SASTA OLIPHANT
SCIENCE AWARDS

Prize Winner

Programming, Apps & Robotics

Year 11 - 12

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Australian Science and Mathematics School


AA
anko
UNO

sketch_jul25c | Arduino IDE 2.3.10
File Edit Sketch Tools Help
Arduino Uno
Upload
sketch_jul25c.ino
}
void loop() {
// CLOSED
pwm.setPWM(0, 0, 300); // Thumb
pwm.setPWM(1, 0, 300); // Index
pwm.setPWM(2, 0, 300); // Middle
pwm.setPWM(3, 0, 300); // Ring
pwm.setPWM(4, 0, 300); // Little
delay(3000);
// OPEN
pwm.setPWM(0, 0, 200); // Thumb
pwm.setPWM(1, 0, 200); // Index
pwm.setPWM(2, 0, 200); // Middle
pwm.setPWM(3, 0, 200); // Ring
pwm.setPWM(4, 0, 200); // Little
delay(3000);
Output
Sketch uses 5934 bytes (18%) of program storage space. Maximum is 32256 bytes.
Global variables use 244 bytes (11%) of dynamic memory, leaving 1804 bytes for local variables. Maximum is 2048 bytes.
ASUS Vivobook
UNO
AA

Acknowledgements: Tim Cook (3D printing), InMove (STL files)

Aim:
To develop and prototype an affordable 3D printed prosthetic arm that translates muscle activity into precise movement, using cost effective and widely available materials to demonstrate how emerging technologies can make advanced prosthetics more financially and physically accessible to individuals worldwide.

Scientific purpose:
The scientific purpose for this project is to investigate the feasibility and effectiveness of developing a low-cost 3D printed prosthetic arm that integrates electromyography (EMG) sensors combined with arduino coding to detect muscle activity and convert electrical signals into controlled mechanical movement to simulate fine motor movements of a human hand. This research explores how EMG signal acquisition, processing and motor actuation can work together within an additively manufactured system to produce functional upper limb motion. The project aims to evaluate movement accuracy, response time, durability and overall cost efficiency to determine whether emerging manufacturing technologies can provide a reliable and more accessible alternative to traditionally manufactured prosthetic devices. Through systematic testing and refinement, this investigation seeks to contribute to the advancement of affordable assistive biomedical technology and enhances equitable access to all.

Potential applications:
This technology could be used in:
- Affordable prosthetic devices for amputees
- Medical rehabilitation and physiotherapy
- Assistive technology in developing countries
- Educational demonstration of biomedical engineering
- Future robotic and human machine interface research

The project also aims to suggest how 3D printing can reduce manufacturing costs while allowing prosthetics to be customised for individual users.

Materials and components

Mechanical components:
- InMoov 3D printed hand set x1
- Braided fishing line - 750 cm long
- 3 mm nuts 304 stainless steel x10
- 3 mm screws x55
- Super glue x1
- Sandpaper 80-100 grit x1

Tools:
- Screwdriver x 1
- Wire stripper x1
- Drill x1
- 2 mm drill bit x1

Electronic components:
- Arduino Nano x1
- MyoWare Muscle Sensor x1
- Electrode pads x3 per use
- MG996R servo motors x5
- Jumper wires
- 7.2 V battery x1
- Electrical tape x1 roll
- 3 mm drill bit x1

Software:
- Arduino IDE

- Arduino programming language (c/c++)
- UPStudio

<u>Method:</u>

Step 1 - 3D printing and Mechanical Assembly

The hand STL files were downloaded from the InMoov project and all required components were 3D printed. Support materials were removed and roughly edges were sanded down to ensure smooth movement and proper alignment of the parts. The fingers were assembled using hinge pins so each joint could move freely.

A braided fishing line was threaded through the fingers and wrist to act as artificial tendons. The wrist and forearm casing were assembled with sufficient internal space for the servo motors and wiring. Five MG996R servo motors were installed into the servo housing inside the forearm. Servo pulleys were attached to each motor to pull the tendon lines and create finger movement. The tendon system was manually tested to ensure the fingers curled naturally and moved without excessive resistance.

Step 2 - Wiring the Electronics

Each servo motor contained three wires:
- Power (red)
- Ground (blown or black)
- Signal (yellow or orange)

All servo power wires were connected to the battery power supply, while all ground wires connected to the common ground.

The servo signal wires that were connected to the Arduino Nano digital pins:
- D3
- D5
- D6
- D9
- D10

The battery was connected to the Arduino Nano to provide power to the system.

The MyoWare Muscle Sensor was connected as follows:
- Positive = 3.3V on arduino
- Ground = Ground on Arduino
- Signal = A3 analog input

This configuration allowed the Arduino to receive EMG muscle signals and control the servos accordingly.

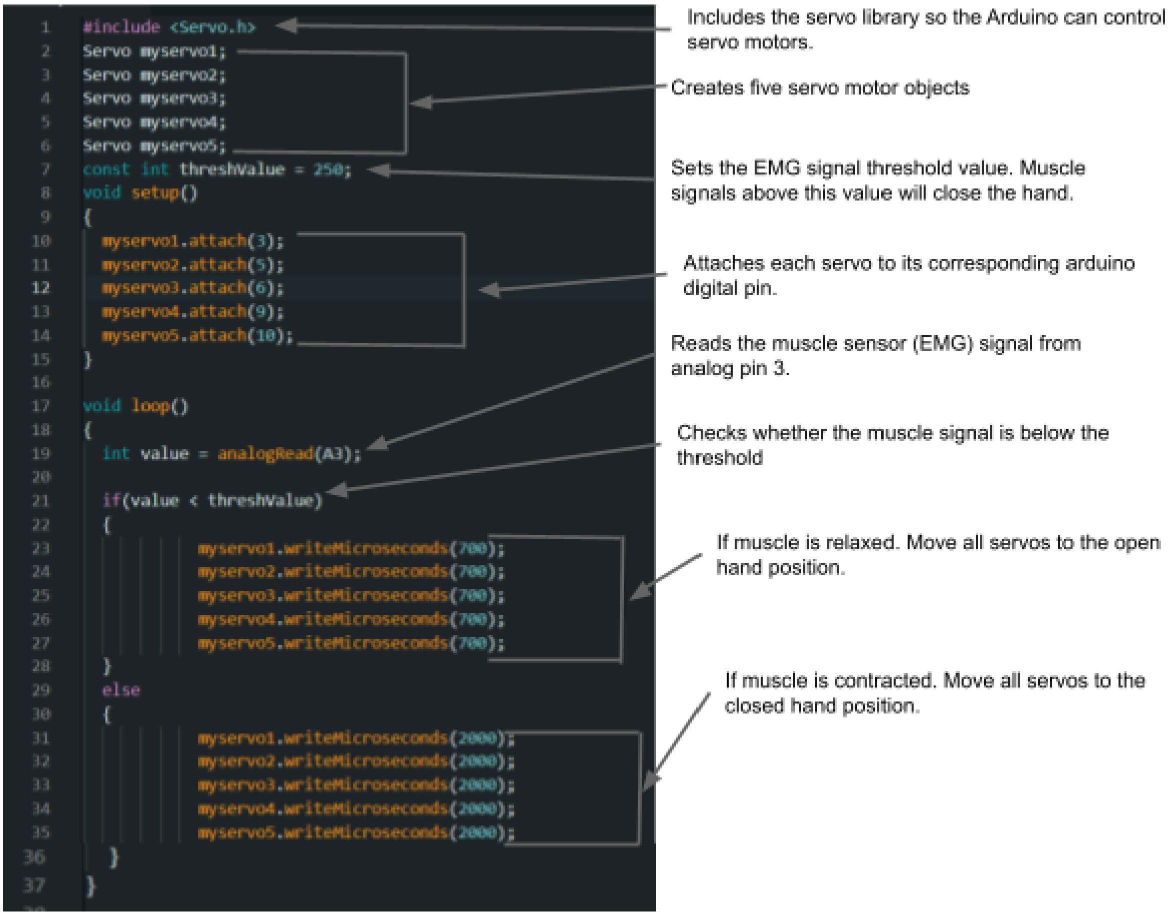
Step 3 - Programing the Arduino

The Arduino IDE was installed on a computer and the control program was uploaded to the Arduino Nano.

The program:
- Read analog values from the muscle sensor
- Processed the EMG signal
- Converted the signal into servo motor movement

The serial monitor was used during testing to observe sensor readings while flexing forearm muscles. Successful operation was confirmed when increased muscle activity caused the servos to rotate and pull tendon lines.

Coding:




```
#include <Servo.h>
Servo myservo1;
Servo myservo2;
Servo myservo3;
Servo myservo4;
Servo myservo5;
const int threshValue = 250;
void setup()
{
  myservo1.attach(3);
  myservo2.attach(5);
  myservo3.attach(6);
  myservo4.attach(9);
  myservo5.attach(10);
}

void loop()
{
  int value = analogRead(A3);

  if(value < threshValue)
  {
        myservo1.writeMicroseconds(700);
        myservo2.writeMicroseconds(700);
        myservo3.writeMicroseconds(700);
        myservo4.writeMicroseconds(700);
        myservo5.writeMicroseconds(700);
  }
  else
  {
        myservo1.writeMicroseconds(2000);
        myservo2.writeMicroseconds(2000);
        myservo3.writeMicroseconds(2000);
        myservo4.writeMicroseconds(2000);
        myservo5.writeMicroseconds(2000);
  }
}
```

Step 4 - Attaching and Testing the EMG Sensor

Two electrode pads were placed along the forearm muscle while a reference electrode was positioned slightly away from the muscle group. The MyoWare sensor was attached to the electrodes and connected to the Arduino system.

When the system was powered on:

1. The EMG sensor detected electrical activity produced by muscle contractions.
2. The Arduino processed the incoming signal.
3. The servo motors rotated.
4. The tendon lines pulled the fingers closed.

When the muscles relaxed, the fingers returned to the open position.

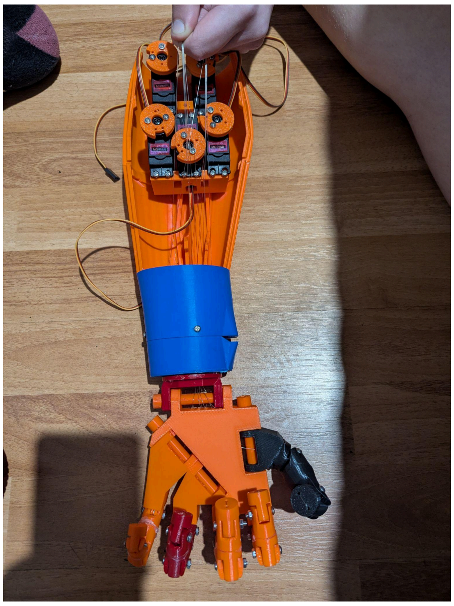
Step 5 - Testing and Adjustments

The prosthetic hand was tested to ensure smooth finger movement and reliable repose to muscle activity.

Adjustments included:

- Tightening or loosening tendon tension
- Checking for wire interference
- Ensuring the wrist joint rotated freely
- Refining servo calibration for smoother motion

Repeated testing was conducted to improve movement accuracy, responsiveness and overall reliability of the prosthetic system.

	
Full arm, open	Full arm, closed

<u>Instructions of usage</u>:

1. Attach the MyoWare EMG sensors to the user's forearm using three electrode pads. Place two electrodes over the target muscle and the reference electrode slightly away from the muscle group.
2. Power on the system by connecting the battery.
3. Ensure the prosthetic is in the open position before use.
4. Relax the forearm muscles to keep the finger open.
5. Contract or flex the forearm muscles. The EMG sensors will detect the electrical activity and send a signal to the Arduino Nano.
6. The arduino processes the signal and activates the servo motors, causing the tendon lines to pull the fingers closed.
7. Relax the muscles to return the fingers to the open position.
8. After use, disconnect the battery and remove the electrode pads from the skin.

Bibliography:

- InMoov. (n.d.). InMoov body parts library : [online] Available at:https://inmoov.fr/inmoov-stl-parts-viewer/?bodyparts=Left-Hand&doing_wp_cron=1780452561.2320029735565185546875

- Tiertime 3D Printer,FDM 3D Printer. (2019). UP Studio - Tiertime 3D Printer,FDM 3D Printer. [online] Available at: https://www.tiertime.com/up-studio/.
- www.arduino.cc. (n.d.). Software. [online] Available at: https://www.arduino.cc/en/software/.