Cost-Effective Quantitative Analysis of Arm and Hand Motion to Aid in Stroke Rehabilitation.

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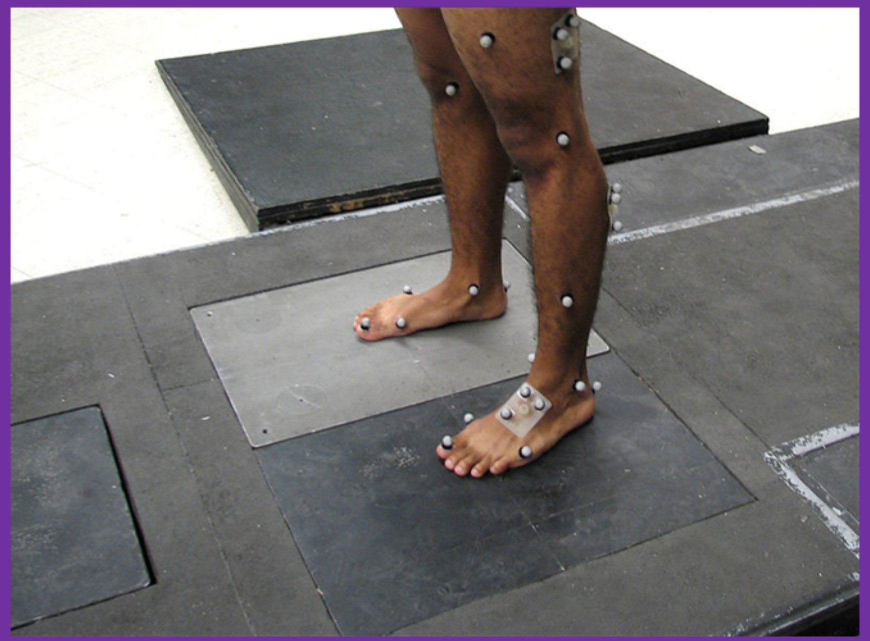
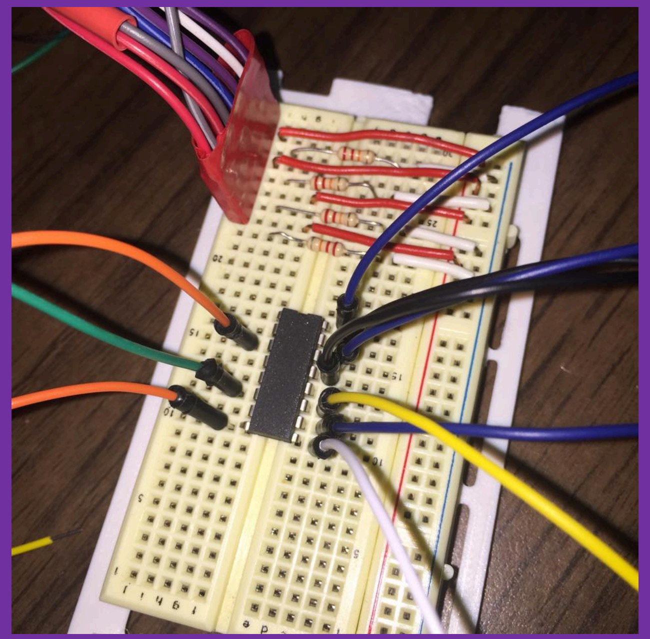
Existing Technologies

Current stroke rehabilitation technologies

Wolf Motor Function Test	Optical Sensing System
• Qualitative	• Prohibitively expensive
• Low cost	• Most precise
• Subjective	• Restricted to use in laboratories





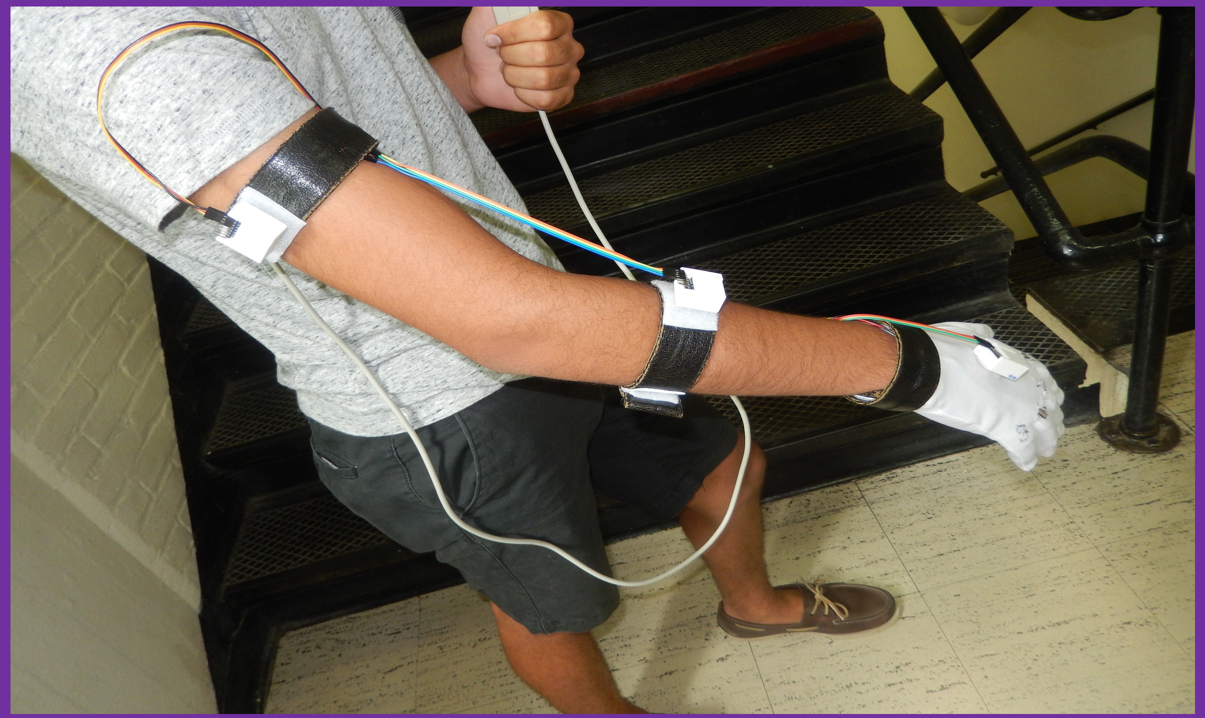


Abstract

Through the combined use of microcontrollers, inertial measurement unit (IMU) sensors, and flex sensors, we fully processed and mapped arm and hand motion.

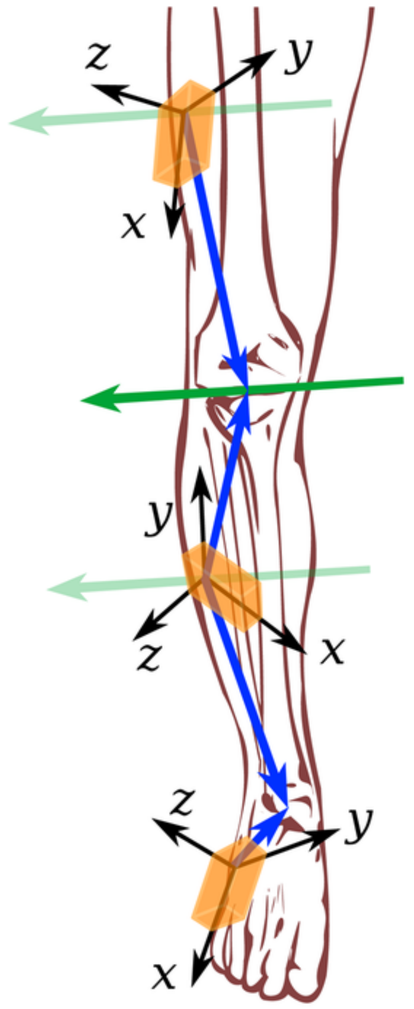
Audience: Stroke Patients with Hemiparesis
Data collection: mechanical development of our hand and arm sensor system
Data transfer: Reading and Streaming of data from our various sensors
Data visualization and analysis: Software that doctors can interact with in order to graphically visualize and analyze the stored motion.

Integrated, low-cost, and modular system



Bill of Materials

1 - Arduino Uno : $25
1 - Multiplexer - mux4051: $2
3 - MPU-6050: $36
4 – Flex Sensors: $44
Total Cost: $107

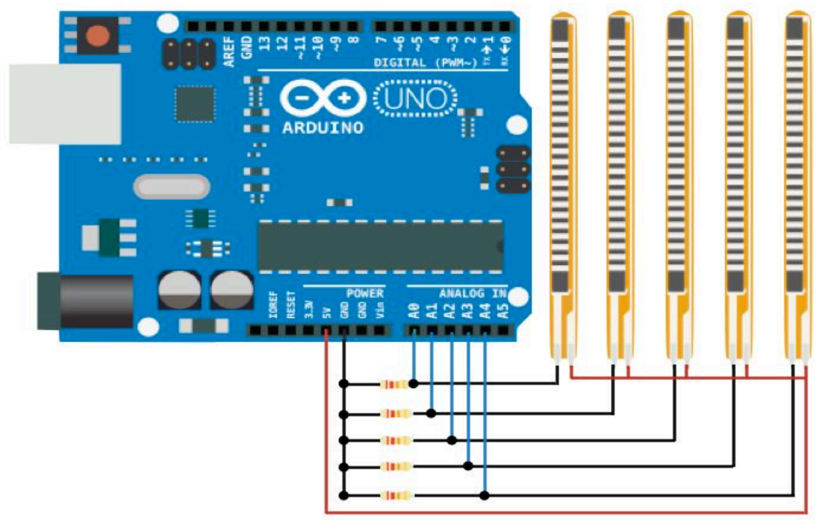


Measured Data:

- Linear Acceleration on three Axes (X,Y,Z)
- Euler angles between IMU’s

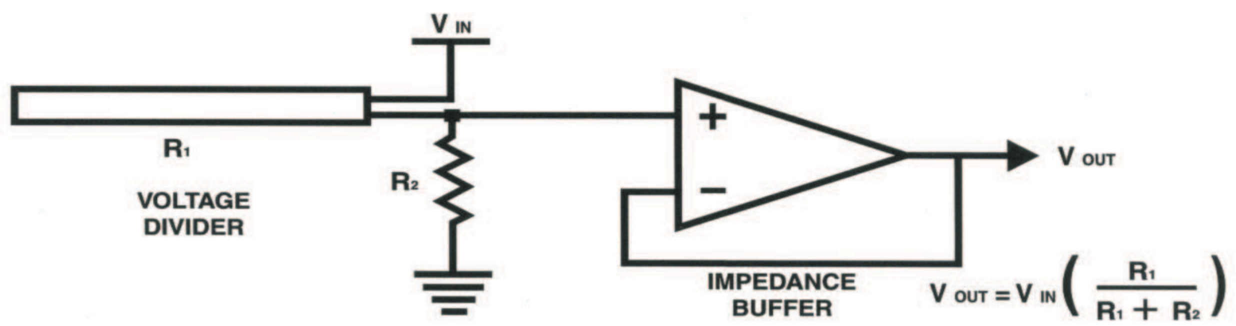
Mechanical Setup
Data Acquisition

Flex Sensors



The resistance of the flex sensor changes when the metal pads are on the outside of the bend. The change in resistance changes the voltage, which is read by the analog pins of the Arduino.

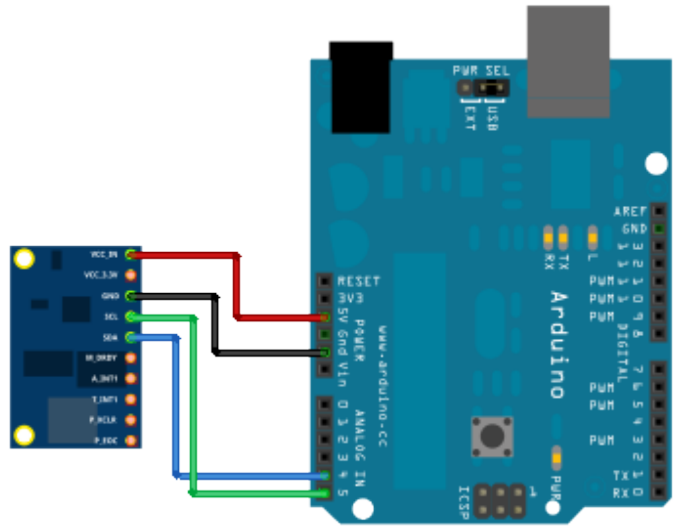
BASIC FLEX SENSOR CIRCUIT:



Following are notes from the ITP Flex Sensor Workshop

Inertial Measurement Unit (IMU)

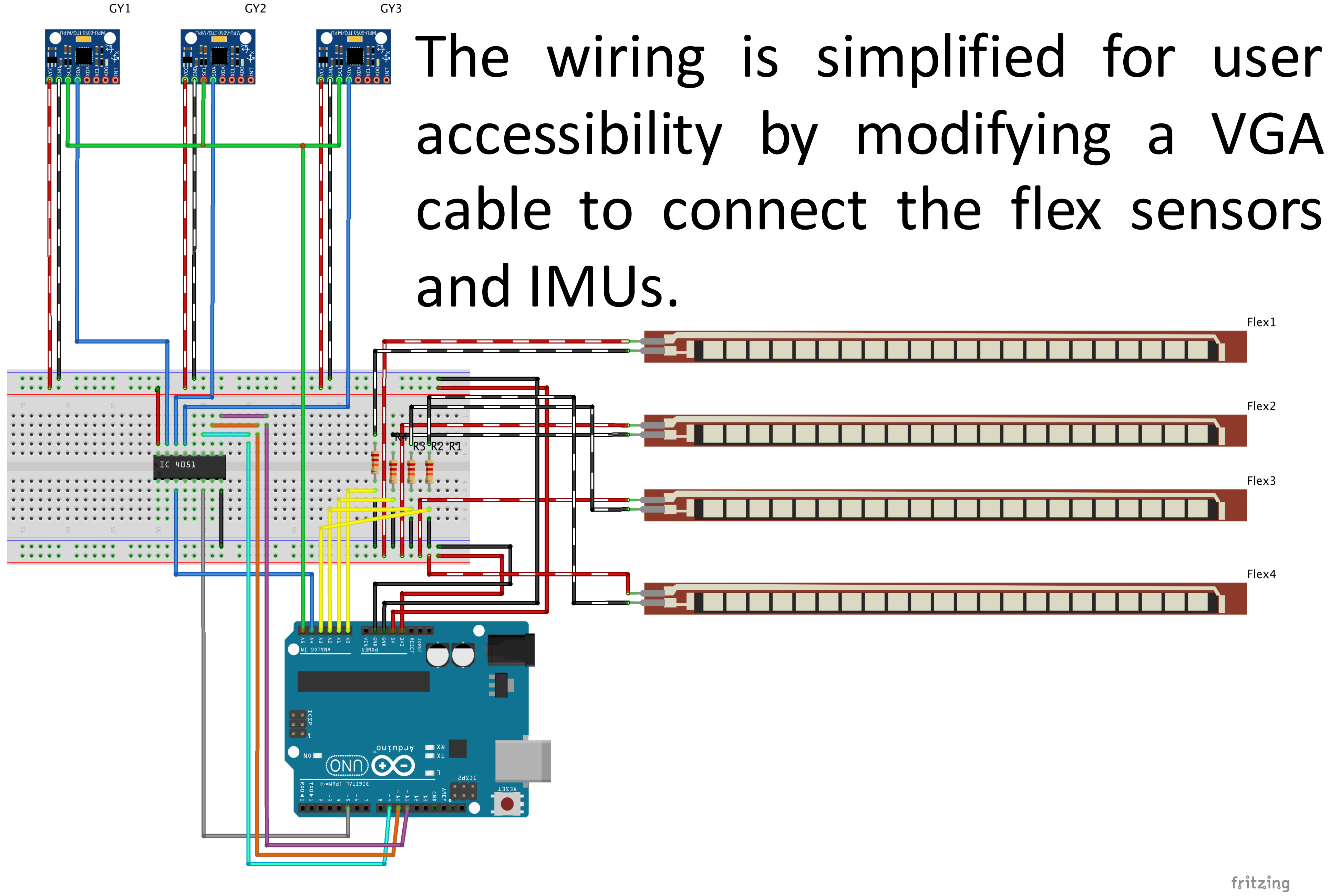
This a MPU-6050. It contains a MEMS accelerometer and a MEMS gyro in a single chip.



The sensor uses the I2C-bus to interface with the Arduino. They have a serial data line (SDA) and a serial clock line (SCL). These lines connect to the SDA and SCL on the Arduino, which are on A4 and A5 respectively.

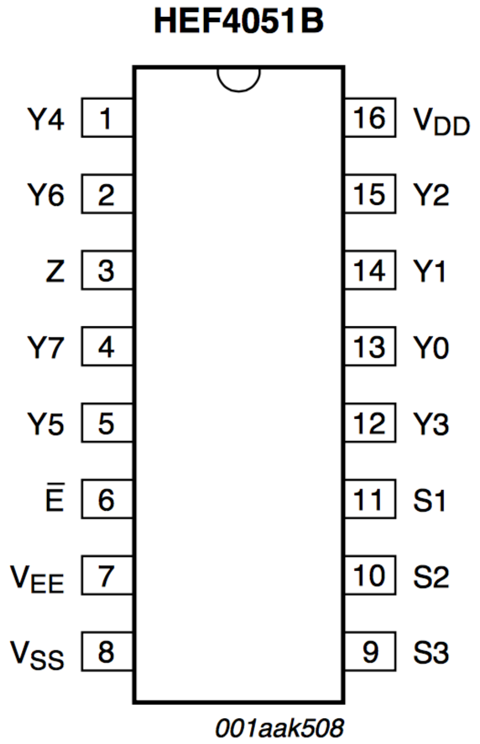
Complete Circuit

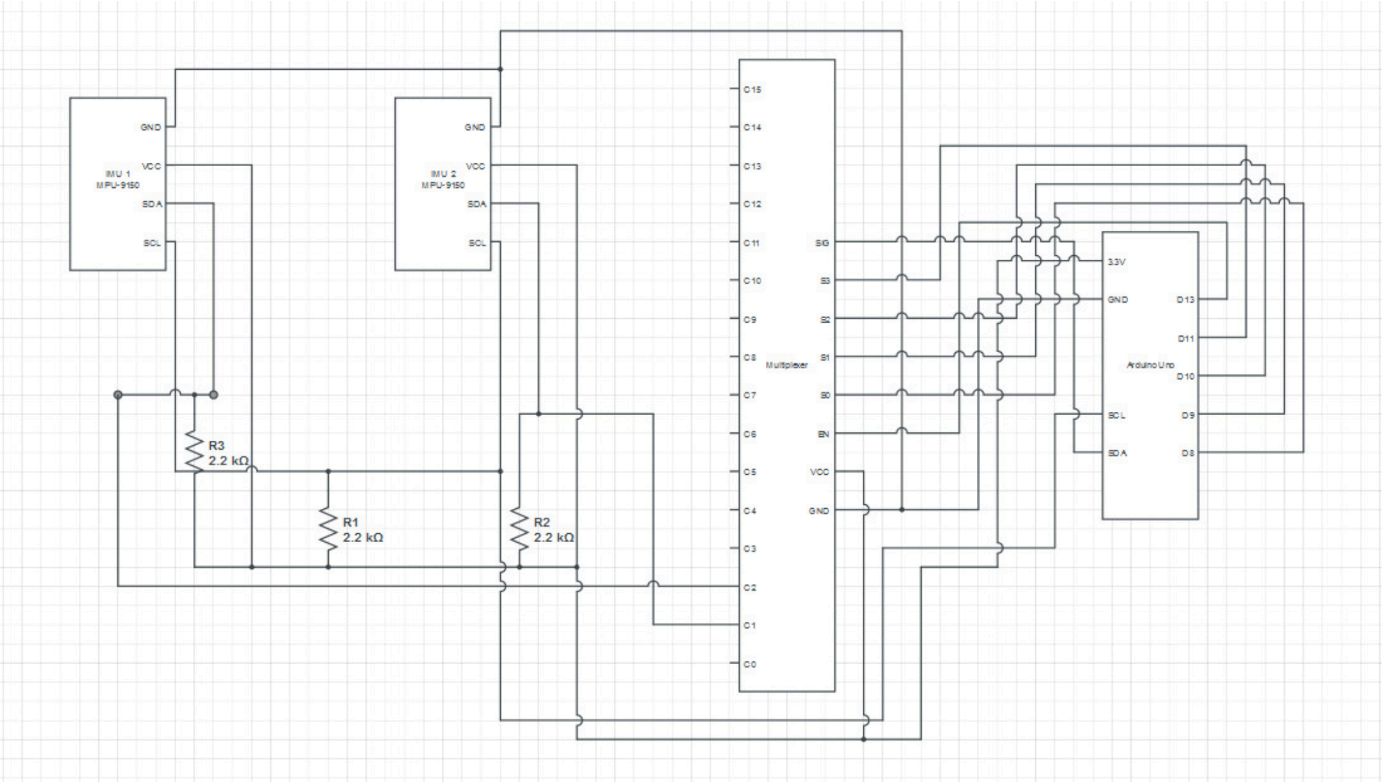
The wiring is simplified for user accessibility by modifying a VGA cable to connect the flex sensors and IMUs.



Multiplexer

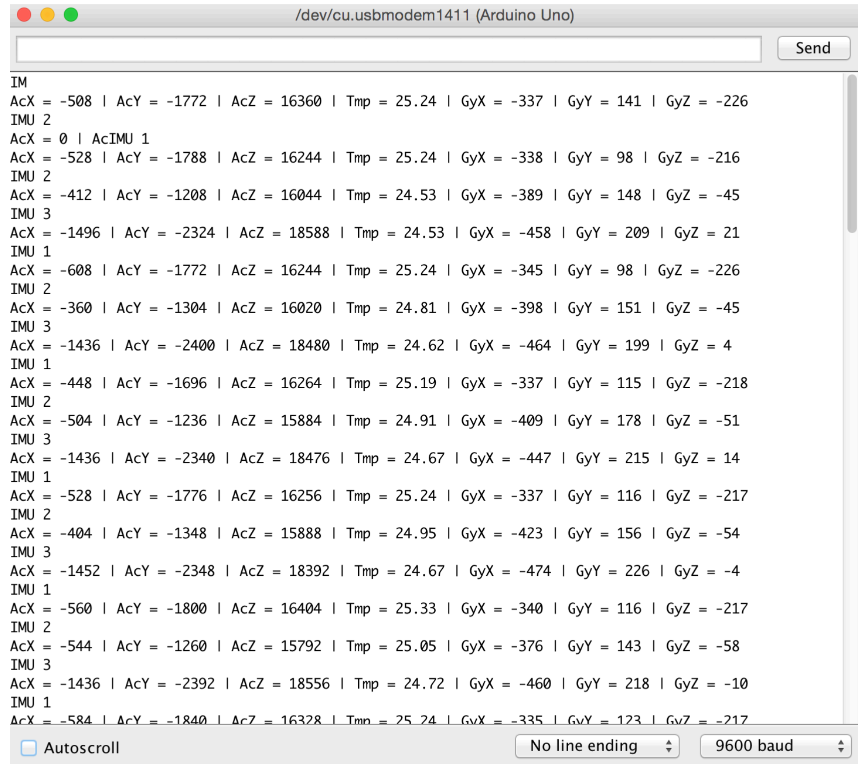
Using a HEF4051B analog multiplexer to switch between SDA lines of multiple IMUs.





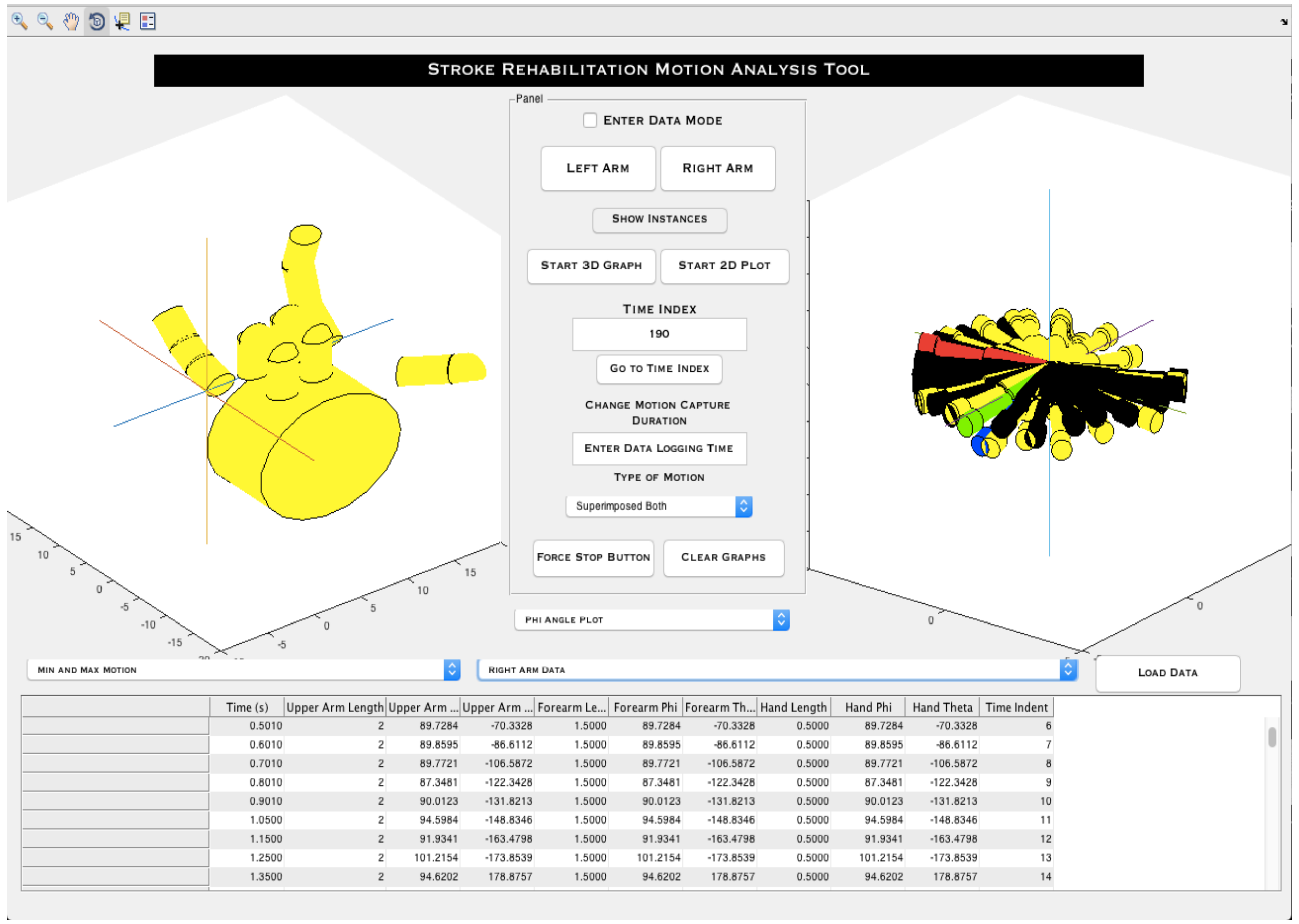
Data

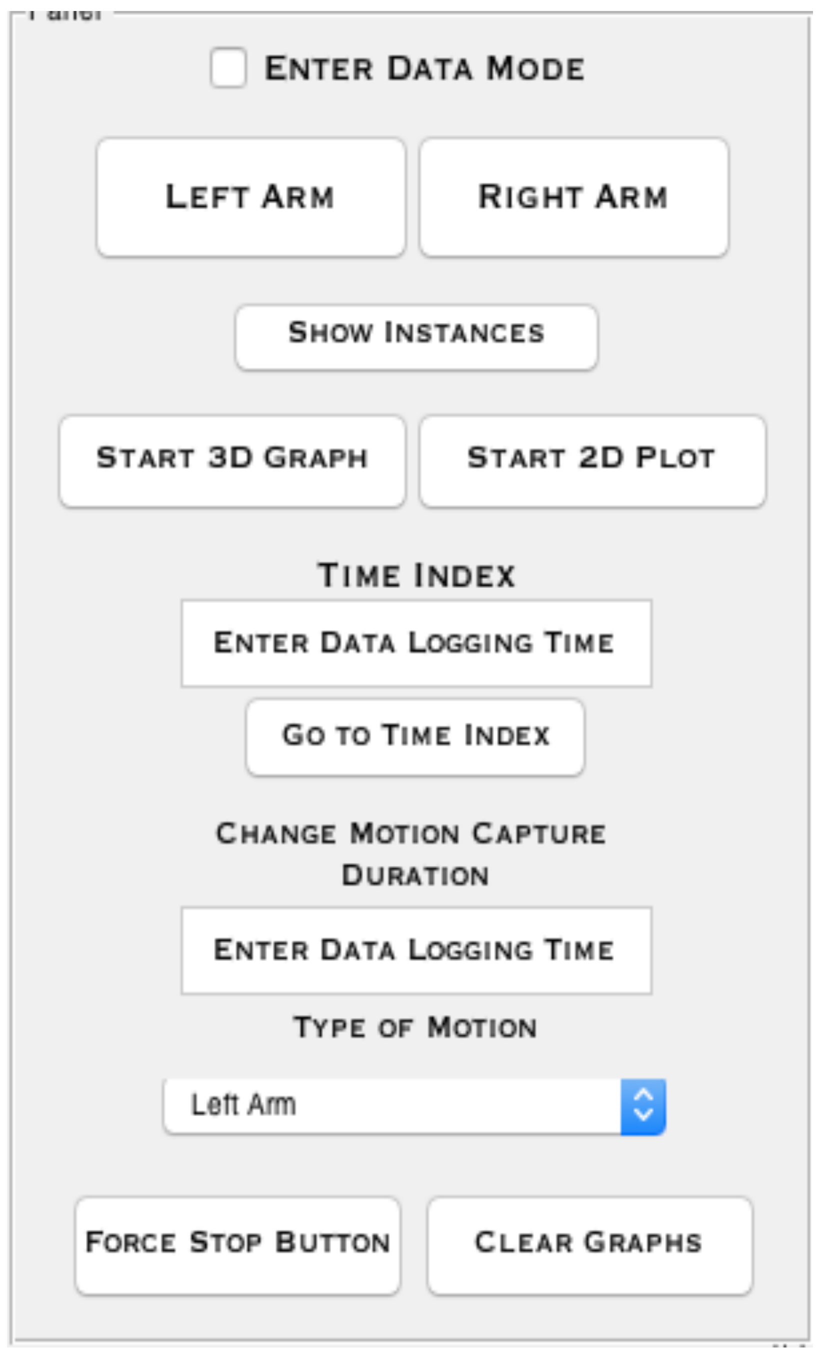
The raw Arduino flex sensor readings are mapped to an appropriate angle range. The IMU readings are similarly mapped in Matlab.



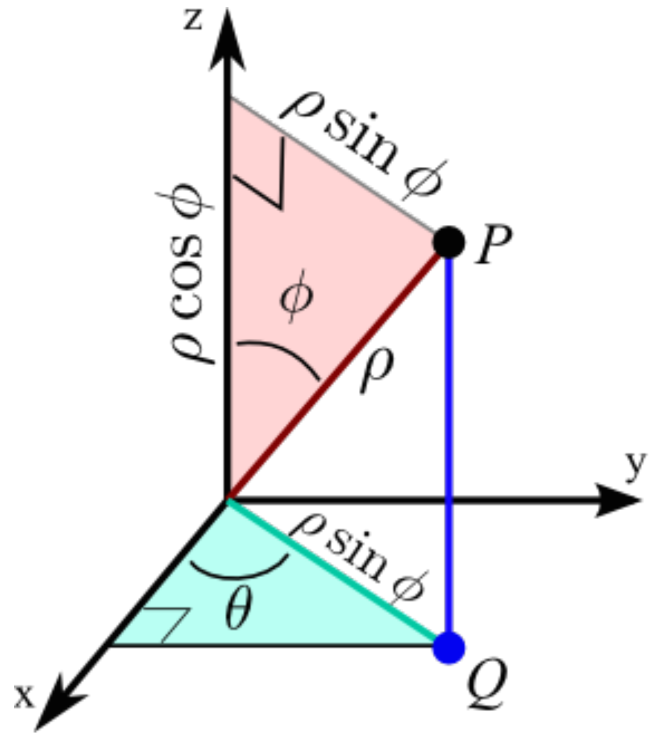
MATLAB Data Analysis | Mathematical Modeling User Interface

Graphical User Interface

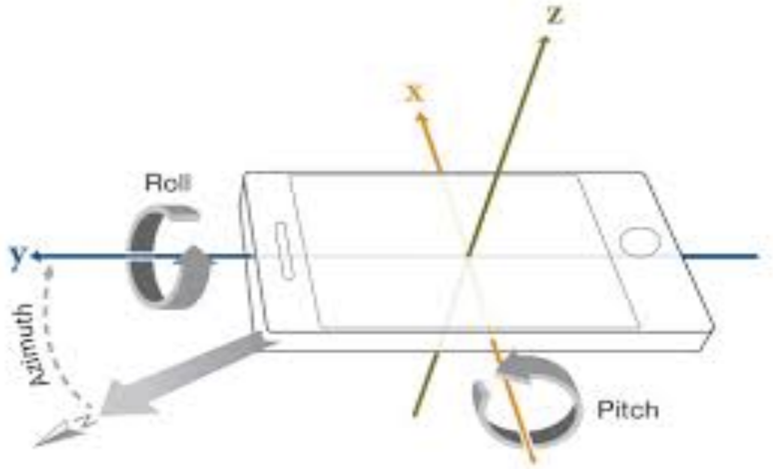


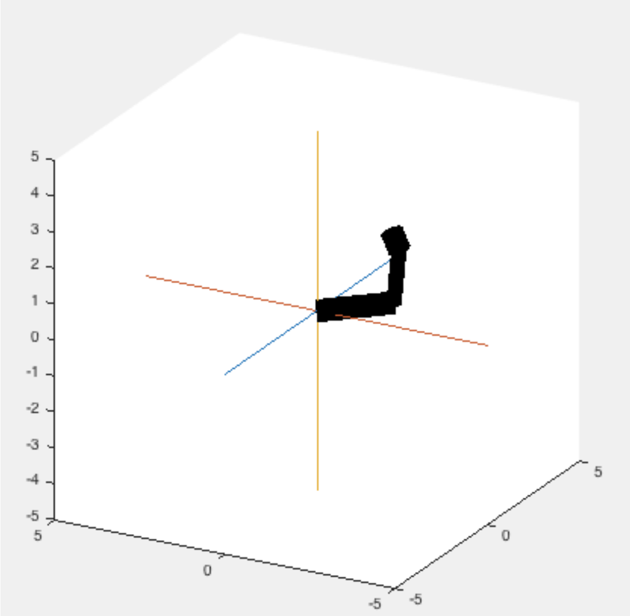


Angles Conversion



From our Euler Angles which is a sensor fusion of the gyroscope, accelerometer, and compass. We utilize the Azimuth angle which we directly map to our Theta angle in spherical coordinates.





-9.8 to 9.8 (m/s^2) → 0 to 180 (degrees)

Future Works

We hope to continue developing our low cost motion capture system by expanding our hand and arm motion capture system to a full body system. The applications of such a low-cost technology are limitless. We also hope to employ filters such as Kalman filters to make our data acquisition more accurate. We also want to make our system more polished and wearable. To accomplish this we can utilize conductive thread, smaller IMUs, and a polished mechanical design. To full map the human body's motion, we will have to better explore motion capture sensors.

Pop-up Menus

Key Features

We are capable of mapping all of the degrees of freedom of hand and arm motion with accuracy. Our analysis tool is able to superimpose left and right arm motion, export motion capture data to csv files to store a patient's progress throughout physical rehabilitation, and numerous graphical tools to analyze a patient's motion – such as vivid distinctions for minima and maxima, and the ability to graphically store instances of the patient's movements. The User Interface also includes algorithms that predict hand motion to make the graphical representation more digestible for both the patients and doctors. By implementing a vector representation system we were able to maximize complexity and accuracy of the graphical representation, while minimizing the render time of our animations.

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