Using Electromyography-Based Controls to Direct a LEGO Mindstorm Unit

James Brooks, *Biomedical Engineering, University of Rhode Island* <jamie11@my.uri.edu>
Nicholas Gomes, *Biomedical Engineering, University of Rhode Island* <nicholas_gomes@my.uri.edu>
Preston Steele, *Biomedical Engineering, University of Rhode Island* <preston_steele@my.uri.edu>
BME 484 Capstone Design Abstract

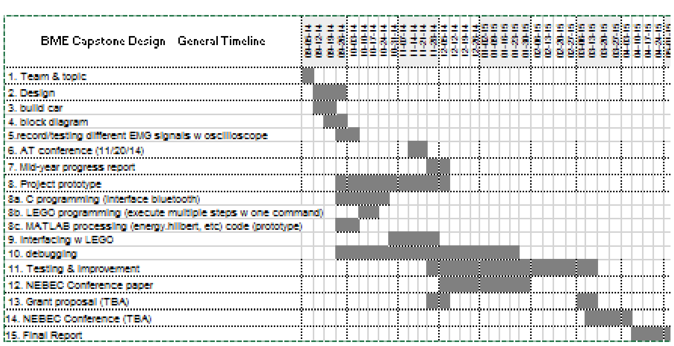
***Abstract*—This paper attempts to provide an overview of the proposed guidelines for a project using surface electromyography to wirelessly control a LEGO Mindstorm unit.**

I. Introduction

Surface electromyography (sEMG), or the study of muscle tissue electrical activity using electrodes placed directly above the muscle grouping on the skin, gained prominence within academia during the 1940s with a study using sEMG to observe the effect of pain on the deltoid muscles of professional volleyball athletes [1]. Currently scientists are researching the use of sEMG as a tool for more precise/natural control of prosthetics and assistive technology [2]. The LEGO Mindstorm is a kit which contains software and hardware for a programmable robot, developed as a joint venture and education tool between LEGO and MIT Media Laboratory. The goal of this paper is to produce an algorithm for sEMG use with the flexor muscles in the forearm and with a LEGO Mindstorm unit for the use of mimicry of movement.

II. Project Management

James Brooks is the Software Engineer for the project. His duties include LEGO Mindstorm programming, C programming for the PIC Microcontroller, interfacing the two languages, and compatibility. Nicholas Gomes is the Hardware Engineer. His duties include building the LEGO Mindstorm, designing the PIC Microcontroller circuit, interfacing the two units, and hardware compatibility. Preston Steele is the project manager for this project. His duties include coordinating the team, assisting in the hardware and software interfacing, and making sure that the team sticks to a pre-determined schedule.



As referenced in our timeline above, our first focus will be on the sEMG signal collection and analysis for the month of October. This will include writing MatLab code to do fast analysis of different algorithms that we may be able to implement on the PIC microcontroller. At the same time, we will be writing the base C code for the PIC and the LEGO code for the robot itself. The month of November will be focused on interfacing the components with each other, making sure that the signal is sent correctly over Bluetooth, and that the prototype is fully functional. The spring will be used to create a more cohesive model to use to present at the NEBEC Conference.

III. Engineering Standards

IEC 60601-1 is the international standard for Medical Electrical Equipment, which defines the requirements for safety and performance of electrical devices that are used for a medical purpose. Specifically, the standard talks about acceptable terminology, testing requirements, system identification and markers, safety and protection from hazards, accuracy and programming.

IEEE 802.15.1 is the standard that defines Bluetooth technology and all units that use it. Defined in the standard is the architecture, physical layer, baseband, Link Manager Protocol, error codes, host-controller interface, message charts, security, logical link control and adaptation protocol, and service access point interfaces.

The EIA323 Standard defines signal definitions, primary and secondary communications channel, modem status and control signals, test signals, electrical standards, and signal characteristics.

The IPC 2221A standard is a general standard on printed circuit board design that includes conductor thickness and spacing guidelines.

The IEC 61508 is a standard that deals with the functional safety of a system. The scope of this standard is to serve as an introduction to safety management and engineering in all parts of the system, not just the electronic parts.

ISO/IEC 14882:2014(E) is a standard that encompasses the C++ programming language and has parts corresponding to the core language as well as the standard library. The standard library refers to a group of classes and function written in the core language.

ISO/IEC 7816-12 is a standard that specifies the operating conditions of an integrated circuit that has a USB interface.

IV. Design Process

We will start by researching EMG control and learn about previous methods that have been used and brainstorming how those methods can be improved upon. We will start with last year's project, which was measuring the graded responses of sEMG and study their specifications and coding. From their design, we will refine their methods as well as testing new ways of measuring sEMG from different areas of the forearm, to see if it is possible to detect the differences in signal from the contractions of different fingers, which could be used as control signals. We will also need to focus on interfacing these systems using Bluetooth protocols, as there have been problems in the past with component communication. Finally, we will debug our coding, the circuit, and the interface points to make sure that everything is functional.

V. Methods

Previously, our institution has performed research into effective algorithms that can be used to detect sEMG peaks [3] as well as to detect the strength of the firing muscles and adapt to their timing [4].

Our goal is to combine SEMG with a PIC microprocessor using a wireless Bluetooth connection, using the previously established algorithms to detect the peaks of the muscle contractions and their strength, which in turn is sent to the LEGO Mindstorm NXT which controls the movements of the LEGO robot.

The electrodes to control the movement of the robot would be placed at the distal end of the three muscles (close to the tendons) in the forearm (the brachioradialis, the flexor carpi radialis, and flexor carpi ulnaris) which would control the servomotors of the wheels of the LEGO Mindstorm robot. The reference electrode would be placed on or near the medial epicondyle.

These signals, after collection, will be analysed using Matlab software to detect the pure signal within the data that we collect. From there different types of algorithms for analysis of the signal and its strength will be created and employed to determine which one works best with our system. These algorithms will then be programmed in C onto our PIC so that it can perform these calculations on the signal while it is being transmitted to the LEGO NXT, effectively cutting out a personal computer component.

Finally, the Bluetooth interface will be setup in order to create a wireless system between the PIC and amplifier circuit and the robot, which will allow it free range of motion without cable restrictions.

VI. Discussion

The PIC18F4525 is a microcontroller produced by Microchip. It is an 8-bit processor with 48 kilobytes of flash memory, 4 kilobytes of RAM, 64MHz processing speed and 1024 bytes of Data EEPROM [4]. The PIC is an education tool that teaches engineering students the skills needed to debug code and troubleshoot hardware, as it is relatively simple version of current industry standards, such as Arduino and BeagleBone.

References

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