Project summary

**Introduction**:

3 million people worldwide have an arm amputation (this makes up 30% of all amputees). This means 3 million people miss out on activities and projects that require the motion of these limbs. Basketball is the third most played sport in the world and requires movement from the hand, wrist, and arm. This makes it difficult for people with one arm or less to play. Although it is possible for an individual with one arm to play basketball it can be made more convenient with two arms present. Our goal is to program a prosthetic hand to throw a ball using gyroscope readings to control the hand and arm. Achieving this will assist amputees to be able to enjoy playing basketball as well as throwing balls with more convenience. As basketball is a popular sport worldwide this will give more people opportunities to enjoy and experience the sport and being able to throw a ball can also allow them to participate in social activities resulting in better mental health and self-esteem.

**Problem statement**:

The lack of a limb often narrows a person’s access to crucial activities such as work, leisure, sports and more. Although accommodations like reserved parking spots and restroom stalls help to soften the impact on the individual, people who are physically handicapped are still largely isolated from other aspects of society and tend to suffer from depression and anxiety.

**Background information**:

We concluded that the activities and sports during recess at our schools were socially formative and therefore instrumental to us. We predict that taking the steps to enable people with physical handicaps to participate in these activities will benefit their overall well-being. To that end, we initiated work on a prosthetic arm capable of throwing a ball, allowing wearers to participate in simple games and sports to feel included the same way that we did, therefore improving their mental health and self-esteem.

Biomedical prosthetics research:

* The need for prostheses has increased because of increasing diabetes, trauma, and increased life expectancy.
* Prosthetic study has been conducted since World War ll.
* More research has been done on lower limbs compared to upper limbs.

How are biomedical engineers different from other human health engineering principles?

* Biomedical engineers use and apply knowledge of modern biological principles in the engineering design process.
* Uses aspects of multiple different engineering fields combined to improve human health, whether it be an advanced prosthetic limb or a breakthrough in identifying proteins within cells.

**Design Process**:A notebook with writing on it

Description automatically generatedA drawing on a notebook

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These are our design plans for the construction of the arm. All measurements were recorded to cut wood to proper proportions. Wood was assembled, being held together with screws. The motor was attached to the wrist with nails. While brainstorming different design ideas, many changes were made. The picture to the left (fig.1) is the final design that was built. The block of wood attached to the wrist allows the motor to rotate the hand up and down rather than left to right. The forearm and upper arm are attached in a way to allow full range of movement when the linear actuator moves in and out. All being attached to base block of wood with metal brackets and screws.

Figure 2

Figure 1

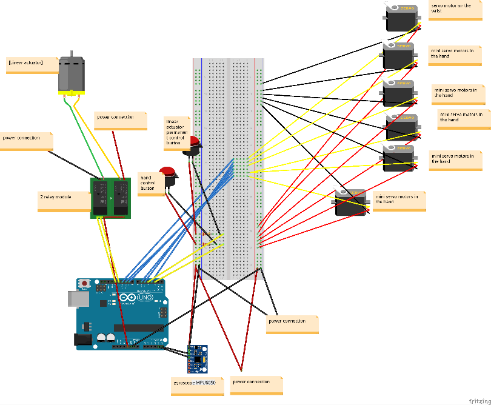
At the beginning, we gave an idea of dribbling and launching basketball by using robotic arm, to satisfy the EMG control of the movement of arm, we decided to use muscles of neck as the object, and therefore we have done an EMG experiment for various neck muscles. In the experiment, we tried to find the pattern of nerve signals among the muscles when they relax and stretch through electrodes, hence we tested muscles that are responsible for the rotational, vertical and horizontal movement of the head.

Data table:

A table with numbers and letters

Description automatically generatedHowever, the EMG tests cannot indicate a strong relationship between the nerve signals and movement of muscles of neck. So, we used an ordinary object—arm muscle, although the nerve signal of triceps brachii muscle illustrates a significant period of signals, we cannot find a suitable conditional statement to utilize the signal continuously in terms of code. Finally, we investigated using a gyroscope instead of an EMG to detect changes in motion direction along the x-y-z axis. To hold the gyroscope, we designed a gyroscope container with tape that can adhere to body parts like the arm and neck, among others. The “T” shape supports two grooves for the tape to stick on, which gives a shape like fish, providing an imagination space for children to decrease their fear of gyroscope container attachment.

Figure 1

A screenshot of a computer program

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Figure 5: Wire sketch

Figure 4: Drawing for gyroscope holder

**Results**:

As part of the first design, we had decided to use stepper motor for the movement of the arm (elbow), however it was concluded that the stepper motor would be too weak to effectively move the arm. Next, we decided to 3D print an object that, with the use of gears and other motors, would facilitate the movement of the arm in all directions. This idea was quickly shut down and eventually we settled on using a linear actuator that would allow the movement of the arm to go up and down; we figured to dribble or to throw, the arm wouldn’t need to move sideways. Our very first design sketch was similar to our final design, however we made a few changes to improve the appearance and accessibility. One major change was adding the wrist block that attaches the hand to the forearm. Originally, we had only the motor directly above the forearm, however this caused the hand to look disconnected. The design was then changed to appear more realistic with the hand being directly above the forearm. The forearm and upper arm are attached to rotate close to 90 degrees. The linear actuator allows the arm to move in controlled up and down motions. All wood was measured and cut to fit together and screwed in to combine all components.

As for the wiring, there are five mini servo motors inside the hand to control fingers individually and a servo motor to control wrist exclusively, so we distribute control cables of them to the pins with PWM at Arduino board. The gyroscope has four essential pins for it works: two power ports and the I2C communication ports SCL and SDA which should connect to A5 and A4 individually. These power wires and ground wires of motors and gyroscope are combined into the breadboard, which is powered by a DC power supply. The red line represents positive, black ones represents ground that connected to GND on the Arduino board. The relay module is prepared for the linear actuator which needs more power than other motors.

**Reflection**:

We learned about new coding libraries and basic coding as well as more complex functions. The project helped develop our team-working skills by combining previous knowledge to learn from each other. We also learned how to wire the breadboard and work with BIC equipment. As the project comes to an end, we noticed that the arm did not have as much range as we wanted. If we could try the project again, we would change the angle of the linear actuator and the shape of the arm joints to allow more range of motion. Since our wrist motor was slightly weaker than we wanted, we would have added an extra servo to help with the rotation. Now having more experience, we would not need to spend as much time designing and learning. Therefore, we would have more time to work on the arm and its functions.

**Resources**:

Eshraghi, A., Osman, N.A.A., Gholizadeh, H. *et al.* 100 top-cited scientific papers in limb prosthetics. *BioMed Eng OnLine* **12**, 119 (2013). <https://doi.org/10.1186/1475-925X-12-119>

Cree RA, Okoro CA, Zack MM, Carbone E (2020). Frequent Mental Distress Among Adults by Disability Status, Disability Type, and Selected Characteristics – United States 2018. Morbidity and Mortality Weekly Report (MMWR).