A Voice Activated Prosthetic Mode of Control

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ABSTRACT

There are many options for a prosthetic mode of control. The most commonly created modes of control involve surface EMG (sEMG) and require that the user have well defined muscle activation in order to trigger the movement of the prosthetic. Unfortunately, many prosthetic users do not have the required muscle tone or strength to trigger these sensors, so the need for a control mechanism that doesn't rely on sEMG is clear. This study focuses on the development of a low-cost, voice activated prosthetic mode of control compatible with the prosthetics developed by Dr. Zuniga and his research team.

The printed circuit board (PCB) was designed using EAGLE EDA and incorporates a battery, with charging circuit, dedicated power supply, microcontroller, and an off the shelf voice recognition device called the EasyVR 3. This is shown in figures one and two.

The obtained power consumption results were analyzed for six different lithium polymer capacities and for a varying number of grip events in a twelve hour period. The battery life of the device is then calculated using a standard battery life equation.

INTRODUCTION

With the advancement and miniaturization of electronic devices and components, new possibilities for integrated assistive devices are possible [3]. For most of the 21^{st} century, electronic control of prosthetics has advanced significantly for sEMG, as can be seen in the large number of commercially available prosthetics. These devices are too costly for most patients who need them, which has led to the advancement of low-cost 3D printed prosthetics, such as the ones developed by Dr. Zuniga et al [2].

The drawback with sEMG is that those with muscle paralysis or degraded EMG signals are not able to create a strong enough signal to activate these prosthetics [1]. This predicates the need for an alternative mode of control that's small enough to fit into a prosthetic device and can be powered through an on-board battery.

The purpose of the present investigation was to address this need for a new mode of control that doesn't require sEMG input and can be powered with an integrated power supply.

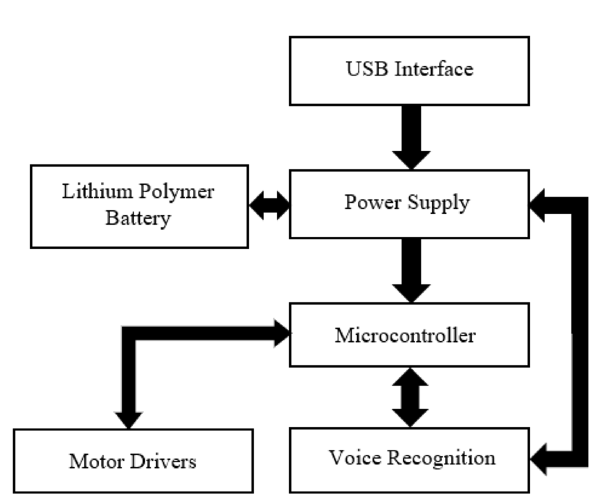

Figure 1: Block diagram of the voice controlled prosthetic mode of control. The USB interface is used to charge the lithium polymer battery. The power supply contains a battery charger, 3.3V 600mA power supply, and a 12V boost device to power the motors. The microcontroller used is an ATmega328P that connects to the voice recognition platform. A TB6612 motor driver is used to drive two DC motors.

METHODS

Printed Circuit Board: A printed circuit board that fits the footprint of the EasyVR 3 was developed utilizing EAGLE EDA that incorporates all necessary components from the block diagram for the system. The PCB is a two layer board that measures 1x2.2 inches and incorporates two PQ12 motor connectors.

Software: The Arduino development environment was used to develop the software as the EasyVR 3 API was compatible with this software. The EasyVR Commander 3.13 was used to train and test the voice recognition device.

Power Testing: A 30V 10A power supply was used to perform power testing along with a TekPower USB multimeter to collect the current measurement results. A Matlab script was developed to simulate multiple grip events over a period of time to be able to capture the battery life of the device over a period of use. In addition the battery life of the device on multiple sized lithium polymer batteries was calculated using this script.

Cost: The developed device was designed to use low cost components that can be easily integrated into a small footprint. The components were also sourced to allow for easy purchase of the bill of materials in the United States.

MATERIALS

The developed PCB was ordered from JLCPCB (JLCPCB, Shenzhen, China) and were populated by hand for the study. The prosthesis this control board was designed to interface with is the hybrid actuation prosthetic arm with two PQ12 motors integrated into the socket. The motors were driven at 12V to optimize the torque produced for each motor. In addition, a 500mAh lithium polymer battery was used for testing the device.

The low-cost 3D printers used to create the prostheses were the Ultimaker 2 Extended+ (Ultimaker B.V., Geldermalsen, The Netherlands). The materials for printing the prostheses were polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS). Other components of the prostheses included: 1 mm nylon lift cord, 1.5 mm diameter elastic cord, Velcro, medical-grade firm padded foam, a protective skin sock, and a BOA dial tensioner system.

The final completed system was capable of being integrated into these prosthetic devices.

The data generated for this study was completed using a dedicated power supply to test the operating requirements of the device.

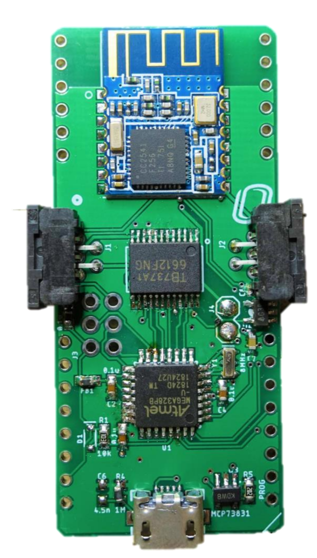

Figure 2: The developed custom control board.

RESULTS

The data collected during this study is shown below and was analyzed using the aforementioned Matlab script.

Battery Life (Hours)

Battery Sizes (mAh)	Number of Grip Events in a Twelve Hour Period								
	250	500	1000	2000	3000	4000	5000	6000	7000
250	10.96	7.98	5.19	3.04	2.16	1.67	1.36	1.15	0.99
400	17.54	12.76	8.30	4.87	3.45	2.67	2.18	1.84	1.59
500	21.93	15.95	10.37	6.09	4.31	3.33	2.72	2.30	1.99
1200	52.63	38.29	24.90	14.61	10.35	8.00	6.53	5.51	4.77
2000	87.72	63.81	41.49	24.35	17.25	13.33	10.88	9.18	7.95
2500	109.65	79.76	51.87	30.43	21.56	16.67	13.60	11.48	9.93

Grip Events	Average Current (mA)
250	15.96
500	21.94
1000	33.74
2000	57.5
3000	81.16
4000	105
5000	128.7
6000	152.5
7000	176.2

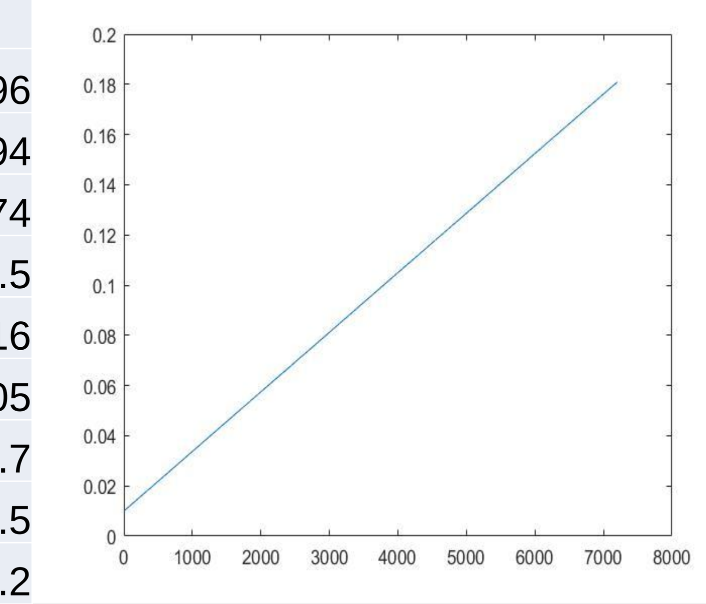

Figure 4: The graphed results of the Matlab processing script.

CONCLUSION

The device developed in this study was promising and warrants future study as an alternative prosthetic mode of control.

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