

Section II: Methodology

Role of Student vs. Mentor

The mentor of this project assisted with the project in the following ways: holding bi-weekly update meetings, printing parts designed by the student, providing templates for written submissions and organizational purposes, and leading a class in which students learn how to deliver information on a STEM research project such as this. The student handled everything else, including but not limited to identifying a problem and project, conducting literature review, writing all documentation, designing all parts of this robot, creating the wiring layout, assembling the project, and the final presentation. The student spent approximately 177 hours on this project.

Equipment and Materials

Necessary software for this project includes SOLIDWORKS, Tesseract OCR, Raspbian, and the Arduino IDE. Important tools include a soldering iron, ball-end hex drivers, and a 3D printer. Raw materials required for the physical arm are the parts designed in SOLIDWORKS, M3 heat-set inserts, M3 button head cap screws. To make the robot move, it's necessary to use six servo motors, a servo motor driver, about fifty jumper wires, and an Arduino UNO. It is possible to use a Raspberry Pi 0 2W and camera module fixed to the robot's claw to identify book titles.

Part Design

All of the parts used in this project were the creation of the author, designed in SOLIDWORKS, and put through heat and force simulations to ensure their durability.

Robot Assembly

The servo motors were fixed to the robot through servo-sized holes in the joints. Most of the screws in this project were screwed into heat-set inserts soldered into holes in the parts. The first joint is

attached at the base to two motor panels. There are motors in each of the panels to control the two sides of the first joint because one servo motor is not necessarily powerful enough to reliably hold up the rest of the robot. The other end of the first joint is connected to the second joint through one servo motor that screws into joint two, the only joint that comes as one part. The third joint is mounted on either side of the second joint with a servo motor. Then, the claw is connected to the rest of the robot by a panel between the parts of joint three.

Wiring

The Raspberry Pi is connected to the camera through a ribbon cable in the camera port. The Raspberry Pi and Arduino share a serial connection. The Arduino is connected to the motor driver through the 5V, ground, serial data pin (SDA), and serial clock pin (SCP) pins. The servo motors are all connected to the driver.

Statistical Tests

A harmonic mean f-score test was used to determine the accuracy of this because it takes into account specific information about false positives, false negatives, true positives, and true negatives. The different types of accuracy (in this case, leaving books alone and moving them) both need to be successful for the test to be statistically significant, in this case above 0.7, the commonly used value for a harmonic mean test.