developers on how the prototype software can be extended.

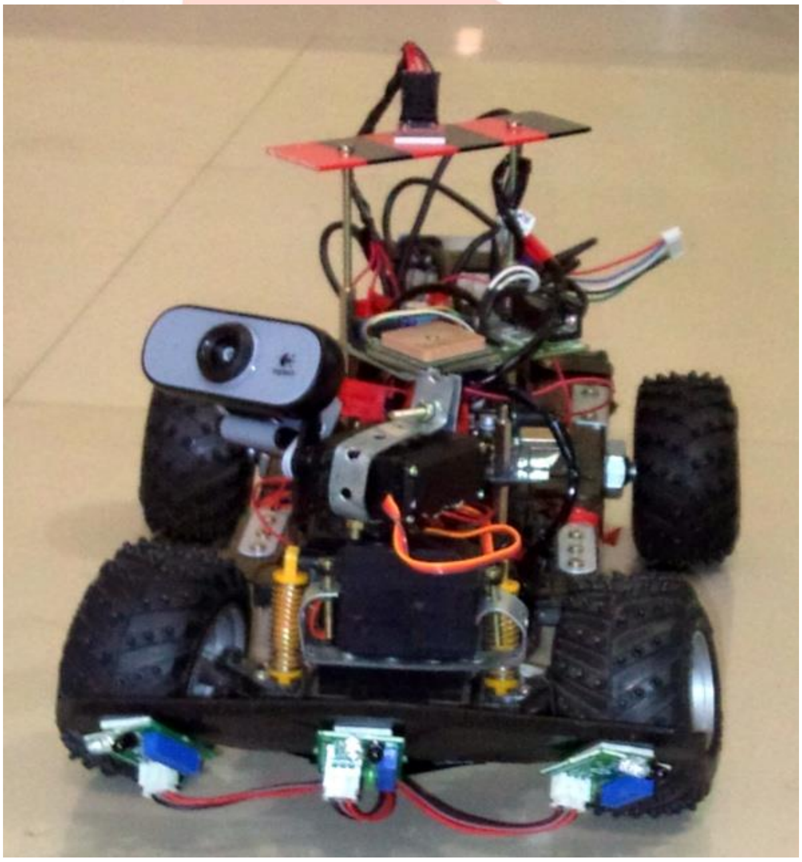

Figure 6. Gesture Controlled Robot [9, 10]

V. CONCLUSION

Robotics has invaded almost every field but its tie-up with MYO is more promising. Myorobotics which witnesses the merge of Cognitive Systems and Robotics has come into existence to make musculoskeletal robots readily available to researchers working in robotics and other domains (e.g. cognition, neuroscience), educators and the industry.

The structurally simple but electronically complicated armband can avoid our dependence on huge control systems. Gone are those days when we had to maintain and manage separate controllers for the robots. This simple wearable band enables us to control and command our robots with our gestures. With the birth of MYO dimensions of research on robotics has broadened. The optimization of the controller's performance and the simulation of MYO interaction with the environment and the robot will be the key to this research. Practical implementation will help us gain in-depth analysis and optimization techniques.

MYO technology can be very well implemented in video games for shooting enemies using gestures or by triggering fingers. Focusing on the application of such technology, this feature can be very well used by the Defence Department of any country for pointing the enemies and shooting them with the help of Gesture Controlled Robots using MYO. This will reduce our dependence on any external tracking system which will first track the happenings of the surroundings, identify the enemy, target them and then shoot making the whole process a time consuming one. The MYO armband will give you raw EMG data from the 8 sensor pods, orientation and acceleration data from the IMU, and pose data from our classifier informing you of which pose you are making with your hand.

The Clearpath Husky Unmanned Vehicle[2] is a budding example to display the merge of Robotics with MYO. The MYO has been effectively synchronized with Husky to control its movements in all directions. Velocity and braking of Husky are also well controlled using MYO. It's just the start of experiments with MYO. We are focused on finding new and intuitive ways to program and control collaborative robots. Collaborative robots are those skilled robots that can work side by side with humans and can contribute in the workplace. By combining years of robotic experience with the latest innovative wearable technology like MYO new dimensions of research, experimentation and application can be unlocked.

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REFERENCES

[1] R. Aigner, D. Wigdor, H. Benko, M. Haller, D. Lindlbauer, A. Ion, S. Zhao, and J. T. K. V. Koh, "Understanding Mid-Air Hand Gestures : A Study of Human Preferences in Usage of Gesture Types for HCI," p. 10, 2012.

[2] V. I. Pavlovic, R. Sharma, and T. S. Huang, "Visual interpretation of hand gestures for human-computer interaction: A review," IEEE Trans. Pattern Anal. Mach. Intell., vol. 19, no. 7, pp. 677–695, 1997.

[3] D. Wigdor and D. Wixon, Brave NUI world: designing natural user interfaces for touch and gesture, 1st ed. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2011.

[4] A. Chaudhary, J. . Raheja, K. Das, and S. Raheja, "Intelligent Approaches to interact with Machines using Hand Gesture Recognition in Natural way: A Survey," Int. J. Comput. Sci. Eng. Survey., vol. 2, no. 1, pp. 122–133, 2011.

[5] K. Qian, N. Jie, and Y. Hong, "Developing a Gesture Based Remote Human-Robot Interaction System Using Kinect." International Journal of Smart Home 7, no. 4, 2013.

[6] S. Waldherr, R. Roseli, and T. Sebastian, "A gesture based interface for human-robot interaction." Autonomous Robots 9, vol 2, pp. 151-173, 2000.

[7] J. Triesch, and V.D.M Christoph, "A gesture interface for human-robot-interaction." In 2013 10th IEEE International Conference and Workshops on Automatic Face and Gesture Recognition (FG), pp. 546-546. IEEE Computer Society, 1998.

[8] D.M.Gavrila, "The visual analysis of human movement: A survey."Computer vision and image understanding 73, no. 1 (1999): 82-98.

[9] M. Sathiyanarayanan, S. Azharuddin, and S. Kumar, "Four Different Modes To Control Unmanned Ground Vehicle For Military Purpose." International Journal of Engineering Development and Research, vol. 2, no. 3 (Sept 2014). IJEDR, 2014.

[10] M. Sathiyanarayanan, S. Azharuddin, S. Kumar, and G. Khan, "Gesture Controlled Robot for Military Purpose." International Journal for Technological Research in Engineering 1, no. 11 (2014): 1300-1303.

[11] T. Mulling, and M. Sathiyanarayanan, "Characteristics of Hand Gesture Navigation: a case study using a wearable device (MYO)", Proc. of the 29th British Human Computer Interaction (HCI), pp. 283-284, ACM, July 2015.

[12] M. Sathiyanarayanan, and T. Mulling, "Navigation using hand gesture recognition: a case study using MYO Connector on Apple maps", the Second International Symposium on Computer Vision and the Internet (VisionNet'15), Kochi, India, Elsevier Procedia Computer Science, August 2015 (accepted).

[2] http://www.clearpathrobotics.com/press_release/drive-robot-with-arm-motion/ [Accessed on 16th July 2015].