Project title

Mind-Controlled Robotic Arm Using Wearable EEG Headset

Project summary

TL;DR : A working demo video of this project is included as link attachment to this portfolio

https://www.youtube.com/watch?v=W8EzUuWgi4o

This project utilizes a commercially available EEG headset, the NeuroSky Mindwave Mobile 2, to capture brain signals from the user. A Python program processes these signals to track the user's blink and concentration levels, converting them into messages that are sent to an Arduino controller. The Arduino Uno microprocessor interprets these messages to move servo motors attached to each finger of the robotic arm. It is programmed to recognize messages ranging from 1 to 5, corresponding to the user's blink count, and a message 99 that indicates the user's concentration level has met a certain threshold. The controller then moves the servo motors to show the number of blinks, with the fingers, or performs a wave-like motion to show concentration.

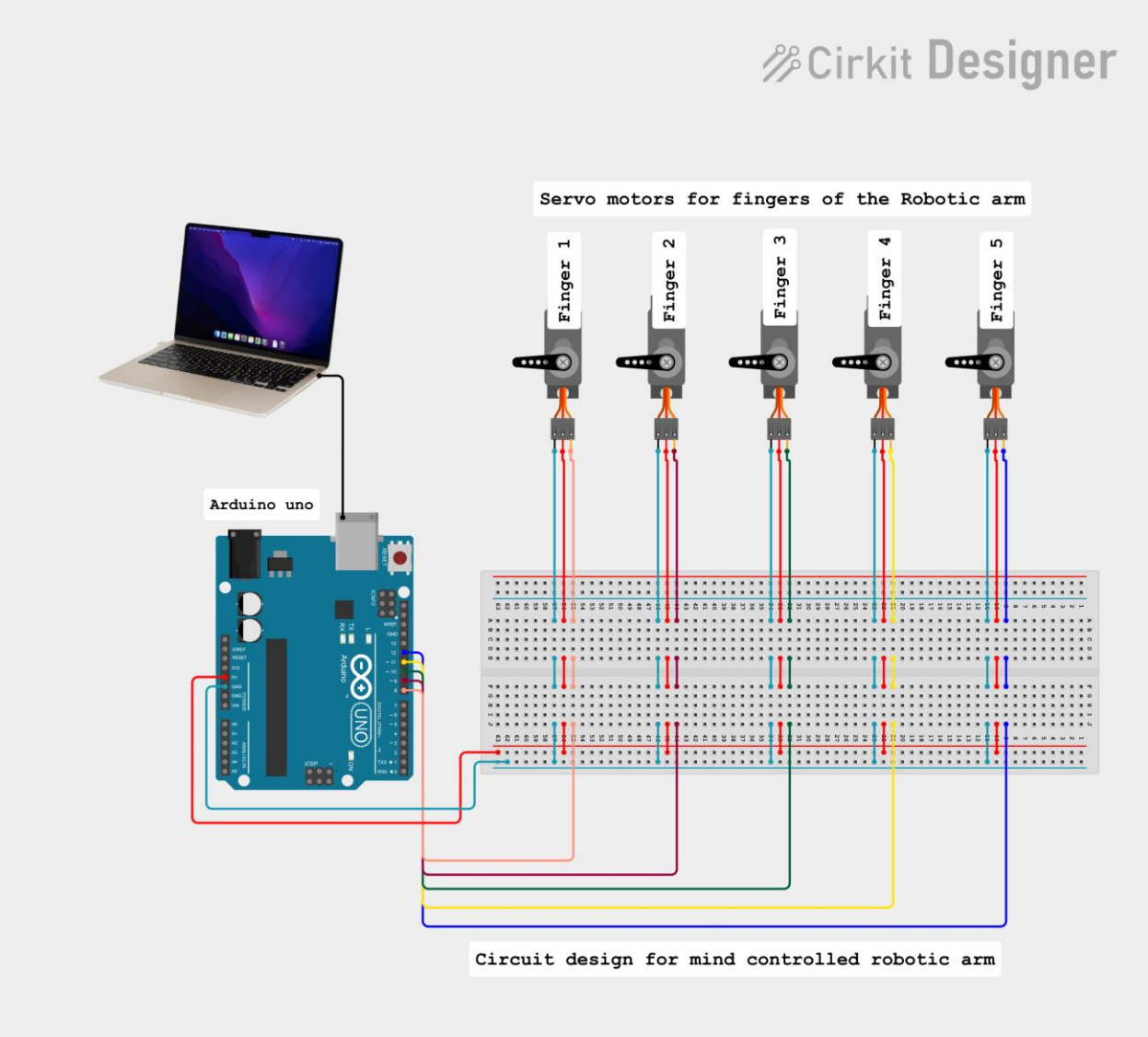
Background context

This project serves to demonstrate the feasibility of controlling basic robotic arm movements using thought. It has potential future applications, such as enabling individuals with disabilities to use their thoughts to move a robotic arm. For instance, it could be a base for a BCI product that translates the intentions of differently-abled individuals into sign language gestures, by using their brain signals.

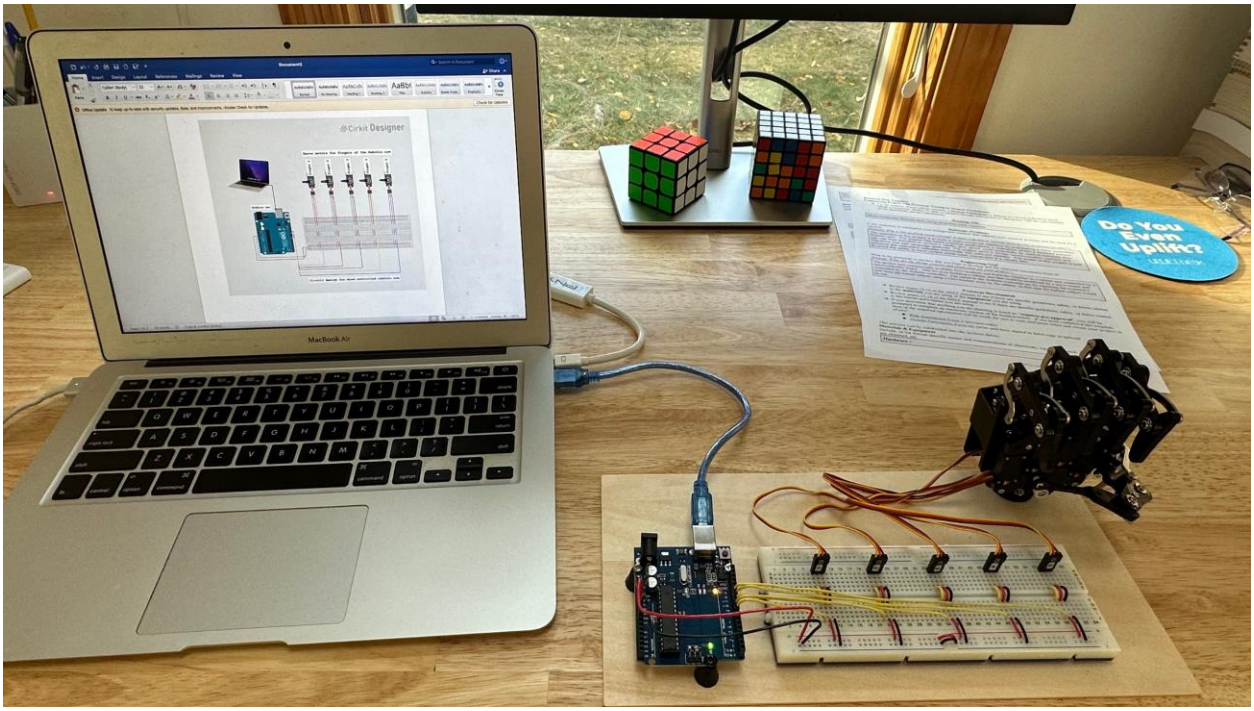
Build process

Hardware Build: The Hardware build comprised of Designing and assembling the circuit for the Arduino controller and robotic hand assembly.

The diagram below shows the circuit design of the robotic arm controller. It includes the Arduino UNO microprocessor, which connects to the computer. The UNO board is responsible for receiving movement commands from the computer and sending power to the right servo motors to move the appropriate fingers.



Final construction:



Software Build: I first started by developing the Arduino code because it was quite a simple program that simply listened for certain messages and moved the robotic hand accordingly. I then moved on to developing the more complex python program that receives and processes the raw EEG signals. During the testing phase, I entered into a development loop and continuously changed the code, deployed it, and tested it until the final product was working.

Code repository: Below are the links to specific files in my code repository. You are welcome to take a look at other files and projects in my repository too.

Here is the python code and what it's meant to do:

https://github.com/rithvikpkx/MindControlRoboticArm/blob/main/MindReader.py

1) Connects to bluetooth headset to stream EEG data

2) Processes the data and formulates messages

3) Connects to Arduino controller and sends the message

Here is the Arduino code and what it's meant to do:

https://github.com/rithvikpkx/MindControlRoboticArm/blob/main/HandController/HandController.ino

1) Receives messages 1 through 5 and moves corresponding number of fingers in the robotic arm.

2) Receives message 99 and moves the robotic arm to show a wave like motion.

Reflection and learnings

The Arduino controller code was relatively easier to develop and fit to my specific needs. It turned out well because the robotic arm controller is modular now and it is independent and not coupled with any EEG knowledge. All it needs is messages 1 through 5 or 99 as inputs to function. The controller then moves the corresponding number of servo motors, showing the number of fingers on the robotic hand. When the controller receives 99, it will move the robotic hand in a wave like motion.

Challenge: The NeuroSky headset comes with a flaky bluetooth connection which I am unable to resolve, but it works when it connects.

The favorite thing about this project is the experience of being in the development loop: repeated code change, deployment, and testing of both Arduino controller code and the Python processor code that process data from the headset and sends the code to Arduino controller. I really loved the iterative nature of building the programs, and this is where the true development of the code happens.

For the next version of the project (on going), I would use a more reliable head set such as one from OpenBCI, they have more reliable connections via a dongle and also come with a good developer community with API documentation. My ongoing project uses this headset.

Overall, I got a taste of building a whole project, right from formulating the idea to bringing it to completion. More so than the end product, the development process itself is what will stick with me. Though it was hard to see at first, every challenge always transformed into moments of learning, followed by a breakthrough. With that, I understood that persisting through obstacles, which I think are inevitable in life, is key to success.

Credits

Johns Hopkins Medicine. (n.d.). Electroencephalogram (EEG). Retrieved from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/electroencephalogram-eeg

NeuroSky. (n.d.). MindWave Mobile and Arduino Integration. Retrieved from https://developer.neurosky.com/docs/doku.php?id=mindwave_mobile_and_arduino

Science Buddies Staff. (2023, December 6). Motorizing a Robotic Hand. Retrieved from https://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p003/robotics/build-motorized-robot-hand