Introduction

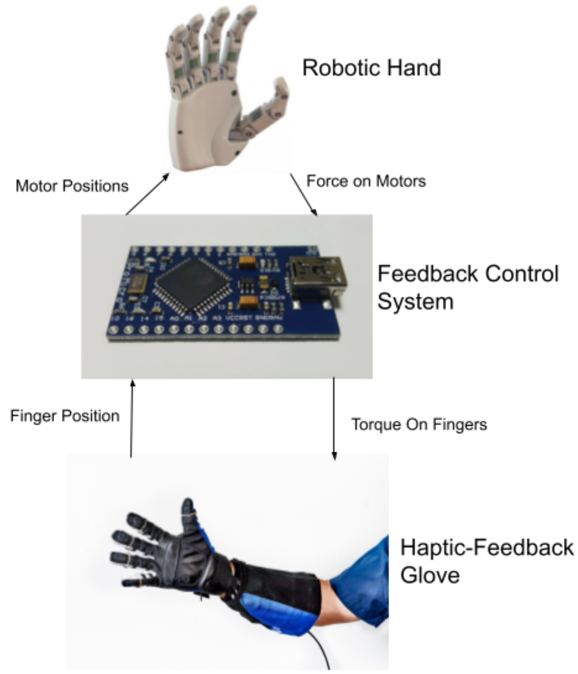
- **Problem**

  A common need in Industry, and especially in today's increasingly virtual world is to interact with objects where it may not be possible from a logistic or health standpoint to do so. We have robotic manipulators and virtual simulations, but there is still a huge gap between real life and these current solutions. In a setting where an object is hazardous and may be fragile, it is paramount to be able to control how much pressure one is applying to the object, and be able to adjust it quickly and in a way that feels natural.

- **Solution**

  We would like to make two devices that work together to solve this issue. We want to create a manipulator that mirrors the user's movements and can accurately communicate the amount of force being exerted back to the user. The user would wear a glove that can track each finger's movement independently and apply the force experienced by the manipulator back to the user's hand. This would allow the wearer to easily discern the amount of force they are applying to an object without actually touching it themselves. This both solves the issue of being able to quickly and easily feel the force they are applying, as well as increasing user immersion, as wearing a glove is much more natural than using a different control mechanism. It would also allow a user to differentiate between objects quickly, for example the feeling of a foam ball vs a solid one.

Visual Aid

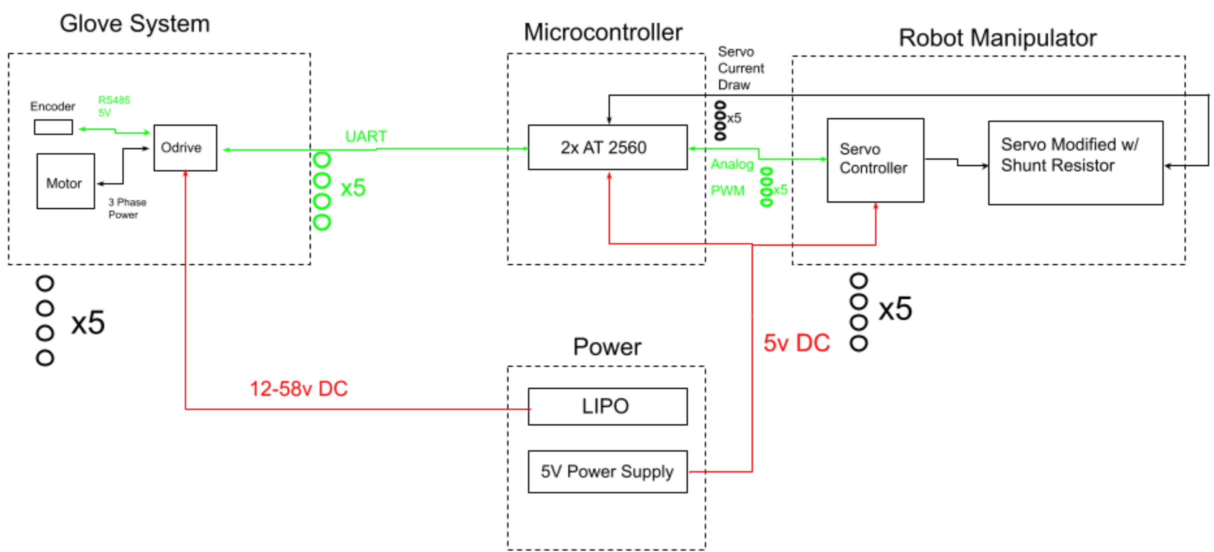


High Level Requirements

- Measure and apply forces back to user's hand to at least 10 pounds of force
- Have a latency of less than 1 second
- Support dynamically changing the force to match anything from slight resistance to fully stopping movement

Design

Block Diagram



Subsystem Overview

- **Glove**

  This subsystem will be what the user actually wears, and will both track movements of each finger as well as apply the forces back to the wearer. It will need to support a wide range of resistance to motion, from light resistance as if one was squishing a foam ball, to being able to fully stop the fingers from moving. This connects to the other subsystems via UART, the microcontroller sits between this and the manipulator.

- **Manipulator**

  This subsystem will be what interacts with the object and relays resistance encountered by it to the glove. It will use servos that have been modified to support current detection with low side shunt resistors. This current will be used to determine the amount of resistance the manipulator is encountering. The manipulator itself will be 3D printed from inexpensive plastic such as PLA. The mcu will communicate to this through analog pins

- **Microcontroller**

  This is the brain of our project, it will be a microcontroller based device that can process the raw data coming from both the glove and manipulator, then facilitate the communication between the two. It will communicate with the other subsystems via UART and analog PWM control.

- **Power**

  This subsystem is what will power the entire project. It comes in two parts, a 5v power supply and a LIPO battery. The 5v power supply will provide power to our microcontrollers as well as our servo controllers. The LIPO will provide at least 12v to our ODrives as they consume much more power than the basic microcontrollers.

Subsystem Requirements

- **Glove**

  This device allows the wearer to feel the forces applied by the manipulator, as well as track individual finger movements. It communicates to the MCU via UART.

  - Must be able to apply enough force to stop a reasonable amount of hand pressure.
  - Must support variable resistance
  - Must be able to be polled via UART
  - Report position to MCU
  - Receive force commands from MCU

- **Manipulator**

  This device allows the user to interact with an object and sends the force information to the glove

  - Controlled via servos
  - Must report current consumed by servos via a shunt resistor
  - Receive position commands via PWM
  - Report current via an analog signal

- **Microcontroller**

  This is the brain of our project. It takes in and processes the signals for both the glove and manipulator.

  - Supports 5x UART and 10x Analog
  - 5v Logic level
  - Must be fast, less than 1s latency

- **Power**

  This subsystem is what will power the entire project. It comes in two parts, a 5V power supply and a LiPo battery

  - 5V power supply must provide at least 700 mA to the rest of the system continuously at 5V +/-0.1V
  - LiPo battery must provide at least 500 mA to the rest of the system continuously at 12V +/-0.1V

Tolerance Analysis

- **Manipulator**
    - We can potentially damage our motors if they are subjected to high currents without heat dissipation, or if they are forced to exert forces for too long. In order to prevent this, we can configure our motor controllers to limit the amount of current being applied, and program our MCU to cut power if it exceeds a certain amount for a certain time. For example, our motors are rated for 40A, but we would limit them to a fraction of that as to reduce the risk of damaging them

Ethical and Safety

According to the IEEE standard of ethics, we have a responsibility to not harm others during the course of creating and also testing out project. The one concern that comes with a haptic-feedback glove is that the motors will apply torque to the user's hand. To a naïve implementation, someone could maliciously bend the fingers of the robotic hand backwards and the glove would attempt to comply and forcibly bend the user's fingers backs as well. To remedy this, we will add a maximum angle to which the glove can provide torque to. Anything beyond that and the glove will no longer provide feedback as to ensure the safety of the user. Same goes for any applied torques to the user's hand. After a certain maximum torque applied to the user's fingers, the glove will either stall at that torque or stop providing feedback until the torque would go down to an acceptable range.

Along the same line of injuring people comes the worry of if somebody's hand became caught or was being crushed by the robotic hand. Although realistically the hand will only apply the same force as a human hand can, during the development of our project we may make a mistake where the hand exerts too much force. As such, we will implement in our design a simple button that when pressed will completely power down the robotic hand thus disabling all of the servos that could be causing injury.

Another ethical concern that is present in every senior design project is to seek honest criticism of our work. Hearing feedback can often be difficult, but we will strive to keep an open mind because that feedback could lead to new avenues with the project that have not previously been considered or may bring up a valid safety concern that we did not think of.