EMG-Controlled Assistive Prosthetic for Upper-Limb

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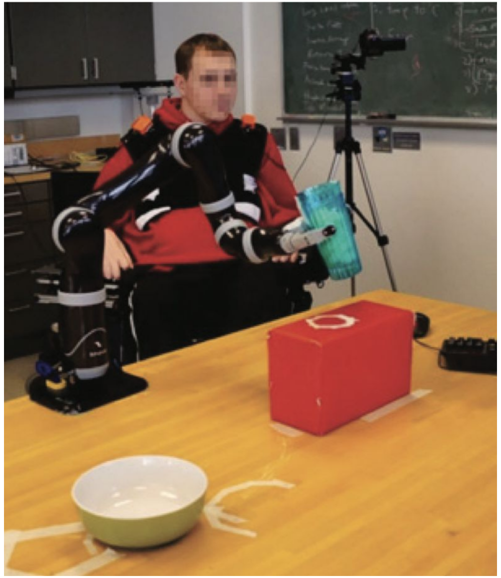
EECE5552: Assistive Robotics Group 7

Project Introduction and Motivation

- ***Project Objective***
  - Construct a prosthetic arm and hand that can interact with and manipulate household objects in a simulated environment
  - Provide users have full control over grasping and placing objects while the arm moves along predetermined path
  - Simulate activities in daily life (ADLs) as a proof-of-concept for everyday assistive robot
- ***Intended Audience***
  - Users with muscle-related upper-limb impairments like dystrophy or Guillain-Barre Syndrome
  - Algorithmic approach can adapt to user's changing input and provide steady performance at essential tasks



Jaco Kinova assistive robot, operating under shared control with the user, in a simulated training environment [1]

Project Overview: Mechanical Hardware

- ***Robotic Arm***
  - Twisting base with shoulder and elbow joints, controlled by servo motors for movement in *X*, *Y*, and *Z* axes

  - Exterior will be 3D-printed with ABS for lightweight, sturdy shell

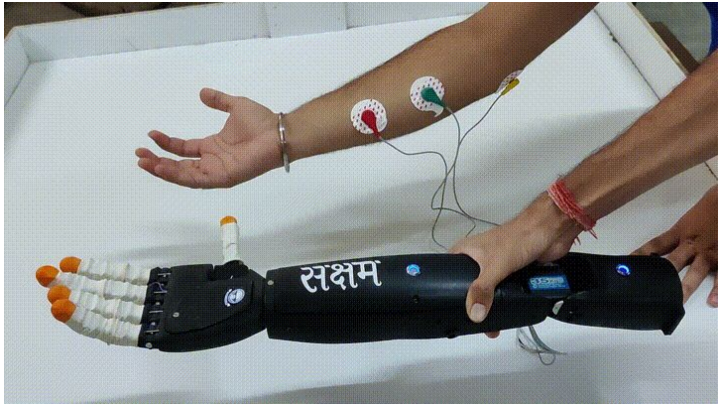
- ***Prosthetic Hand***
  - Each finger can independently actuate via servo motor

- ***Tabletop Simulated Environment***
  - Houses robotic arm with two designated tests of coarse- and fine-motor control:
    - Marked starting/ending positions of 300 mL glass of water
    - Electric plug to connect to faux wall outlet

A robotic arm, previously built by Jaykumar Goswami, serves as the project's inspiration [2]

Project Overview: Electrical Hardware

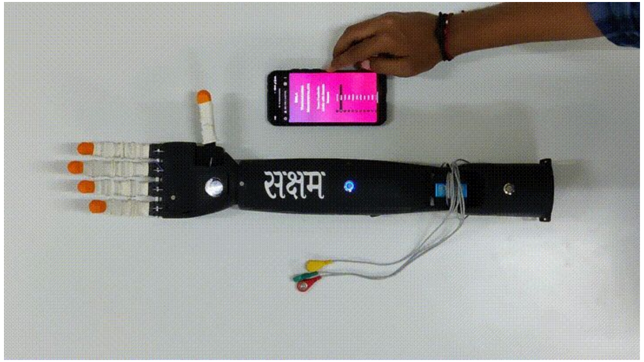
- ***Hardware Controllers***
  - Arduino Nano RP2040
    - WiFi and Bluetooth functionality
    - 14 digital I/O pins, 6 dedicated PWM pins
    - Small form factor and powerful enough to implement software control loop
  - 16-channel servo motor controller for arm movement and finger articulations
- ***Electrical Input***
  - sEMG sensors placed across user's forearm, ranging from elbow to wrist
  - Measures stimulus from forearm and muscle excitations
- ***User Feedback***
  - Integrates force measurement sensors and haptic touch motors for user to sense force exerted from robot's grasp



A demonstration of the previous robotic arm's response to muscle input

Project Overview: Software

- ***Low-Level Control***
  - Software will infer user's grasping actions from EMG signals via neural network algorithm implemented in C++
  - Device will be trained on user's movements during a "calibration" phase
  - Algorithm will determine when to continue along defined movement path between grasping and placing operations; represented as a rising-edge binary signal
- ***High-Level User Interface***
  - Web interface will help with collecting data during development and monitoring performance during testing and implementation
  - User has control over which action they want to perform, as well as testing specific operations like articulating a particular finger



A demonstration of the previous robotic arm's high-level software integration

Project Timeline and Relevant Milestones

Implementation Deadlines

- **October 25:** System hardware build complete
- **November 1:** Electrical layout and wiring complete
- **November 15*:*** Sensor array laid out
- **November 15:** Software implementation verified
- **November 22:** Tabletop test course constructed

Functional Milestones

- **November 1:** Arm is controllable by general electrical input
- **November 15:** Arm is controllable by muscle-specific EMG signals
- **November 22:** User can test arm's functionality on training course
- **November 27:** System finalization

Project Deliverables and Summary

- **EMG-Controlled Prosthetic Arm –** A functional prosthetic arm controlled by the user's muscle signals to perform tasks like gripping and moving objects
- **3D Printed Arm and Hardware –** Assembled arm with high degrees of freedom and adaptive force control
- **EMG Sensor System –** Array of sensors to capture and interpret muscle inputs for precise control
- **Table-Top Training Course –** A test environment for users to practice and refine movements
- **Working Prototype Demonstration –** Live demo showing the arm in action, completing real-world tasks.

We are developing an EMG-controlled prosthetic arm to assist individuals with upper-limb impairments. The prosthetic uses muscle signals to control precise hand and arm movements, housed within a table-top training environment to simulate real-world tasks. This project combines advanced sensors and mechanical design to create a versatile, user-friendly assistive device.

Project References

1. S. Jain, A. Farshchiansadegh, A. Broad, F. Abdollahi, F. Mussa-Ivaldi and B. Argall, "Assistive robotic manipulation through shared autonomy and a Body-Machine Interface," 2015 IEEE International Conference on Rehabilitation Robotics (ICORR), Singapore, 2015, pp. 526-531, doi: 10.1109/ICORR.2015.7281253. keywords: {Manipulators;Trajectory;Rehabilitation robotics;Robot kinematics;Aerospace electronics},

2. Goswami, J. (2022). *Smart Upper Prosthetic Limb*. Prosthetic Limb | Jay Goswami. https://goswamijaykumar.github.io/pages/pros.html

Questions?