Replication of Human limb motion in Real-time and EMG sensor reading while lifting weight

Design Credits
MEN1010

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MOTIVATION OF THE PROJECT

- For upper body exoskeleton, we need to measure orientation of human limbs and muscle stress simultaneously for operating the actuators.
- Orientation can be obtained through potentiometer, encoders, and IMUs.
- The potentiometer and encoders need a physical structure to get mounted on human limbs. But IMU can be independently put at any location of human limb.
- Also to help the exoskeleton for giving proper supportive torque we need to calculate the muscle stress.
- So our setup will be targeting the combination of EMG and IMU for getting human muscular stress data.

OBJECTIVES OF THE PROJECT

- To make an experimental set-up for measurement of human arm motion using IMU sensor.
- To integrate EMG sensors with IMU sensor setup for measurement of muscle stress.
- Conduct experiments to verify the working of IMU sensors and EMG sensors together.

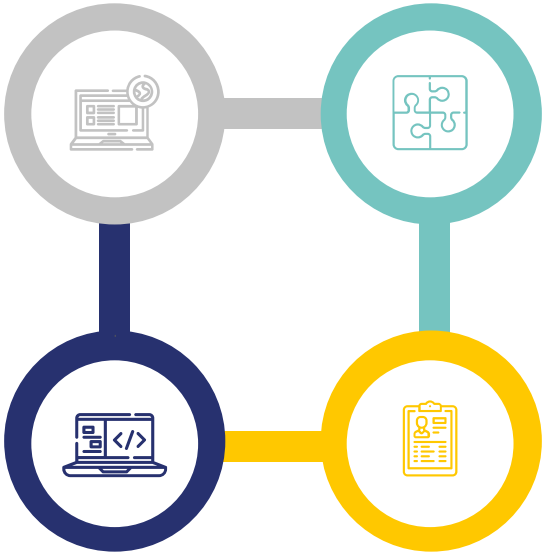
COMPONENTS OF THE PROJECT

Arduino UNO

It is a microcontroller board that is used as a converter of data captured by the sensor into data that is machine-readable.

MATLAB

It is a programming platform



MPU 6050

It is a Micro-Electro-Mechanical system, which consists of a 3-axis accelerometer and 3-axis gyroscope inside it.

EMG sensor

It is one that measures small electrical signals generated by your muscles when we move them!

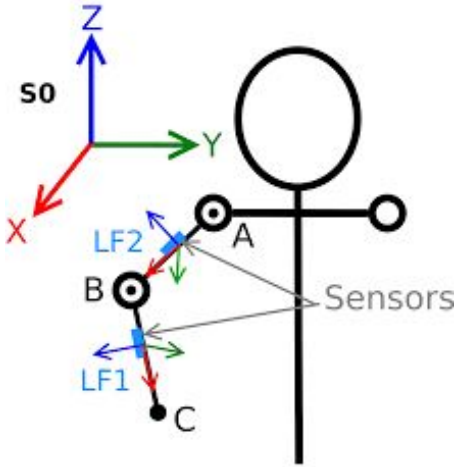
SYSTEM DESCRIPTION

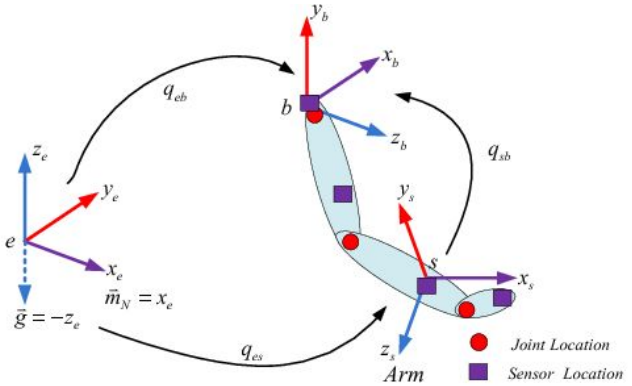
The system get the velocity readings from MPU6050 sensor and muscle stress data reading from emg sensors. Both sensors are placed at tricep and forearm of the participant.

$$\theta_{1,i+1} = \theta_{1,i} + w_0 dt$$
$$\theta_{2,i+1} = \theta_{2,i} + (0.95) w_1 dt$$

$$\theta_{1,i} = 90^0(\theta_{1,i} - 1)$$
$$\theta_{2,i} = 90^0(\theta_{2,i} - 1)$$

$$l_{1,x}(i) = l_1 cos(\theta_{1,i})$$
$$l_{1,y}(i) = l_1 sin(\theta_{1,i})$$
$$l_{2,x}(i) = l_1 cos(\theta_{1,i}) + l_2 cos(\theta_{2,i})$$
$$l_{2,y}(i) = l_1 sin(\theta_{1,i}) + l_2 sin(\theta_{2,i})$$

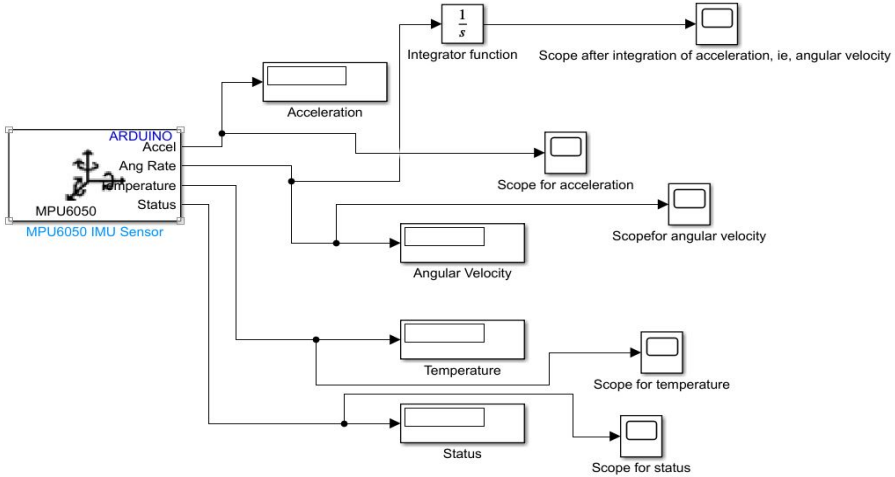


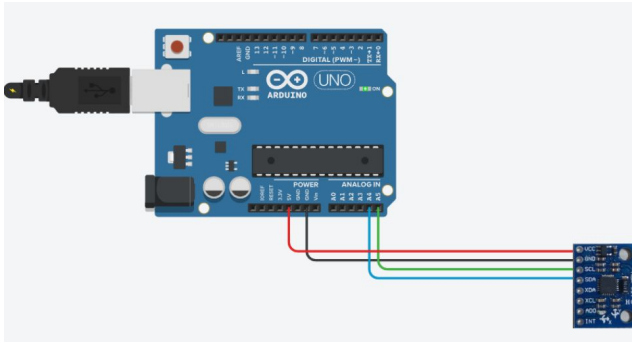


(a) Upper limb coordinate systems

Connections of MPU6050

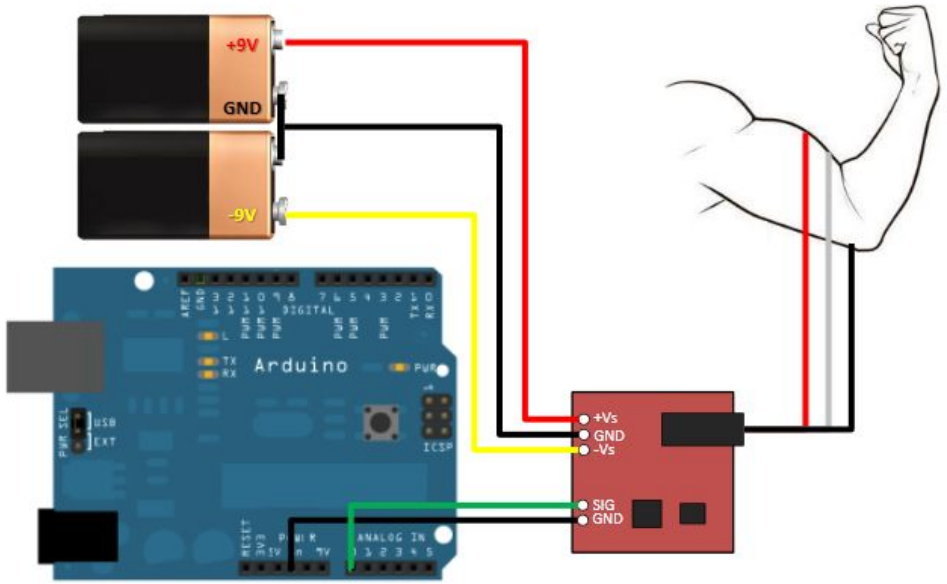
The basic circuit uses an MPU6050, jumper wires, an Arduino, a laptop, and a USB connecting wire for Arduino. Both MATLAB and Simulink softwares are used to interpret the data.



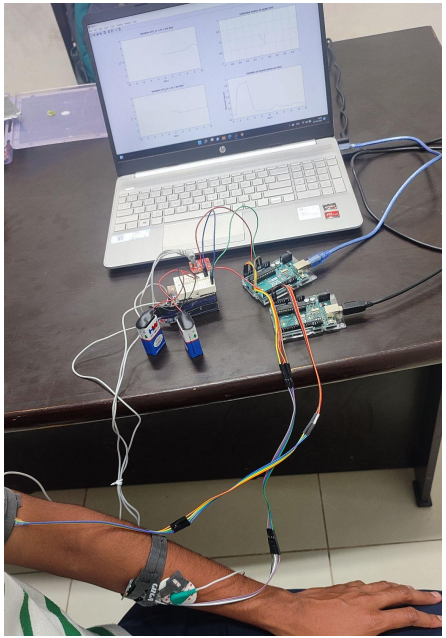


Connections of EMG sensor

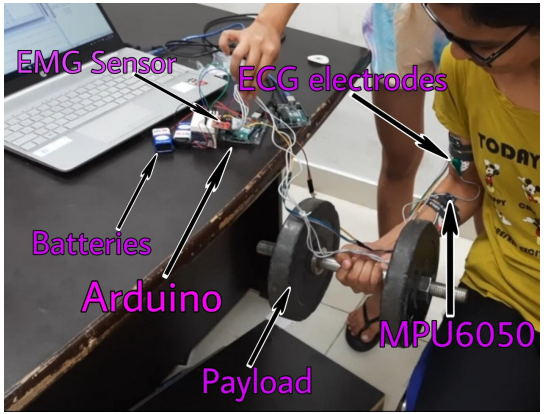
- Two electrodes are connected to the muscular part.
- One electrode is connected to the bony part.

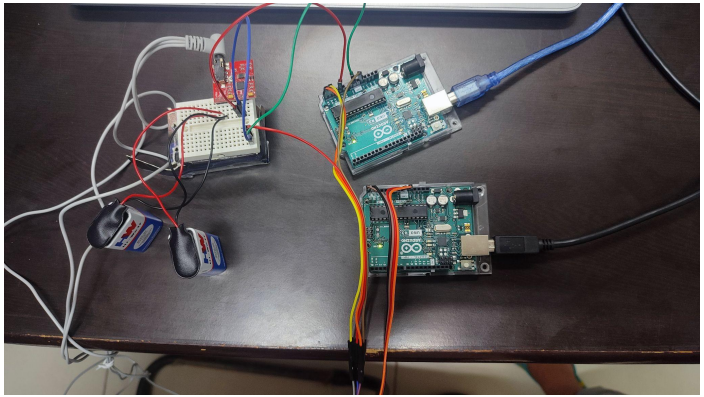


EXPERIMENT & WORKING

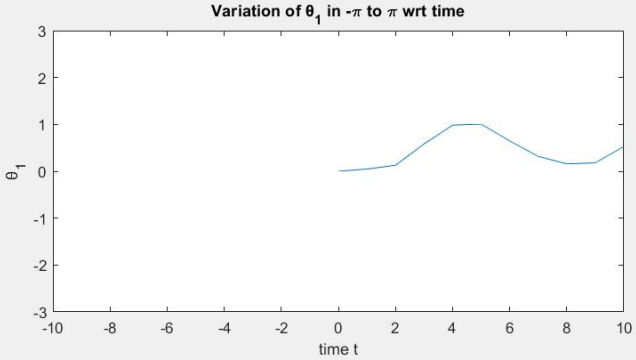


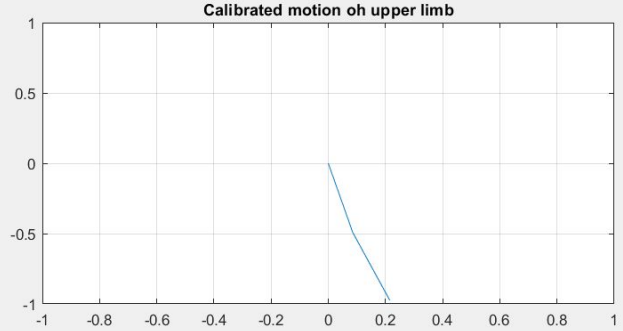
Several experiments are done on different people based on their strength level, and on both hands with different weights and their data is collected.

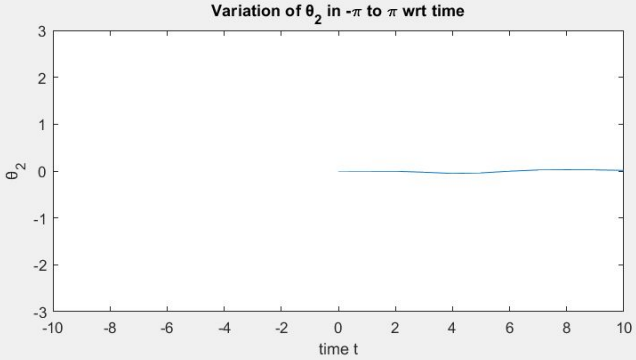


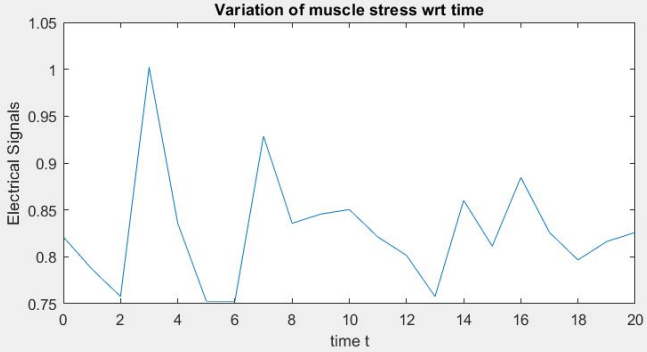


TESTING


Variation of θ_1 in $-\pi$ to π wrt time
θ_1
time t

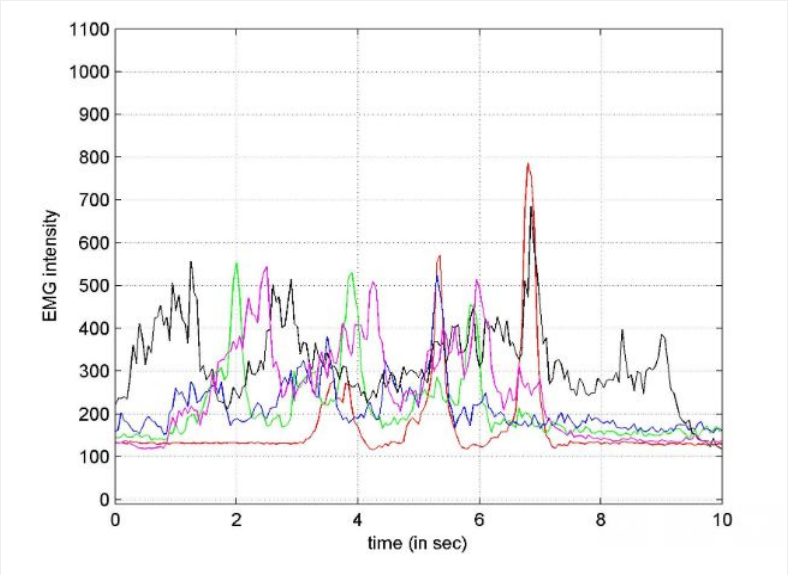

Calibrated motion oh upper limb


Variation of θ_2 in $-\pi$ to π wrt time
θ_2
time t

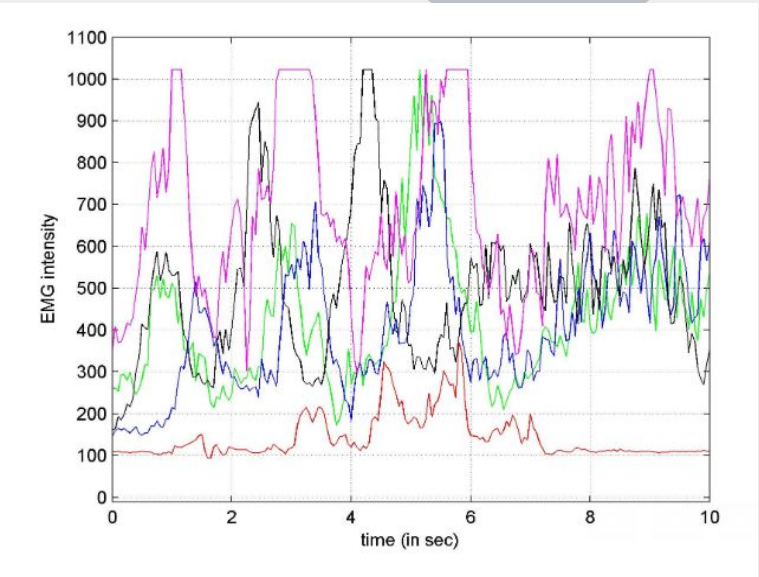

Variation of muscle stress wrt time
Electrical Signals
time t

Results:

Red: 0 Kg
Green: 1 Kg
Blue: 2 Kg
Voilet: 3 Kg
Black: 5 Kg



EMG signals for Gym-goers



EMG signals for non Gym-goers

“Thank You”