Muscle Fatigue Interface

Project Proposal

ECE 445: Senior Design

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1.0 Introduction

1.1 Statement of Purpose

This project was chosen because there presently are no devices that allow fitness enthusiasts to visually track their fatigue as they perform specific exercises. Such a device can aid in determining how effective their exercise is, as well as prevent overtraining. Knowing this information, one can program their rep/set scheme accordingly and thus increase the effectiveness of their workouts. Moreover, there are many other biological applications including rehabilitation, physical therapy, and research. We have chosen to focus on the modularity of the device to make it inexpensive, transportable, and easy to maintain.

1.2 Objectives

1.2.1 Goals

- Develop functional EMG with intuitive interface
- Guarantee a quality commercial device
- Allow optimization of different users and muscles
- Develop timing system

1.2.2 Functions

- Biopotential amplifier and filters to reduce artifacts in the EMG signals for accurate tracking
- Analog to digital converter that also timestamps and stores the digitized information
- Easy and intuitive interface
- High intensity (6500 mcd) green LEDS lights to and beeper indicates fatigue level.

1.2.3 Benefits

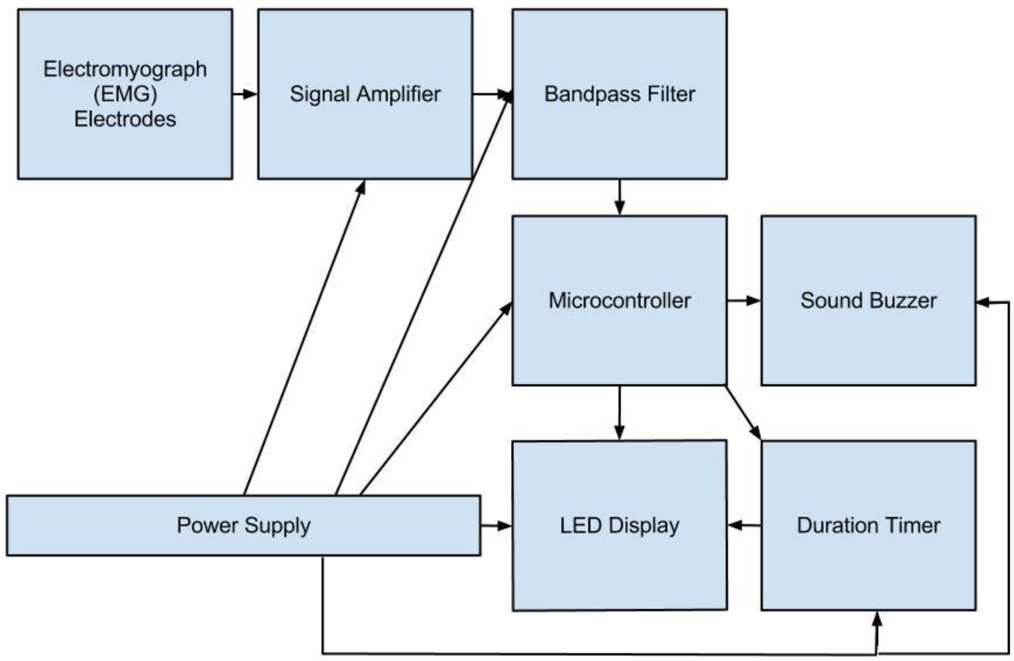
- Inexpensive
- Transportable
- Prevents injuries from overtraining
- Quantifiable measure of fatigue not available from human measurement

1.2.4 Features

- LEDs indicating level of fatigue
- Sound indicating when muscle is near failure (maximum muscle hypertrophy)
- Ability to vary the baseline median power frequency to accommodate different users/muscles
- Timer to measure duration of sets

2.0 Design

2.1 Block Diagrams



2.2 Block Diagram Descriptions

<u>Electrodes:</u>

The electrodes are to be placed over the long and short head of the bicep. These will be used to detect the physiological properties of the muscle while under strain. This data will be transmitted to the amplifier.

<u>Signal Amplifier:</u>

The purpose of this is to amplify the signal coming in from the electrode. A differential amplifier will be used to amplify the signal about 50V/V. The op-amp in addition will also amplify any residual noise around the circuit. Hence, we require an additional band pass filter to remove this noise. In addition, there will be protection circuitry in the form of diodes and capacitors which ensure that the inputs to the amplifier cannot be greater than their turn on voltage. The capacitors would provide low impedance paths for voltage spikes and the resistors to dissipate the energy in the form of heat.

Band pass Filter:

The band pass filter will be able to remove any outside noise or interference. Generally, 0-20Hz is an unstable range indicating noise from the patient's motion, the electrode placement, and the electrode cord. Frequencies above 500 Hz are usually noise from RF interferences. The band pass filter will also have an additional gain of about 30V/V bringing the total gain to 1500V/V.

Microcontroller:

The microcontroller will be used to process the signal coming from the filter part of the circuit. This will be connected to three additional components, that is, the LED display, timer, and the sound buzzer. The microcontroller will also calibrate the device based on the user, since each user has their own baseline signals.

LED Display:

The LED display will take its inputs from the microcontroller, and will give the user a visual representation of the amount of stress/fatigue that is being placed on the muscles. Also, the LED's will display the timer.

Sound Buzzer:

Like the LED display, the sound buzzer too, takes its inputs from the microcontroller. The purpose of the buzzer is to give the user an additional source of stimuli in order to warn the user when their muscles are near failure. These parameters vary from person to person; however, the microcontroller will be calibrated per user.

Duration Timer:

The timer times the user's sets. Begins when during the start of the EMG capture and ends at the end of the exercise.

2.3 Performance Requirements

1. The completed product should be able to withstand human body temperatures while exercising and should not affect the functionality or stability of the components.
2. The enclosure and design should be small enough for convenient usage and transport, including the power supply and data communication.
3. The device should be able to calibrate itself to different users & their baselines to provide pertinent data.
4. LEDs are correctly correlated to muscle fatigue and the sound buzzer is activated once at a predefined threshold.

3.0 Verification

Block	Verification Procedures	Acceptable Quantitative Results
Electrodes	Ensure that it is connected to the amplifier and establishes a connection	Voltage values between 200-300 μV on oscilloscope
Signal Amplifier	Connect to electrodes and have both the input signal & amplified signal visible on oscilloscope	Should see linear amplification and non-distortion of signal by comparing the input to the output of the amp
Band pass Filter:	Input white noise into the filter (overlap of all frequencies) and view the Fourier transform of the output on oscilloscope	The Fourier transform should show the desired cutoffs frequencies designated by the band pass
Microcontroller	Check if microcontroller accurately interprets the output of the filter and drives the LED's and sound buzzer as necessary	Ensure that the LED's are lit up appropriately. Ensure that the sound buzzer is activated upon reaching a particular threshold
LED Display	Connect LEDs to Vcc and Ground via resistor	The LED's should be lit up
Sound Buzzer:	Connect to appropriate Vcc and Ground via resistor	It should make a sound
Duration Timer	Implemented via software, run several trials	Results should be correctly logged and stored

3.1 Testing Procedures

The initial testing that we will be doing will be on the EMG amplifier. This test will insure that we get correct performance from the circuit. We will do this testing on an oscilloscope and test the EMG on the bicep muscles with different degrees of strain. This will establish the necessary settings for the EMG test circuit. We can then tell at what potential the EMG says a bicep operates at and compare that to the expected EMG readings that others have found. We will have a table displaying muscle potential versus strain so that we can see what weight should be used for a particular person. We may also connect the EMG to other muscles and repeat the testing so that we can correctly determine what noise could be coming from surrounding muscles and how to optimally filter it.

3.2 Tolerance Analysis

Tolerance analysis will be performed mainly on the EMG itself. The EMG is the primary component to our device and without an accurate signal, everything becomes moot. Our EMG signal must be properly amplified, and properly filtered. We plan to use an AD622 Instrumentation Amplifier which has a gain relationship or Rg=50.5Kohm/ (G-1). We will vary Rg and test its tolerance extremes. Also, we will test the resistors in the band pass filter and note the change in gain. Overall we want to find an adequate raw EMG signal for further digital signal processing.

4.0 COST AND SCHEDULE

4.1.0 Labor

We estimate working hour ranges from 15 to 25 hours per week with a total duration of 10 weeks to complete this project.

Name	Hourly Rate	Total Hours Invested	Total = Hourly Rate x 2.5 x Total Hours Invested
Shay Chen	$25	200	$12,500
Roman Levitas	$25	200	$12,500
Tushar Bhushan	$25	200	$12,500
Total		600	$37,500

4.1.1 Parts

Part	**Cost Per Unit**	**Quantity**	**Total Cost**
Skin Electrodes	$.50	4	$2
Surface Mount PCB	$30	1	$30
Wires	$2.50	2 spools	$5
Resistors & Caps & Diodes	$.10	30	$3
Batteries	$.30	8	$2.40
Battery holder	$3.17	1	$3.17
LED’s	$.15	10	$1.50
Bar Graph Disp.	$4.97	1	$4.97
Metal Enclosure	$40	1	$40

Beeper	$5.30	1	$5.30
A/D Converter	$20	1	$20
Misc.	$20	1	$20
Total			$137.34

4.1.2 Grand Total
$37,500 in labor + $137.34 in parts = $37,637.37

4.2.0 Schedule

Week	Task	Responsibility
2/3	Finalize and hand in proposal	Shay
	Research biopotential amplifiers	Roman
	Research ideas for implementation	Tushar
2/10	Design biopotential amplifier	Shay
	Design band pass and anti-noise filters	Tushar
	Mock Design Review	All
2/17	Simulate design and start drawing out board design	Shay
	Design rep/set tracking software	Roman
	Order parts for EMG	Tushar
2/24	Design Review	Roman
	Assemble power supply and EMG for testing	Shay
	Lay out PCB board for display module and beeper	Tushar
3/3	Order display module and PCB's	Shay
	Optimize EMG for multiple users/muscles	Roman
	Testing/Debugging EMG	Tushar
3/10	Assemble PCBs for display	Tushar
	Testing/Debugging EMG	Shay

	Assemble PCBs with tracking software	Roman
3/17	Prepare mock-up demo	Roman
	Testing/Debugging EMG	Shay
	Finalize PCB	Tushar
3/24	Mock up demo	All
3/31	Mock up presentation	All
4/7	Ensure Completion. Last minute debugging & finalization	All
4/14	Prepare Demo and Presentation	All
4/21	Demo	All
4/28	Presentation	All
	Final paper	All
	Checkout	All