EMG-Based Human Machine Interface System

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Overview

1. Introduction
2. Scope of project
3. System block diagram and subsystems
4. Preliminary results
5. Project deliverables, division of labor, and schedule
6. References
7. Questions
Introduction

- The medical field has benefited from intensive research in EMG signal analysis in the past couple decades.
- EMG signals have been used in research including wheelchair and prosthetics development.
- Electromyogram (EMG) signals are electric potential generated by muscles when activated by the nervous system.
- Electrodes are placed to detect the electric potential produced by the muscle. Surface EMG (sEMG) signal is recorded.
- The positioning of electrodes is crucial for accurate readings.
● RELATING FOREARM MUSCLE ELECTRICAL ACTIVITY TO FINGER FORCES

● Data Sheets
  ○ Particle Photon WiFi Board (ARM Cortex M3 MCU)
  ○ Myoware Muscle Board

Figure 1. Photon size comparison

Figure 2. Electrode placement [1]
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Scope of the Project

- The project aims to develop an EMG-based human machine interface system.
- A wearable WiFi board is used to record sEMG signals and send out wireless control commands.
- A wheeled robot equipped with vision system is controlled by the user wirelessly.
- Video monitoring system assists the user to navigate the robot.
- The system has potential applications in improving the quality of life for those with physical disabilities.
• Mission Parameters
  ○ Read EMG signal from user
  ○ Wirelessly send four commands to service robot
  ○ The four commands for the service robot are *left*, *right*, *forward*, *stop*
  ○ Generate PWM signals on service robot for motor control
  ○ Send live video feedback to video monitoring system
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System block diagram and subsystems

Figure 3. System block diagram
EMG Control Subsystem

Figure 4. EMG - Control Subsystem
EMG Control Subsystem

Functional description: EMG signals from the muscle sensors are acquired and processed for operation or calibration. Movement commands are generated and sent to the service robot subsystem.

1. Inputs
   a. EMG signals from muscle sensors
   b. Mode selection switch
   c. Power switch (ON/OFF)
   d. Power source from Particle Photon

2. Outputs
   a. Movement commands
   b. System status information
Service Robot Subsystem

Figure 5. Service Robot Block Diagram
Service Robot Subsystem

Functional Description: It receives commands wirelessly from EMG control subsystems and sends PWM signals to motor for movement. A mounted IP camera is used to provide video feed for the video monitoring system. Note: collision avoidance of the robot is not considered in this project.

1. Inputs
   a. Movement commands from the EMG control system
   b. Video feed from Logitech Webcam
   c. Power switch (ON/OFF)
   d. Power source battery expansion pack

2. Outputs
   a. Video feed transmitted through internet to the video monitoring system
   b. PWM signals
Video Monitoring Subsystem

Figure 6. Video Monitoring Subsystem Block Diagram
Video Monitoring Subsystem

Functional Description: It provides useful information for the user. The information includes live video from the service robot subsystem and diagnostics from EMG-Control subsystem.

1. Inputs
   a. Video feed
   b. Power switch (ON/OFF)

2. Outputs
   a. Video (monitor display for the user)
   b. Mode of operation
   c. Diagnostics
Mode Selection

Figure 7. Mode Selection Flow Chart
Network Diagram

Figure 8. Wireless Communication Flow Chart
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Placement Configurations

Figure 9. Configuration 1

Figure 10. Configuration 2
Configuration 1

Figure 11. Closed Fist-Stop Command

Figure 12. Index Finger-Left Command
Figure 13. Middle Finger-Forward Command

Figure 14. Ring Finger-Right Command
Configuration 2

Figure 15. Closed Fist-Stop Command

Figure 16. Index Finger-Left Command
Figure 17. Middle Finger-Forward Command

Figure 18. Ring Finger-Right Command
Observations and related specifications

● Our test shows that the EMG signal reading ranges from 0.2 V to 1.5 V.
  ○ Assuming 80% contraction of muscle.

● The analog-to-digital converter (ADC) on photon particle board:
  ○ $V_{\text{ref}}=3.3\text{V}$
  ○ 12-bit resolution
  ○ Step size = 0.8mV
  ○ Serial clock : $f_{\text{adc}}=30\text{ MHz}$
  ○ Sampling rate: maximum 2MSPS (samples per second)
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Division of Labor

Jon Morón

1. Service Robot subsystem
2. Video Monitoring System
   a. Sending video feed from Service Robot System

John Cochrane

1. EMG-Control subsystem
   a. Calibration Mode
   b. System diagnostics
2. Video Monitoring System
   a. User Interface

Thomas DiProva

1. EMG-Control System
   a. EMG DSP
   b. Operation mode
   c. Wireless Communication
## Schedule for Completion

<table>
<thead>
<tr>
<th>Task</th>
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<tbody>
<tr>
<td>Complete analysis and classify finger movements.</td>
</tr>
<tr>
<td>Get computations for data rate and other formulas</td>
</tr>
<tr>
<td>Receive live video feedback on video monitoring system</td>
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<tr>
<td>Design Software and start working with Photon Particle</td>
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Table 2. Fall and Winter Break Schedule
<table>
<thead>
<tr>
<th>Week</th>
<th>Agenda</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEEK 1</td>
<td>Work on implementation of DSP system to get a clear digital output of the EMG signal. Also work connecting raspberry pi to service robot. Work on getting communication up between the systems.</td>
</tr>
<tr>
<td>WEEK 2</td>
<td>Continue last week's agenda. Run systems check to see if the subsystems correctly work together.</td>
</tr>
<tr>
<td>WEEK 3</td>
<td>Depending on Diagnostics test work to fix any connection issues. Begin working on mapping emg signal frequencies to our commands.</td>
</tr>
<tr>
<td>WEEK 4</td>
<td>Continue mapping digital signal to commands in both subsystems. Run test to determine progress of each subsystem.</td>
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<tr>
<td>WEEK 5</td>
<td>Service Robot subsystem work on translating incoming commands to pwm for the robot's movement. Start work on different operations within the user subsystem.</td>
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<tr>
<td>WEEK 6</td>
<td>Continue work and Run test to determine subsystems progress.</td>
</tr>
<tr>
<td>WEEK 7</td>
<td>Fix any issues with either subsystem from test. Begin setting up ip camera system.</td>
</tr>
<tr>
<td>WEEK 8-14</td>
<td>Complete ECE 499 Deliverables.</td>
</tr>
<tr>
<td>WEEK 9-14</td>
<td>Complete ECE 499 Deliverables.</td>
</tr>
</tbody>
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Table 3. Spring Semester Schedule
ECE 499 Deliverables

- Final Project Report
- Final Project Presentation
- Final Project Demo
- Industry Advisory Board Poster Presentation
- Bradley Student Scholarship Expo
Future Directions

1. Mobile user display option
2. User speed control for service robot subsystem
3. Application can be applied to motorized wheel chair
   a. Video monitoring can be used for a caretaker of elderly to monitor elderly while away from them.
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Questions?
Particle Photon Wi-Fi Board

- STM32F205 120Mhz ARM Cortex M3
- 1MB flash
- 128KB RAM
- 18 mixed-signal GPIO and advanced peripherals

- Cypress BCM43362 Wi-Fi chip
- Single band 2.4GHz IEEE 802.11b/g/n
- Supports wireless data rates of up to 65Mbit/s
- Ultra low power sleep, stand-by and stop modes
- Supports Open, WEP, WAPI, WPA and WPA2-PSK WiFi security modes