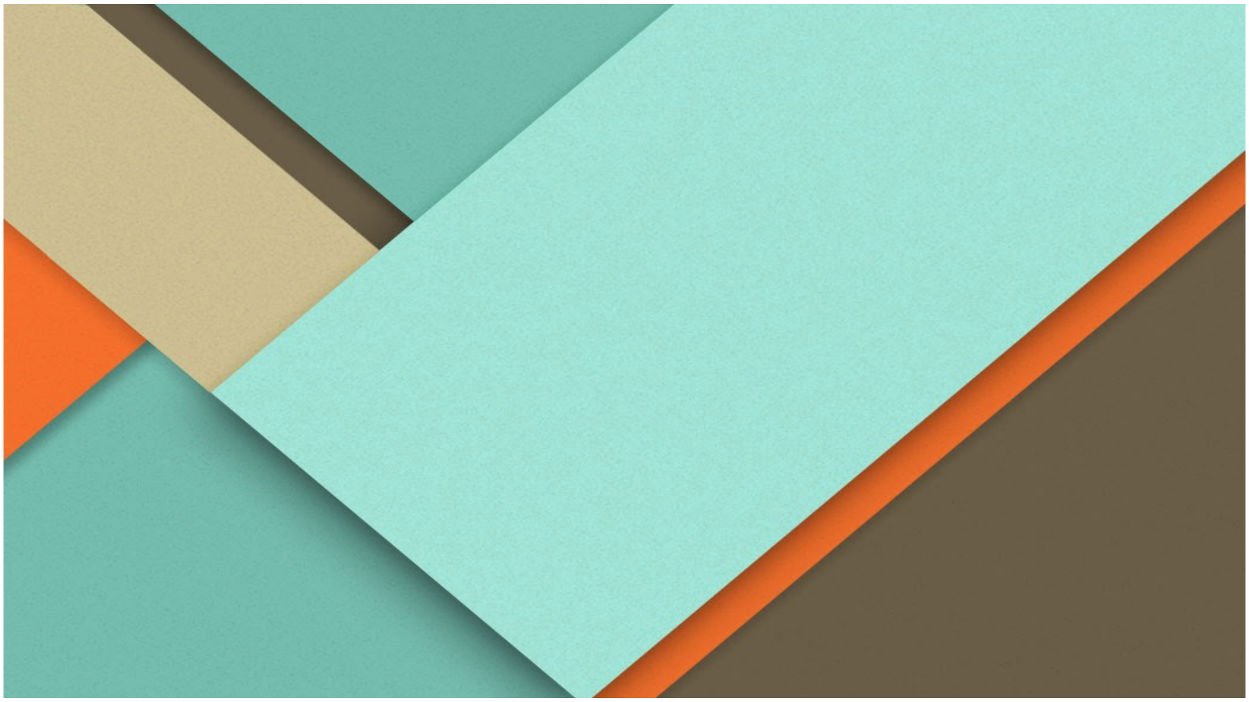
Indian Institute of Technology Jodhpur



Replication of Human limb motion from real-time

Design Credit (MEN1010)

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Content

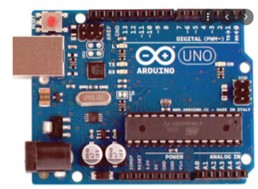
Introduction

In our daily life, we see objects, which are made up of particles in space. We define the location of any particle by using a 3D coordinate system. Every object takes a specific location in the space in form of (x,y,z) points. To define the movement of a particle, we need its position and its motion.

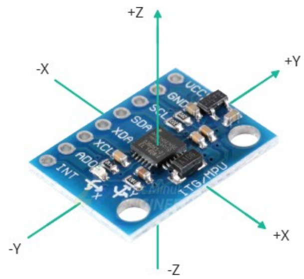
In this project, our motive is to study the motion of limbs and to replicate that motion in software.

Instruments Used

1. Arduino UNO - a microcontroller board that is used as a converter of data captured by the sensor into data that is machine-readable.
2. Jumper wires - to make connections between sensor and Arduino.
3. MPU6050 sensor - a Micro-Electro-Mechanical system, which consists of a 3-axis accelerometer and 3-axis gyroscope inside it.
4. Straps - used to fit the sensor on it and can be put it on hand limbs.
5. In software - MATLAB, Simulink



Arduino UNO



System Description

The basic circuit uses an MPU6050, 4 jumper wires, an Arduino, a laptop, and a USB connecting wire for Arduino. This circuit gets the gyroscopic data with the help of a sensor and gives it to Arduino, and the Arduino transfer the data into a laptop, with the use of a code in MATLAB.

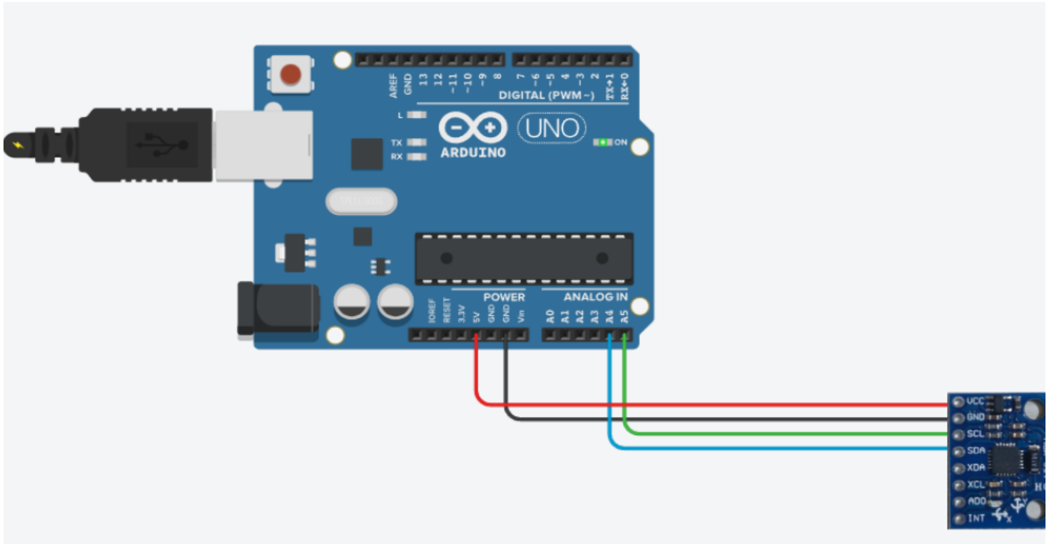
In this circuit, first, we connect these pins:

(i) VCC of Sensor to 5V in the power section of Arduino

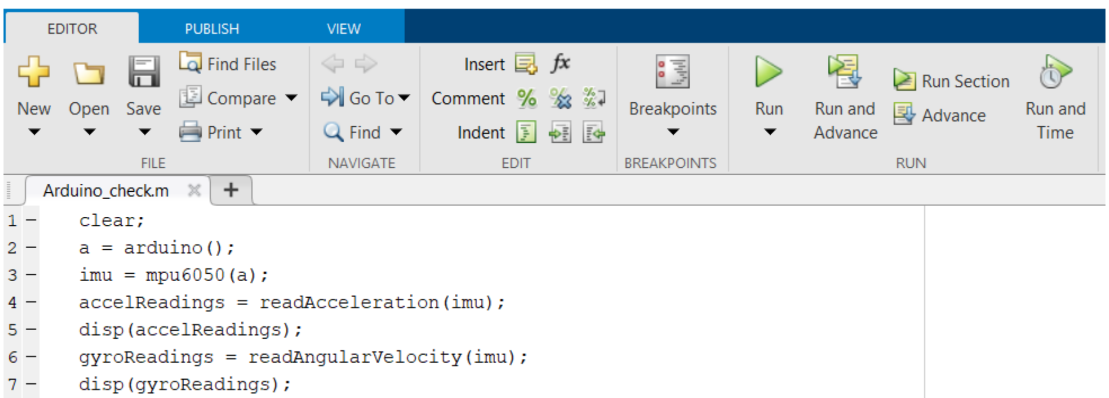
(ii) GND of Sensor to GND of arduino

(iii) SCL (Serial clock) of Sensor to A5 in the analog pin section of Arduino

(iv) SDA (Serial Data) of Sensor to A4 in the analog pin section of Arduino.



To get the gyroscopic reading in the MATLAB software, we use this code:




```
clear;
a = arduino();
imu = mpu6050(a);
accelReadings = readAcceleration(imu);
disp(accelReadings);
gyroReadings = readAngularVelocity(imu);
disp(gyroReadings);
```

It will give 3 values of acceleration in (x,y,z) direction and 3 values of angular velocity in (x,y,z) direction.

So next step is to integrate this angular velocity wrt time interval to get the angular position in the range (**-pi, pi**). The integration is carried out as the sum of small interval (**0.1-second interval for 10 seconds**) angular velocity, multiplied by the time and adding it to the previous value of angular position (recursion function). Then plotting the graphs between angular position/ coordinate (thetas) and time.

From this step, we get the value of theta from both the Arduinos. We have assumed the length of the position of attachment of the sensor from the elbow is **0.5m** (that is, l1 = l2 = 0.5). We then calculate the value of the length of arms in x and y-direction by using these formulas:

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

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

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

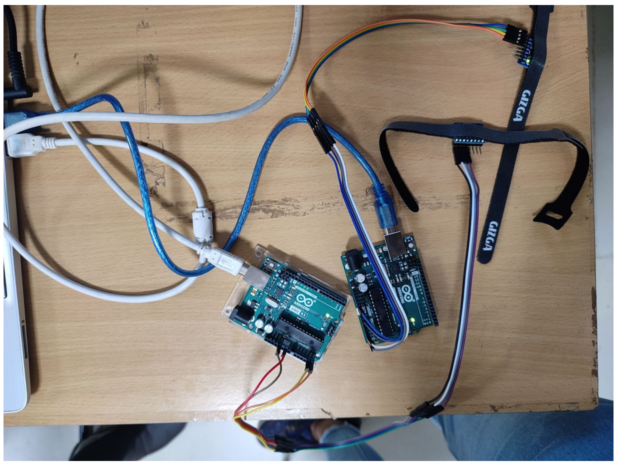
Then plotting it in the graph. The code for these calculations are:

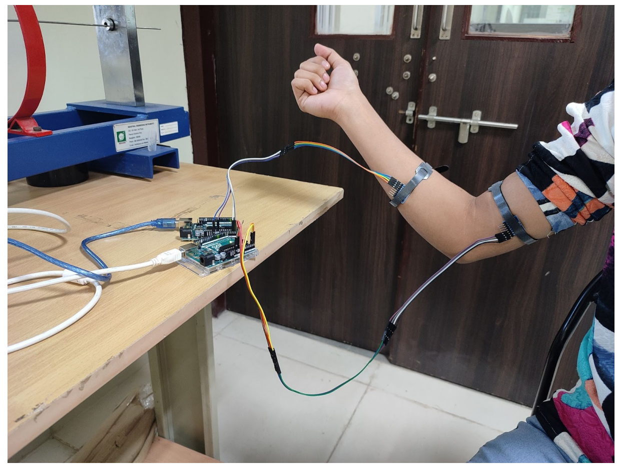
Arduino_check.m*

```
clear all;
a = arduino('com8','uno');
imu1 = mpu6050(a);
b = arduino('com3','uno');
imu2 = mpu6050(b);
dt = 0.1;
ts = 10;
t = 0:dt:ts;
l1=0.5;
l2=0.5;
theta(1) = 0;
Theta(1) =0;
for i = 1:length(t)
    gyroReadings1 = readAngularVelocity(imu1);
    gyroReadings2 = readAngularVelocity(imu2);
    theta(i+1) = theta(i) + gyroReadings1(3)*dt;
    Theta(i+1) = Theta(i) + gyroReadings2(3)*dt;

    subplot(2,2,1);
    plot(t(1:i),theta(1:i))
    axis([-10,10,-3,3])
    subplot(2,2,3);
    plot(t(1:i),Theta(1:i))
    axis([-10,10,-3,3])

    th1(i)= 90*Theta(i)-90;
    th2(i)= 90*theta(i);
    l1_x(i)= l1*cosd(th1(i));
    l1_y(i)=l1*sind(th1(i));
    l2_x(i)=l1*cosd(th1(i))+l2*cosd(-th2(i));
    l2_y(i)=l1*sind(th1(i))+l2*sind(-th2(i));
    subplot(1,2,2);
    plot([0 l1_x(i) l2_x(i)],[0 l1_y(i) l2_y(i)])
    grid on
    axis([-1 1 -1 1]);
    pause(dt)
end
```

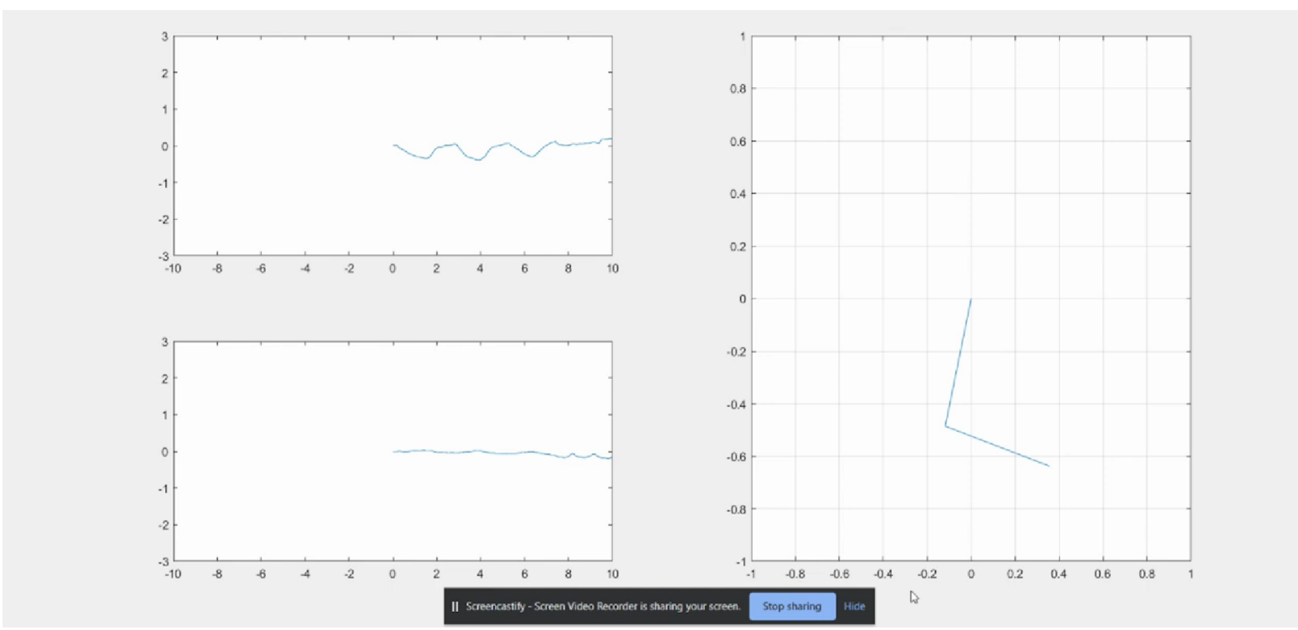
Testing And Experiments:

For testing, the circuit connections are made as follows:

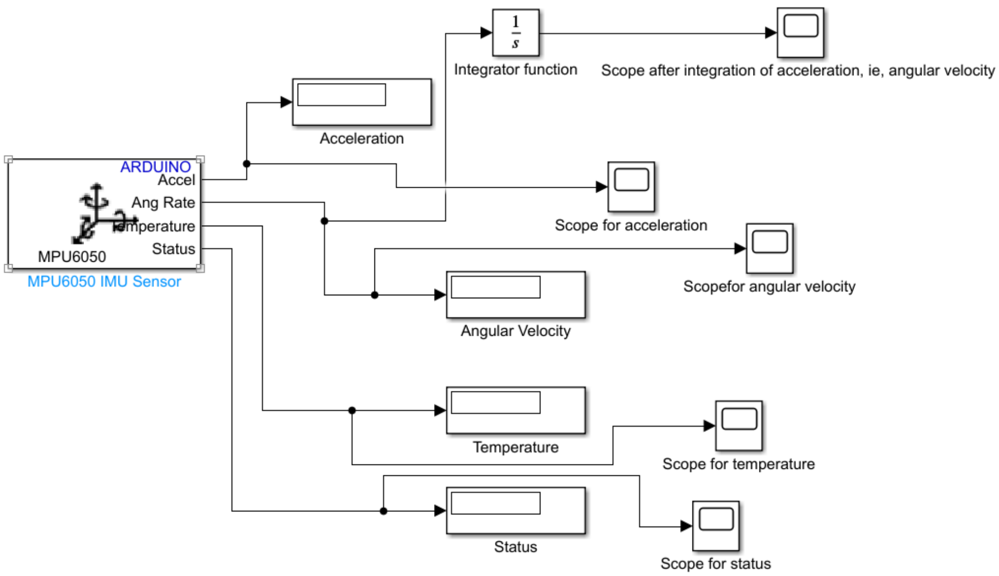




By doing this we can replicate the motion of the upper limb and plot it on MATLAB.



The Simulink schematic is as follows:



Result and Conclusion:

In this project, real-time replication of human upper limb motion is carried out, with the help of Arduino and sensors. This project can be a part of Robotic Arm, in which it can be used to give real-time instructions to robotic arm, by the use of final outcome of this project.