John Buchholz, Michael Esposito, Sragvi Tirumala

Senior Design, Fall 2016

**Automated Transport Vehicle**

1. **Project Plan**

For those with disabilities, there exists a need for a device which transports their possessions. The goal of our project is to create an Automated Transport Vehicle (ATV) which can independently carry cargo, reducing any bodily strain on the user.

1. **Project Requirements**
   1. Size
      1. Vehicle must be smaller than 8 cubic feet
      2. Must be lightweight
      3. Must be optimized for portability, mobility, and durability
   2. Cargo Area
      1. Can be repurposed for multiple types of cargo
      2. May be powered, to provide the option of a heating or cooling cargo
   3. Controls
      1. The first control schema involves using surface electromyography (sEMG) signals to correspond to designated commands
      2. The secondary control schema involves acquiring sensory information from the robot’s surroundings to recognize the user’s location. The robot’s movements will be entirely automated
2. **Member Responsibilities Breakdown**

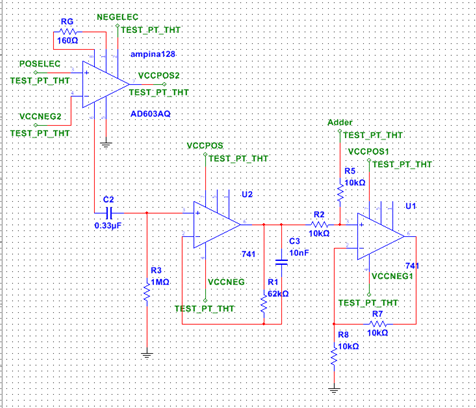
This is a rough breakdown of each of our primary responsibilities for the project. Though we each have our specializations, we all possess a breadth of engineering and computer science knowledge. This project divides well across the various disciplines of study of our group members.

* 1. John - Mechanical Engineering
     1. Planning, design, and construction of the ATV
     2. Rocker-Bogie Mechanism
  2. Sragvi - Biomedical Engineering
     1. Physiological signal acquisition, filtering, and analysis
     2. Image processing
  3. Michael - Computer Science
     1. Bridge between sensory input and control of the motors
     2. Image processing/automation

1. **Proposed Budget**

|  |  |  |
| --- | --- | --- |
| **Item Name** | **Quantity** | **Price** |
| Nexus 7 Tablet | 1 | $100.00 |
| IOIO OTG | 1 | $39.95 |
|  |  |  |
| **Signal Acquisition Materials** |  |  |
| Instrumentation Amplifiers | 2 | $11.00 |
| Operational Amplifiers | 8 | $1.00 |
| Basic Circuit Elements | 1 | $10.00 |
| Assorted Wiring/Cables | 1 | $10.00 |
| ADC | 1 | $5.00 |
| Electrode Set | 2 | $7.00 |
|  |  |  |
| **Structural Components** |  |  |
| Bearing | 12 | $5.00 |
| Steel Rods | 1 | $5.00 |
| Stepper Motors | 6 | $20.00 |
| Body (PVC or acrylic) | 10 | $0.22 |
|  |  |  |
| **Total Cost** | $376.15 |  |

1. **Design** 
   1. Robot physical construction
      1. ATV construction
         1. Rocker-Bogie Mechanism to allow for more freedom of movement for the end user, allowing for simple curbs and small steps to be bypassed while the cargo bay remains flat using a differential gear system
      2. Motor configurations
         1. One motor will be applied to each wheel, providing enhanced maneuverability and control
      3. Batteries will be held in a separate compartment, providing power for the tablet and wheels. A second set of batteries will power the sEMG signal acquisition circuit
      4. Inset location within design to contain and protect tablet and wiring
   2. Control Schemata
      1. Biosignal Acquisition Circuit Design



The above circuit diagram shows the three main phases of signal acquisition. The input signal from the electrodes first enters the instrumentation amplifier - INA128. The next phase of the circuit is filtering. The diagram shows a band-pass filter using a basic 741, but more efficient op-amps can be easily substituted. The final phase of this circuit is a voltage adder which allows an Analog-to-Digital Converter (ADC) with Transistor-Transistor Logic (TTL) to accept the output. TTL devices can only accept positive voltages.

* + 1. RGB Camera/Infrared camera analysis to track and follow user
  1. Controlling the Motors

The IOIO-OTG breakout board provides the ability to control up to 9 PWM-controlled stepper motors from an Android tablet. Our control schemata will control the motors through this interface.

* + 1. Biosignal Analysis

The sEMG signals will be analyzed in discrete time intervals. During each interval, characteristics of the signals such as mean squared amplitude will be extracted. If the value exceeds a threshold, a corresponding motor will activate in the following time interval. For example, if the sEMG signal on a user’s right arm is activated, the stepper motor controlling the right wheel will turn during the next time interval. To reverse the direction of the motors, one sEMG signal, likely from the one of the user’s legs, will serve as a toggle for the polarity of the voltage applied to motors when it surpasses a threshold. All thresholds will be dynamic.

* + 1. Automation via onboard sensors

The robot will be able to follow a user and assist in transporting cargo. In order to do so, a method of capturing and analyzing image data from an RGB and infrared camera will be created. Image processing will be performed locally on the Android tablet. The visual data will be used to create instructions that control the motors. We will test various methodologies in order to determine the best way of tracking a user. Other sensors, like an array of ultrasonic sensors, may be needed in order to quickly and successfully locate and follow the user.

* + 1. Manual control

Before the more complex schemata can be implemented, a manual control will be used to test the motion of the robot. A joystick will be used to deliver commands to the motors.

* + - 1. Fallback scenario

I can work on a simpler robot that just tracks a user around. It would most likely only have 4 wheels, or a set of treads, and not be as intense of an off-road vehicle. I am responsible for the visual tracking and automation, and in case either member of my group fails to contribute their part, I will still have a demonstration tactic. Instead of following a dot on a user, the robot will have to identify unique features about a user use this to track their movement. It may also require a LIDAR/ultrasonic sensor to maintain a constant distance behind a user.

* + - 1. Something different entirely?

Something security related

* + - 1. How will I work on it by myself?

My group will build a basic mini-robot within the next week, so I can start ordering and assembling sensors, cameras, phone applications, and other necessities to enable robotic movement.

* + - 1. Figure out how the other parts work

The robot’s storage compartment will stay relatively flat on the ground, which is beneficial for both cargo and my electronics. It uses a differential system much like that of the Mars rovers. A good explanation can be found here: <http://www.alicesastroinfo.com/2012/07/mars-rover-rocker-bogie-differential/>



Signal Analysis

The robot will have alternate control schemes. I will create the automation segment, while my group member will create a control scheme derived from muscle extensions and contractions. The signals will be read from electrode sets, and then filtered into commands that can control forward, reverse, and rotational movement, as well as movement speed. This would be beneficial for those that may be paralyzed, or temporarily immobilized, and allows them to control the robot using only their arms, legs, etc. This sensor arrangement will also need to be wirelessly separated from the actual robot, so I will assist in the data transmission between filtered electrode sensor data and robot control.