Arduino Robot Muscle

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Motivation

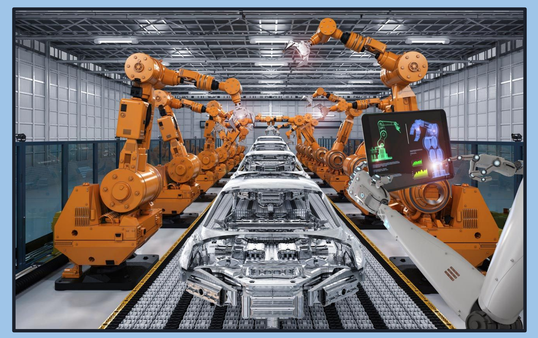
The field of robotics is rapidly growing, with vast implications in our everyday lives. Robots generally fall into two categories – *Industrial*, and *Collaborative*. Existing robots in both categories are expensive, and complicated, reducing accessibility despite growing market demand and application potential.

Industrial Robots

- Perform tasks in place of humans
- Generally fully automated
- Difficult to operate
- Expensive

Collaborative Robots (Cobots)

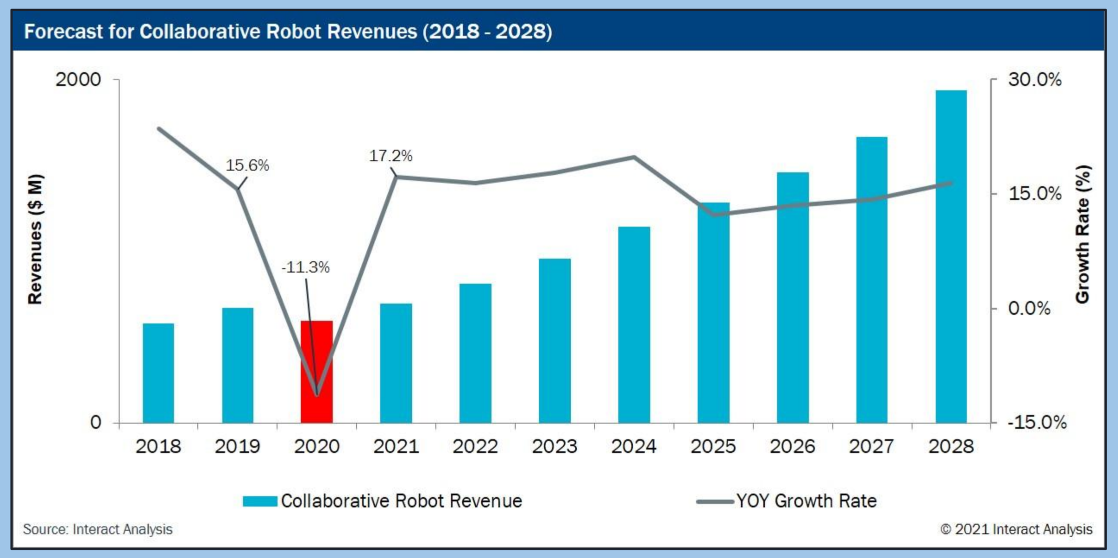
- Share space with people
- Help people perform tasks interactively
- Difficult to operate
- Expensive



[1] Auto manufacturing industrial robots

[2] Cobots working with humans

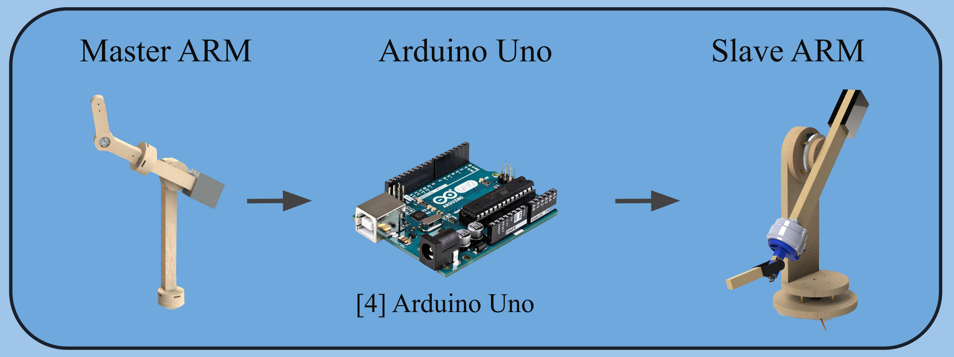
A surge in market demand for collaborative robots is forecasted for the near future. Bridging the gap between collaborative and industrial robots will capitalize on this opportunity.



Concept

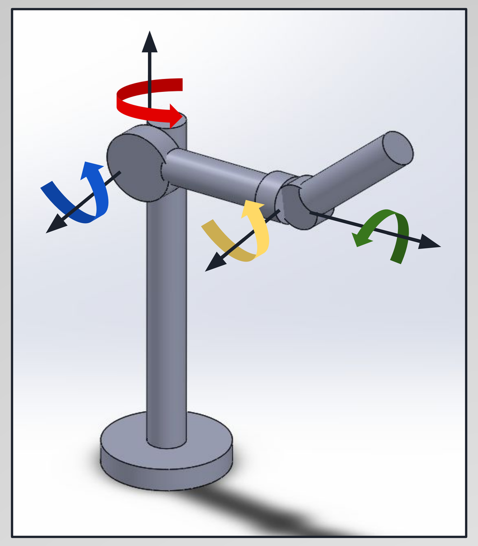
ARM aims to reduce the barriers of entry into robotics by creating an *intuitive* and *accessible* robotic arm control system. Our focus on this concept led to the design of our master-slave design, rather than creating a robot that can perform specific tasks.

This design allows anyone to operate ARM with virtually no learning curve. Originally envisioned as a wearable device, this prototype was scaled down to allow the user to input control motions directly into a small replica of the Slave ARM.



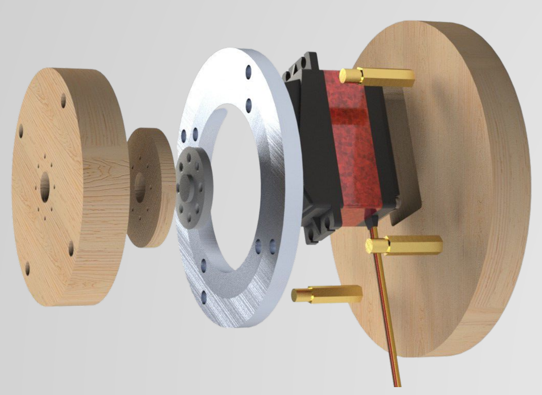
Design

Degrees of Freedom (DOF)
DOF (Degrees of Freedom) is generally defined as the number of variable joints in a robot.[4] The ARM team considered the motion available to a human arm and concluded that four degrees of freedom was the minimum requirement to reasonably replicate the motion of a human arm.

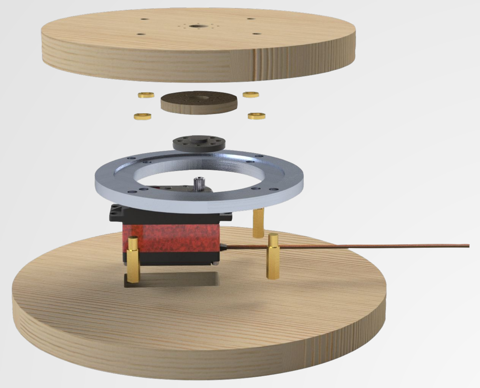


The four DOF render of ARM

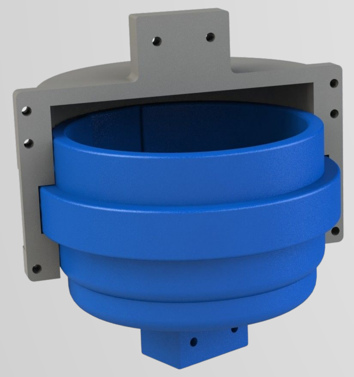
Slave ARM
The Slave ARM uses four digital servos - one at each joint. The base and shoulder rotation joints employ 60 kg·cm servos, while the elbow twisting and bending joints each employ a 35 kg·cm servo.



CAD render of Shoulder Joint [I]



CAD render of Base Joint [III]



CAD render showing cutaway of elbow twist joint [II]

The base and shoulder rotation joints use a hardboard design paired with off-the-shelf 'lazy susan' bearings. The elbow twisting joint uses a 3D-printed cup-in-cup design, and the elbow bending joint uses a standard servo mounting bracket. These joints allow for rotation in the desired axes with minimal undesired motion or friction.

Master ARM
The Master ARM uses four potentiometers connected to an Arduino Uno to measure the angles at each joint. Arduino processes this information and sends angle information to control the Slave ARM. Due to the simplicity of the code and circuit, the Slave ARM responds with negligible latency.

CAD render of the Master ARM

The Master ARM prototype was created with laser-cut wood and uses joint friction and a counterweight to maintain its position. Using this manufacturing method allowed the ARM team to produce a precisely dimensioned control-arm without an issue.

Results

ARM fulfills the requirements defined at the outset of the project.

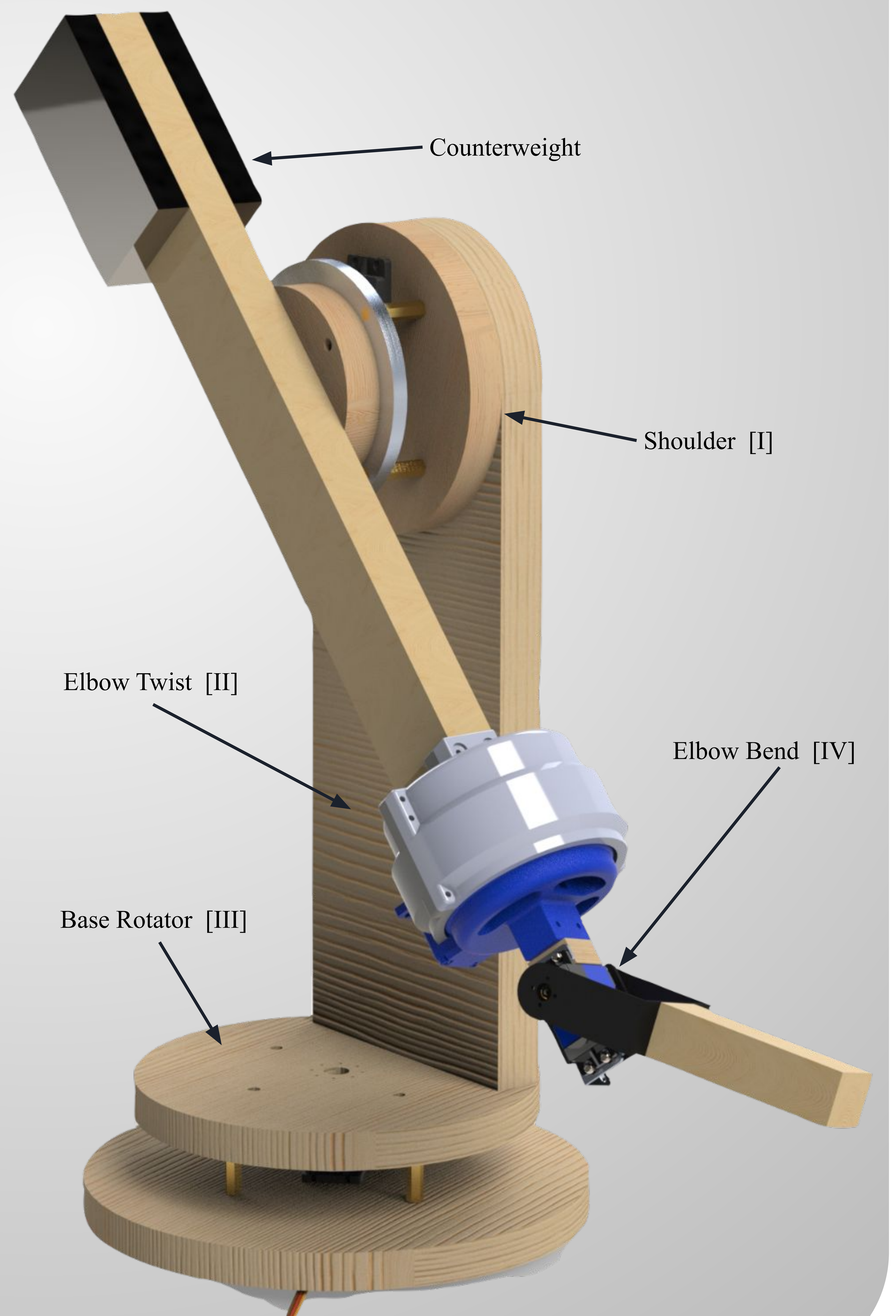
✔ **Weight - 360g or more**
ARM is able to lift upwards of 360 g - the weight of a smartphone with added factor of safety.

✔ **Budget - $600 or less**
The ARM prototype came in under the $600 budget generously provided by UBC IGEN and Tidball Projects.

✔ **Human Controlled - Easy to Operate**
ARM's Master ARM control device is easy for anyone to operate, and avoids the use of complicated controls

✔ **Response Time - 1s or less**
ARM responds to user input well within the requirements, with an estimated latency of 300 ms.

✔ **Range of Motion - 4 DOF**
Minimum requirement of 4 degrees of freedom has been met, approximating the range of motion of a human arm.



CAD Render of Slave ARM

Conclusions

Further development will lead ARM to become a robust, affordable, and easy-to-use robotic system. These developments will include:

- Wearable master arm for even more intuitive control
- 6 DOF to most accurately replicate natural human arm motion
- Swappable, controllable end effectors
- Higher quality potentiometers in the control arm
- Review and iteration to optimize design for manufacturing
- Implementation of updated code to smoothen movement
- Review of material selection
- Waterproof and heat resistance design changes could be implemented to help more niche industrial uses

Current concerns facing the current prototype:

Concern	Reasoning
Master ARM fragility	The material of the Master ARM is 3mm hardboard, selected for ease of manufacturing, but this material is fairly weak.
Wear and tear on the joints	Servo horns in joints are an area of concern - the teeth that provide rotational motion may become stripped under high load.
Current requirements for strenuous usage	If all the servos used their maximum rated current, this draw may momentarily surpass the rating of the power supply.
Friction within joints	Due to ARM's load bearing capabilities, and the use of lazy susan bearings in radial load applications, friction may result in unsmooth movement.

Special Thanks

We would like to thank the following for their support:

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