Divide and Conquer

Members

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Customer: Limbitless Solutions
Sponsors: Limbitless Solutions and Texas Instruments

Narrative Description

Background: Limbitless Solutions is an organization that is dedicated to building low cost, 3D printed Bionic Limbs for children that would traditionally benefit from a prosthetic. Currently, insurance companies tend to not provide funding for children missing limbs to get prosthetic limbs because the child will outgrow it in a few years and need new a new one. This is where the 3D printing comes in. 3D printing allows a new limb to be created at a very low cost whenever the child outgrows their current limb.

Motivation: Limbitless Solutions has a current electronics design for their bionic arms that is built using different boards bought from various vendors and assembled on protoboard (see Figure 1). This is nonideal from multiple standpoints, including price, footprint, and expandability. The current design has only basic functionality as well as stability issues (due to issues such as lack of power regulation and voltage compatibilities). As such, Limbitless Solutions has contracted this team to design a new set of integrated electronics that will solve problems as well as increase functionality in these areas.
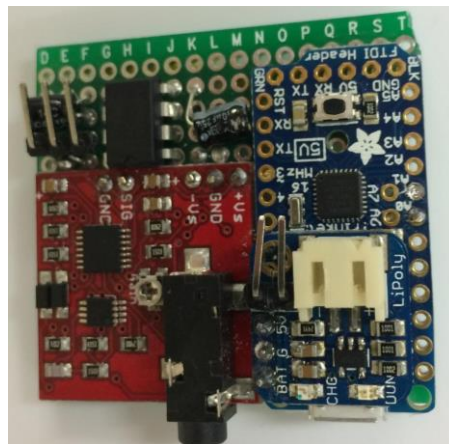

Figure 1: Current Limbitless Solution

Function: The package created will serve as a demonstration of various technologies that can be utilized in future designs. Care will be taken to ensure modularization of each section, such that if certain elements are not wanted for a specific arm, they can be easily truncated from the board. This will ensure that the solution can be used in a variety of different situations as needed by the client. Future compatibility will also be kept in mind during design. The team will ensure that future goals will be able to be implemented using this board (having multiple EMG inputs, multiple Servo outputs, etc.) such that plug and play expandability exists for the hardware components, and only software updates will be required.

Goals and Objectives: The team has met with Limbitless Solutions several times to get input about what they would like in the new prototype. The major discussion points are as follows:
- Ensure that the new set of electronics has all the same functionality as the current set up and more: at a minimum the electronics should allow the user to control the hand by flexing a muscle on the limb with the bionic attachment
- Create a Printed Circuit Board (PCB), or a series of PCBs to optimize the electronic footprint
- Switch to a different microcontroller (potentially MSP430 or other TI controller)
  - The main motivation behind this is the current solution utilizes an Adafruit evaluation board for its processing needs. This results in several components which are not utilized, but still being purchased for each arm. The new solution will seek to eliminate this wastage and only utilize components necessary for a successful solution
- Upgrade the code and develop a calibration subroutine
- Install haptic feedback (include a way for the user to get some sort of feedback so that they are aware that the hand is actually closed on an object)
- Ensure that the electronics are environmentally protected: both splash proof and shock resistant
- Make a housing for the electronics that will prevent users from tampering
- Add charging capabilities that does not expose the charging port to environmental hazards
- Add wireless programming capability so that the electronics can be programmed without the necessity to remove the electronics from the housing
- Add the ability to include multiple electromyography (EMG) inputs as well as haptic feedback inputs/ outputs
- Ensure the overall cost of the electronics solution is optimized for affordability
- Keep the weight of the electronics to a minimum

Requirements and Specifications

The redesign of the Limbitless Solutions Bionic Arm will be required to meet the following specifications:

Description	Quantifiable Specification
Electronics Weight	Less than 0.45 kg for kids 1.4 kg for Vets
Battery Life	10 Hours Standard Usage
Price (wholesale)	Under $350 for the overall design
Environmental Protection	At least IP27
Wireless Programmable Range	Minimum of 3 meters
Charge Time From Entirely Drained Battery	Less than 8 Hours

Requirements Summary: Limbitless Solutions wants to ensure that the new electronics have all the same functionality as the current electronics and more

The Limbitless bionic arm's current usage is geared towards children. The group set the required weight of the arm to be approximately 0.7 kg in order to make sure that the intended child does not feel off balanced. Ideally for this project the weight of the electronics will be 0.45 kg (roughly 60% of the weight of the arm) or under while keeping full functionality of the current arm. The current standard for the battery life of the arm is 6-8 hours of active usage. During this project the system will be optimized for power usage. However, due to the additional components added to the design, power consumption is expected to increase. The group will be working towards improving the power usage to allow for the additional components and sensors. Limbitless Solutions informed the team that for this project, demonstration of possible functionality is more important than battery life or weight: once they see what technologies they would like to keep from this design, Limbitless will optimize the weight and power consumption for the new design.

Currently the electronics for the arm cost between $100 and $150, with the addition of haptic feedback sensors and improvements to the design the group expects the approximate cost of the arm's electronics to be under $350.

In order to minimize potential damage to the circuit board, the group will utilize methods to ensure the board is dirt and water resistant. In the design process the group will make the design rigid enough to prevent shock damage. The 1 meter specification is to ensure that if a mechanical failure on the housing of the arm occurs, the resulting impact of a potential fall does not impact the performance of the electrical components.

In the event that Limbitless solutions wants to update the software running the MCU, a technician will upload the update via a wireless interface. While most wireless connections can cover a distance larger than 3 meters, the goal of the board is to allow a technician to send the

updates through a computer located within the same room. A large coverage would not be necessary for this purpose.

Currently the battery for the bionic arm is charged at night, while the child is asleep. For this reason the group has set the charge time requirement to be less than 8 hours in order to make sure that the device will be fully charged after sleeping, where they can continue usage throughout the day or charge when not in use.

Constraints and Standards

IP Code

Wireless communication (IEEE 802.15.1, IEEE 802.11n-2009, etc… to be decided)

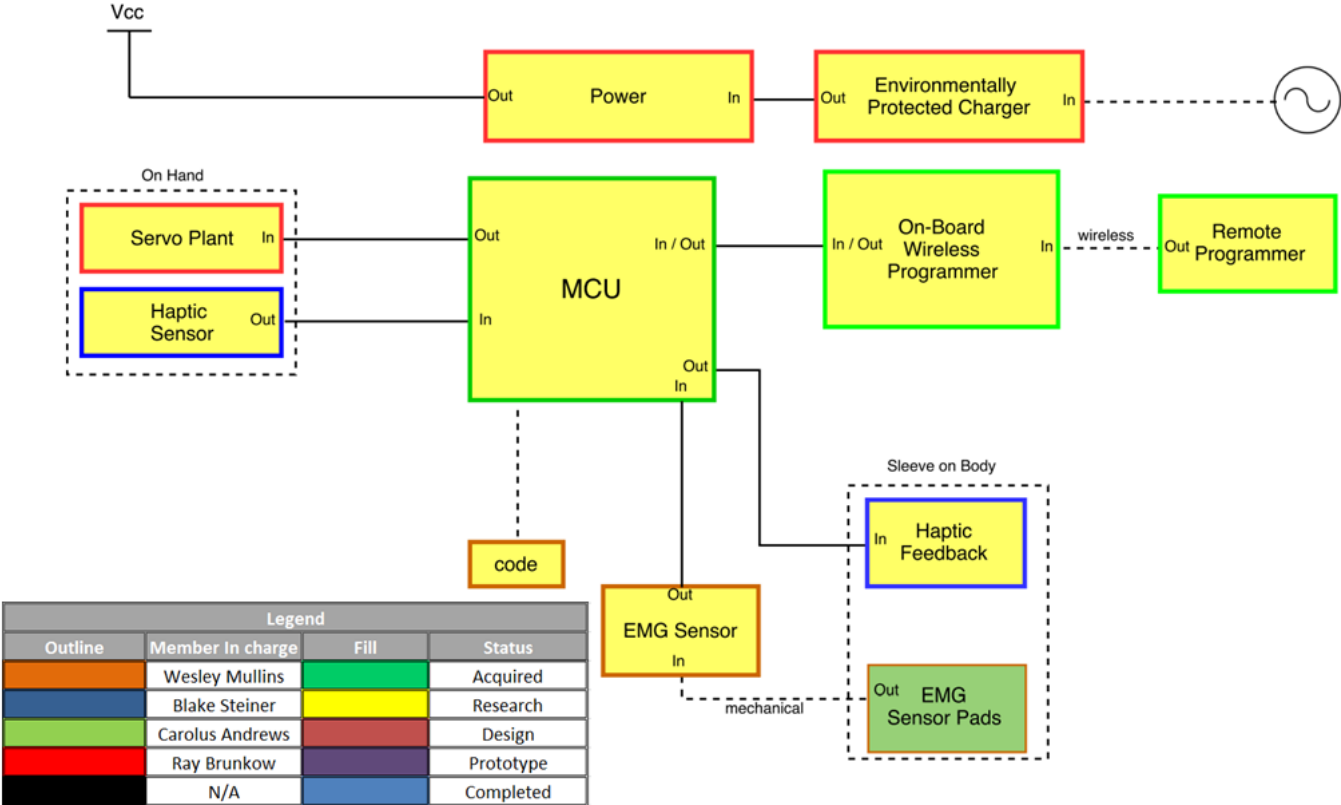Charging (Nema5-15P/R), UL 1236, etc...

Programming Language(s)

I^2C

Tx/Rx (Rs-232)

UART/USART

Shock MIL-STD-810F Method 516.5

Block Diagram

Legend			
Outline	Member In charge	Fill	Status
	Wesley Mullins		Acquired
	Blake Steiner		Research
	Carolus Andrews		Design
	Ray Brunkow		Prototype
	N/A		Completed

Estimated Budget

Item	Cost
Power	$25.00
Charger	$60.00
MCU	$4.00
Servo Plant	$40.00
Haptic Sensor	$40.00
Haptic Feedback	$30.00
EMG Sensor	$35.00
EMG Sensor Pads	$10.00
Wireless Programming System	$30.00
PCB	$30.00
Total Cost	$304.00

Financing

Limbitless Solutions has promised to provide our team an initial budget of $1,000 for the project. Limbitless is also currently attempting to set up our team with a contact at Texas Instruments (TI). If Limbitless succeeds, TI will be providing our team components, development boards, and support as a donation for this project.

In addition to this, our team will be pursuing donations from companies as much as possible. Limbitless Solutions has indicated that due to the nature of their work, companies tend to be willing to donate parts and grants.

Milestone Chart