

Real Time Gesture-Controlled Mobile Robot using a Myo Armband

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Abstract

In this work, we demonstrate a hand-gesture controlled mobile robot with omni-directional movement capability. Hand-gesture control is achieved using a Myo armband. When compared to a hand-held control device, hand-gesture control has the advantage of full robot observability rather than having the operator mainly focusing on the remote control device. Myo armband control has the primary advantage of low-cost and significantly fewer computing algorithms when compared to a vision-based gesture control. In this work, the hand gesture is recognized using an wearable arm device, which has EMG sensors that measure the electrical signals from muscles in the arm. Based on the contraction and rest movements of the muscles, the signals are used to control the locomotion of the mobile robot.

Keywords

Mobile robot, hand-gesture control, EMG, Myo armband

1. Introduction

Gesture recognition is a commonly used approach for human-robotics interaction, as it can be used in all environments. Additionally, body language using hand gestures is the best way to demonstrate human intentions [1].

In recent years, different methods of gesture recognition for human robot interfacing have been used. One such method is the vision-based gesture recognition in which a camera is used for video-sequence-gesture recognition [2]. Gestures are recognized by color tracking [3], skeleton tracking, or even finger joint tracking using Leap Motion sensors, which can be used to communicate emotions [1]. Another method for gesture recognition is based on electromyography (EMG) sensing methods [4] [5] [6]. EMG sensing may be achieved by invasive or non-invasive techniques.

In 2014, the Myo armband, developed by Thalmic Labs in 2014 [4] offered a new method for gesture control that is by far the simplest approach at a competitive cost. It is equipped with electromyography sensors and an Inertial Measurement Unit (IMU) which consists of an accelerometer with a gyroscope and a magnetometer that work on all three axes. The Myo armband works by surface (non-invasive) detection of electrical signals that are produced as a result of muscle contractions. The electrical signals that are produced as a result of muscular movements are known as electromyography signals.

Vision-based methods require computing complex mathematical algorithms such as support vector machines and Kalman filtering [3]. That is in addition to the need of expensive vision systems and powerful processing systems. Using an Inertial Measurement Unit (IMU) and electromyography sensing of muscle electric signals for gesture control applications can simplify the processing needs. Hidden Markov Models (HMM) can be used to increase the recognition rate of multiple gestures [7].

In this paper a mobile robot that is controlled by hand gestures using the Myo armband has been developed and tested. Section 2 presents the system architecture and mobile robot design. Results are presented on section 3.

2. System Architecture and Mobile Robot Design

The robot receives inputs from myo signals to invoke five different movements which are used to move the robot forward, backward, to the left, to the right, and to stop. These movements are controlled by five arm gestures which are consecutively: fist, spread, wave left, wave right, and double tap. The controls are achieved by receiving and processing the signals from a Myo armband, which transmits data through Bluetooth communication.

1.1 Robot Components

- Armband Controller: A Myo Armband , developed by Thalmic Labs [4] , is equipped with electromyography (EMG) sensors and an Inertial Measurement Unit (IMU) which consists of an accelerometer with a gyroscope and a magnetometer that detect motion in all three axes. The Myo armband detects electrical signals that are produced as a result of muscle contractions.
- External Interface Device: wireless touch screen with a Raspberry Pi controller is interfaced with the onboard controller through WiFi.
- Robot unit: with an overall dimensions of 12 in x 12 in, the robot unit is equipped with a 12 V Li-ion battery with a capacity of 18,000 mAh. The Central Processing Unit is a Raspberry Pi controller running at 1.5 GHz with 4 GB of RAM. Omni directional wheels by Moebius were used for robot locomotion. Other components in the unit included a HD/IR camera module, a motor drive board, and a power distribution board. The mobile robot is shown in Figure 1 below.

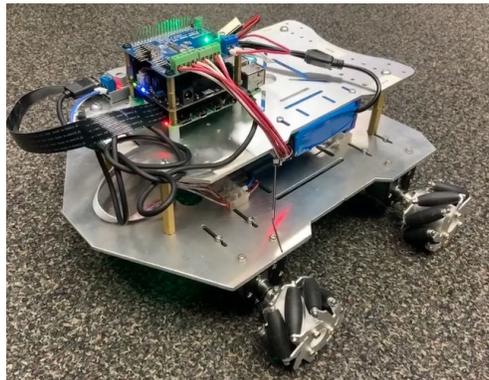


Figure 1: Gesture-controlled mobile robot

1.2 Power Management

By summing the rated powers of the individual components as specified by their manufacturers, the power requirement was determined to be 68W. The primary electrical components, as shown in the electrical schematic of the mobile robot in Figure 2, include four motors that power the wheels (each with a maximum (locked) power of 12 Watts), the motor drive (2 Watts), and the Raspberry Pi controller (15 Watts). A service factor of 1.5 was used to account for unexpected peak power demands. The calculated power is then multiplied by a factor of 2 to avoid any voltage sag, and to avoid deep battery discharge, a condition that may result in shortening the battery life. Finally, to ensure a continuous operation for one hour, the minimum battery capacity is calculated to be 17,000 mA-h. A Li-ion battery with a capacity of 18,000 mAh satisfies the power requirement, and was used to power the robot (See Table 1).

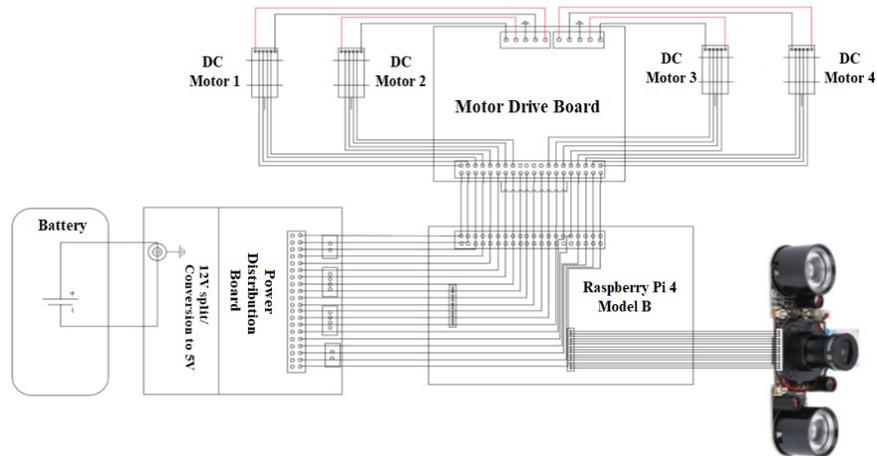


Figure 2: Robot wiring diagram.

Table 1: Power Calculations

Total power requirement:	68 Watts
Service Factor:	1.50
Factor to avoid battery depletion and voltage sag:	2.0
Design Power	$2.0 \times 1.50 \times 68 = 204$ Watts
To keep operational for one hour:	204 Watts· hour
Battery voltage	12 V
Battery capacity needed:	$204 \text{ W} \cdot \text{hour} / 12 \text{ V} = 17$ Ah
Closest available battery capacity:	18,000 mAh

3. System Operation

The Myo armband allows the user to control robot movement without actual physical connection with the robot by detecting signals from arm muscles and movements to send control signals over a Bluetooth communication module. The armband includes an arm cortex-m processor in addition to the stainless-steel EMG sensors and the IMU. Feedback for the user is achieved with a dual indicator LEDs and a haptic feedback vibration [5]. When a hand movement is made, the sensors detect the unique electrical signal that the arm muscles produce, and the information in different categories is transmitted via a Bluetooth module to the mobile robot processor. In addition to natural position of hand, the predefined five gestures can be easily measured by the MYO armband for hand movement. The gestures are: Fist, Finger spread, Wave in, Wave out and Double tap shown in Figure 3.



Figure 3: Hand control gestures 1: Move right, 2: Move Forward, 3: Move Left 4: Stop/Move Backward

The program flow of the robot controller is shown in figure 4. After a remote controller armband is paired with the robot processor, and the processor determines that the Myo armband is the paired controller, it allows it to control the robot wheels. The robot controller will also take overdrive inputs from the user directly via the robot touch screen, as shown in the figure.

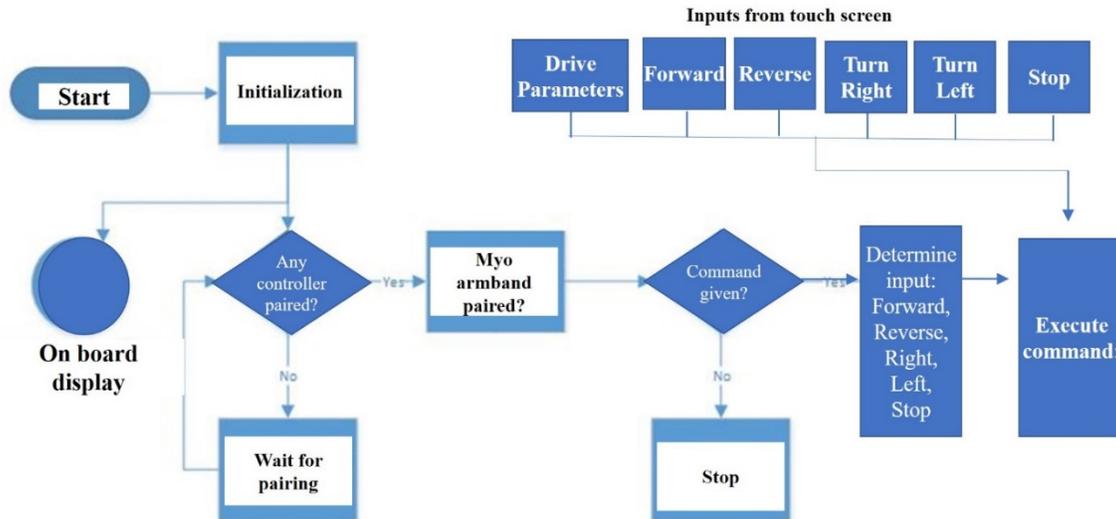


Figure 4: Program flow diagram

4. Conclusion and Future Perspectives

In this paper we demonstrate the use of the Myo armband, developed by Thalmic Labs, for gesture recognition and control of a mobile robot. With the controller being a wearable device, the operator gains full awareness of both his/her own and the robot's surroundings. The robot control successfully exhibited real-time human-robot interaction through hand gesture using a low-cost EMG noninvasive device. The utilization of the armband control requires a short training by the user.

The main drawback of the armband control is the small number of movements of the mobile robot that can be controlled, hence, for medical applications, controllability of a multi-axes robotic manipulator may not be achievable with the armband. For a robotic unit to reach any point in its working space, a minimum of six degrees-of-freedom are needed other than the movements required by the end-of-arm tooling. Furthermore, the armband accuracy and precision in acquiring gesture data may differ from user to another, both inaccuracy in acquisition of hand gestures and inability to detect gesture signals may be magnified in users with medical conditions in which muscular movement is impaired or the motor performance is limited such as in Parkinson's disease [8]. Furthermore, recent studies show that electromyographic signals generated from muscles of patients of Parkinson's disease can change considerably in patients who undergo Deep Brain Stimulation treatment [9].

Although a small number of degrees of freedom may be controlled with the armband, particularly in persons with impaired muscular functionality such as in patients of Parkinson's disease, Myoclonus, and Tremor, however, secondary auto-assist systems may aid collaboratively to achieve full control. Such as including a secondary controller, a built-in obstacle avoidance functionality, force sensing, and vision-based perception capabilities for more robust operation, as well as including a return-to-home functionality to overcome potential loss of signal from the Myo armband.

Future perspectives include determining the precision and accuracy rates of acquisition of gestures in persons with impaired muscular functionality such as in patients of Myoclonus, which causes sudden muscle jerks [10], and the involuntary oscillation of a body part referred to as Tremor [11], and Parkinson's disease.

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Biographies

Enass Mohamed is a graduate student at the Department of Engineering Management and Technology. She has a Bachelor's degree in Electrical Engineering from the University of Tennessee at Chattanooga.

Khalid Tantawi is an Assistant Professor in the Department of Engineering Management and Technology at the University of Tennessee at Chattanooga. Previously, was a trainer for Siemens Technik Akademie for certifying Siemens Mechatronic Systems Certifications (level 1). He was elected to lead the Engineering section of the Tennessee Academy of Science in 2017, an active academic auditor for the Tennessee Board of Regents, and a member of the Tennessee Textbook Advisory Panel, and the European Commission's Erasmus Mundus Association. He is the Lead Principal Investigator on several awards from the National Science Foundation, and the recipient of a grant from the NSF-Alabama EPSCoR (2009-2012). With more than 30 journal and conference publications, Dr. Tantawi was also an invited speaker at several conferences, and reviewed and judged many textbooks, scientific papers, and grant proposals. His Bachelor's degree is in Mechatronics Engineering from the University of Jordan, he holds a double masters in Aerospace Engineering from ISAE (France) and the University of Pisa (Italy). His PhD is in Electrical Engineering from the University of Alabama in Huntsville.

Erkan Kaplanoglu is an associate professor in the Department of Engineering Management and Technology at the University of Tennessee at Chattanooga. He received the bachelor's degree from Marmara University Electric Department, in 1996. He completed his M.Sc. and Ph.D. thesis at Computer-Control Department of Marmara University, Institute for Graduate Studies in Pure and Applied Sciences, in 2000 and 2006, respectively. In March 2014, Dr. Kaplanoglu became Associate Professor at Marmara University, Mechatronics Department. He has been awarded YGGDRASIL Award (Young Guest Doctoral Researchers in Norway) in 2010. He worked as research assistant professor at Department of Mechanical Eng. Vanderbilt University Faculty of Engineering from 2011 to 2012. In 2013, He introduced the idea and oversaw the establishment of a Bio-mechatronics & Assistive Technology Lab (BioMechatLab) at Marmara University that has since built a reputation and is ranked second in the country in

terms of student involvement and research. The establishment of this lab has led to the collaborations with the departments of biomedical and medical at other partner higher education institutions.

Ahad Nasab is the Engineering Management and Technology Department Head and Burkett Miller Chair of Excellence at the University of Tennessee at Chattanooga. He received his PhD and M.Sc. degrees in Mechanical Engineering from Georgia Institute of Technology, and his B.Sc. from California State University. He led the development of the Mechatronics Engineering program at Middle Tennessee State University and established the Mechatronics program at the University of Tennessee at Chattanooga.

Austin Pemberton undergraduate student in Mechatronics at the Department of Engineering Management and Technology in the University of Tennessee at Chattanooga, graduated in 2020. He was the team leader for the project.

Navar Pickard undergraduate student in Mechatronics at the Department of Engineering Management and Technology in the University of Tennessee at Chattanooga, graduated in 2020. He led the detailed design stage and hardware selection of the project.

Mike Dyer undergraduate student in Mechatronics at the Department of Engineering Management and Technology in the University of Tennessee at Chattanooga, graduated in 2020. He led the programming stage of the project.

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