Ek210 Final Team Report

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A3 Group 5 – Room Occupancy Monitor

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Spring 2024 - Due April 25

Executive Summary

Having an overcrowded classroom environment can negatively affect teachers' ability to educate students, allow the rapid spread of germs and diseases, and is an overall safety hazard. This report outlines and discusses the design process of our product to combat these risks and provides a thorough product description of a room occupancy monitoring system. Our goal is for the user to enter the maximum occupancy of a room, collect data on people entering and exiting the room, display the current occupancy of the room, and prevent entrance once the room is full. To obtain these goals, we used a keypad to input our data, a motion sensor to collect data, an LED display to display our data, and a motor and a curtain system to prevent entry of people. Through countless tests, we concluded that our motion sensor has an accuracy rate of 90% at a distance of 8cm away from the sensor. We wanted our motor to roll a curtain 47 inches in 30 seconds and it did so with an accuracy of 98%. These results show that our objectives including high accuracy and precision are satisfied.

Introduction

Problem Statement:

The goal is to create a device to monitor the number of people in a classroom and actuate something to discourage entrance at maximum occupancy to avoid overcrowding. (Table 3)

Constraints and Key Objectives and Metrics:

For our constraints, we need to make sure to maintain a safe voltage of less than 50 volts. the product must also cost less than $200 to make, and must not block the doorway fully (Table 4). For key objectives and metrics, our motion sensors must be at least 90% accurate, our motor must be at least 90% accurate, and the LED display must display the correct number of occupancies in the room. (Table 1 and Table 2)

Innovative Elements and Basis for Selection

The LED display portrays the room occupancy as percentages based on the user's occupancy input. (Figure 1) The light bar fills up along with the occupancy. (Figure 3) Users can set and adjust their desired maximum occupancy through the keypad, an easy-to-use interface for the user. (Table 5) The motor relays control the direction in which the motor rotates based on whether the occupancy of the room is at maximum capacity or just below maximum occupancy. For our motors, we had two options: (1) a 12V DC high Torque motor or (2) a 5V stepper motor. We were considering using the 5V stepper motor because it allows clockwise and counterclockwise rotation by changing the code but it did not provide enough torque for our system. On the specifications sheet provided in the reference, the 12V DC motor provided a 12 Kg*cm torque, which was sufficient for our system. For our display, we decided to go with the large LED array because the other displays that were available had small screen sizes, and the LED array was visible from far away. Finally, our decision to use a curtain as our prevention mechanism was because we do not want to completely prevent people from going in and out of the classroom in case of emergencies. The soft curtain provides safe access in and out of the room while informing people to not enter the room.

Description of Final Product

The final product features a base that supports the main housing which contains the Arduino, motor relays, a 12V battery, a 9V battery, a motion sensor, an LED display, and a keypad. These motor relays are connected to the second housing which contains the motor and the entry prevention system which unfolds once the maximum occupancy level is reached. (Figure 2) The system initializes when the user flips the switch, the user then inputs their desired maximum occupancy through the keypad. As people enter the room the LED display updates, as a percentage of the total input maximum occupancy, from the information provided by the motion sensor. Once maximum occupancy is reached the system activates the motor and deploys the curtain as the prevention system, not allowing entries but allowing exits. Once someone exits the room, the system removes the prevention system and updates the display. Therefore monitoring and controlling the room occupancy. (Figure 4)

Evaluation of Results

As portrayed in Graph 1 and Graph 2 from the appendix the accuracy of the gesture sensor heavily relies on the individual's walking speed and distance from the sensor. The closer the person is to the sensor the more reliable the output. Table 6 and Graph 3 illustrate the efficiency of the motor while carrying different amounts of weight portraying its capacity and reliability, while Graph 5 portrays the distance that the motor can lift the curtain. Graph 4 portrays the sensor's range and its success percentages based on the distance which all point to a greater success rate when the individual is in closer proximity to the sensor. When all components were used as a system the machine had continued success. The reliability of the system was derived from its consistent performance throughout the final testing and development. The device was able to detect, display, and prevent completing all its requirements and consistently upholding its functionality. This system is a solution to the maximum occupancy issues in a classroom.

Lessons Learned

Throughout the project, we learned to prioritize our issues and work in a structured timeline. This came through efficiently planning every step of the project, however there are some things we would do differently. We would upgrade the sensor we currently have as it had limitations that could affect the outcome of the project. Furthermore, we would also adapt and improve our time management as this is key to the success of any project and teamwork. This would increase the impact of our project and would make the development of the system more efficient. We reflected on these lessons after finishing the project and realizing what areas could be improved given more flexibility on time and money. These lessons will help us go forward with other projects and in our engineering careers.

References

1. Arduino Libraries

   Adafruit_APDS9960.h, FastLED.h, and Keypad.h from Arduino

2. Motor Specifications

   https://innovatorsguru.com/jgy-370-dc-motor/

3. Relay Module + Arduino

   https://randomnerdtutorials.com/guide-for-relay-module-with-arduino/

Appendix

	Objectives	**Metrics**
1	Inexpensive and Marketable	- Production cannot exceed $200.
2	Portable	- Less than 5 pounds
3	Easy to Use	- Less than 16 buttons.
4	Accuracy	- Must be over 90% accurate.
5	Precise	- Data must not vary more than 0.5% from expected.

Table 1: Objectives and Metrics

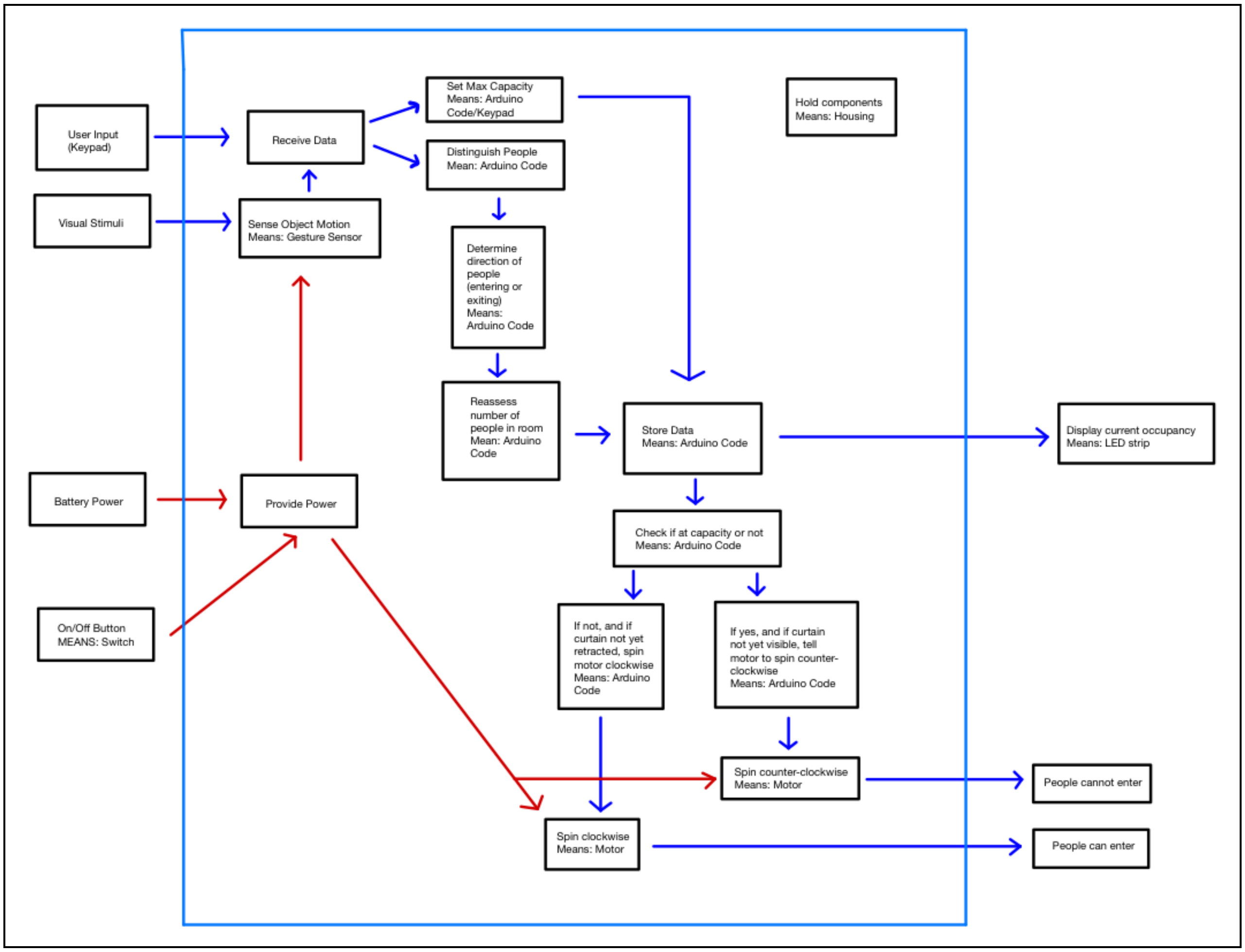


Figure 1: Glass Box

OBJECTIVES

1 = ROW

0 = COLUMN

	Track	Prevent	Dif. Max	Door Imp.	Differ.	Display	Safe	Accurate	Precise	Reliable	Autonomo.	
Track	X	1	1	1	1	1	1	1	1	1	1	10
Prevent	0	X	1	1	1	1	0	0	0	1	0	5
Dif. Max	0	0	X	1	0	0	0	0	0	0	0	1
Door Imp.	0	0	0	X	0	0	0	0	0	0	0	0
Differ.	0	0	1	1	X	1	1	1	1	1	1	8
Display	0	0	1	1	0	X	0	0	0	0	0	2
Safe	0	1	1	1	0	1	X	1	1	1	1	8
Accurate	0	1	1	1	0	1	0	X	1	0	1	6
Precise	0	1	1	1	0	1	0	0	X	0	0	4
Reliable	0	0	1	1	0	1	0	1	1	X	1	6
Autonomo.	0	1	1	1	0	1	0	0	1	0	X	5

>5 = priority <5 = not priority

Table 2: Project Control Chart

MEANS → / FUNCTION ↓	1	2	3	4
Display # of people	Digital screen	Project onto wall	Mechanic Number Flip	Status Bar
Prevent Entrance at Capacity	Pop-Up Mechanism (spring/inflate?)	Extend a "handle" to block	Release a tarp from above	Loud Alarm
Accept Power	Single use batteries	Rechargeable capability	Always plugged into outlet	• • •
Track # of People	Single motion detector	Dual motion Detector (entering vs. leaving)	Button to signal entrance	Voice activated entrance recorder
Hold Components	Sealed Box	openable box	• • •	• • •

Table 3: Morph Chart

Funtional Group	Part Name	QTY.	Price (per unit)
Circuit Elements	12V DC Motor	1	$6.89
Sensors	4x4 Membrane Keypad	1	$7.89
Sensors	Gesture Sensor	3	$7.50
Circuit Elements	Arduino Uno	1	$27.60
Circuit Elements	Relay Module	2	$7.39
LED & Lighting	LED Matrix	1	$17.00
Circuit Elements	12V Battery	1	$38.00
Circuit Elements	9V Battery	1	$1.50
Other	Poly Poplin Fabric	1	$12.90

Table 4: List of Parts, the total cost is $149.06

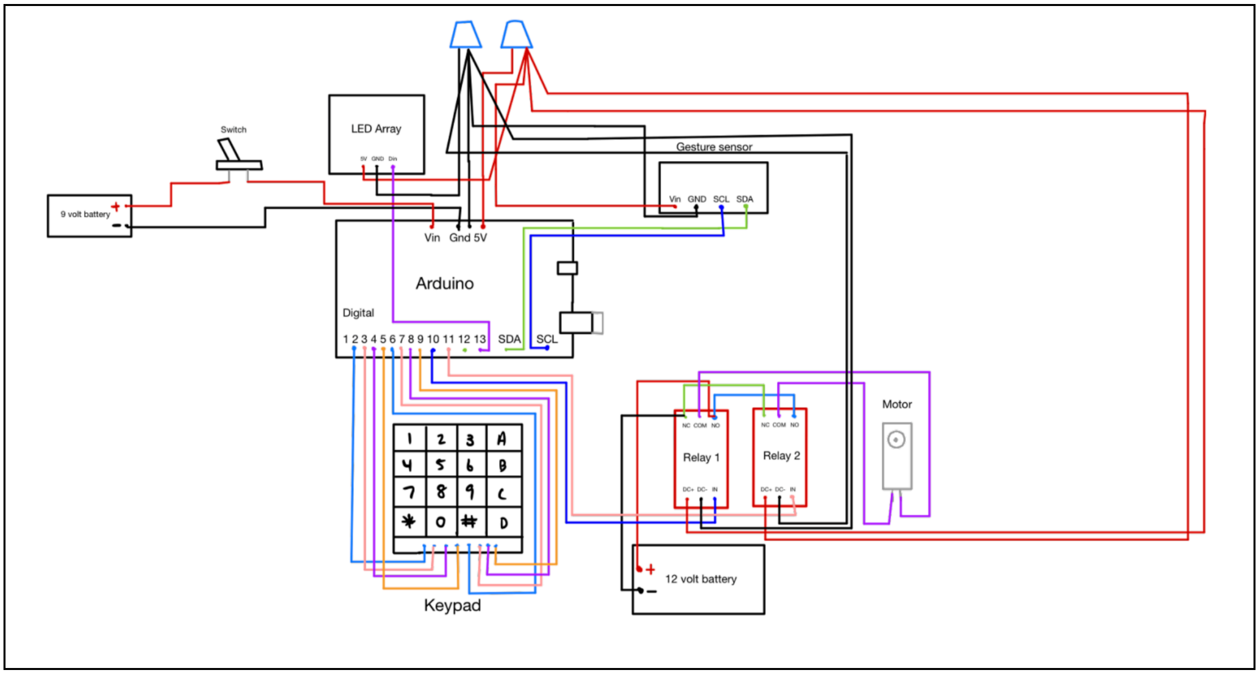


Figure 2: Circuit Diagram

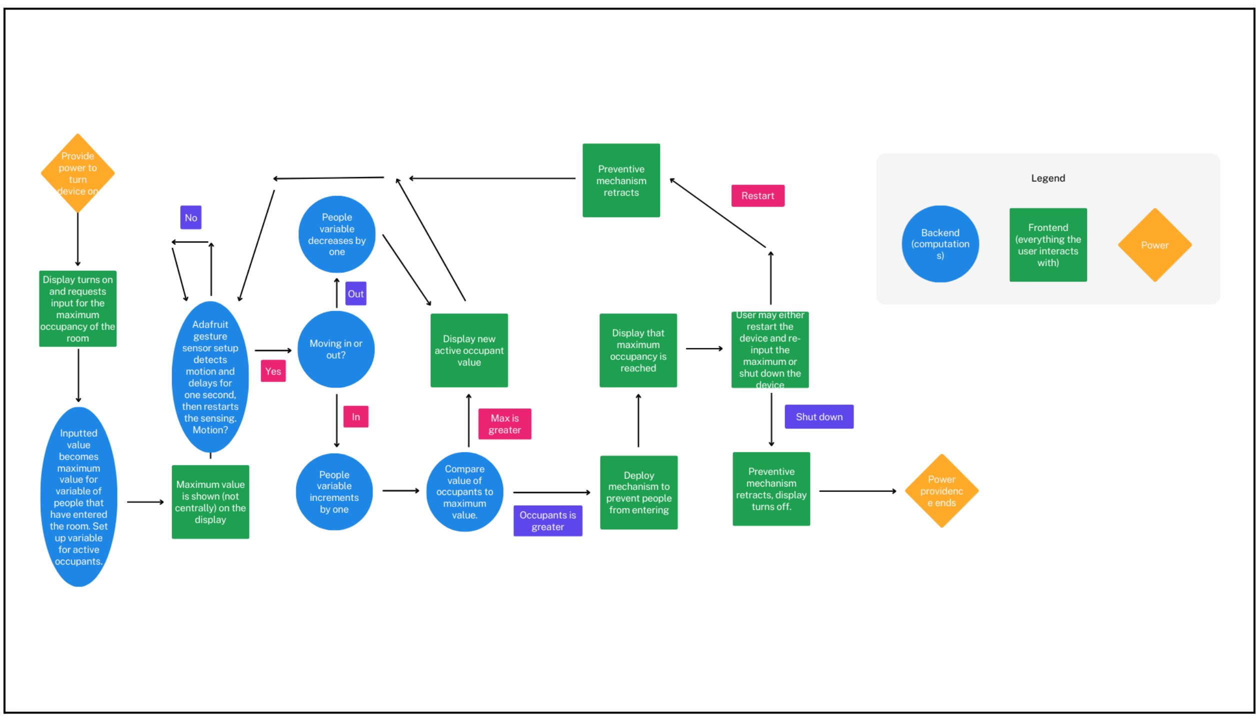


Figure 3: Code Flow Chart

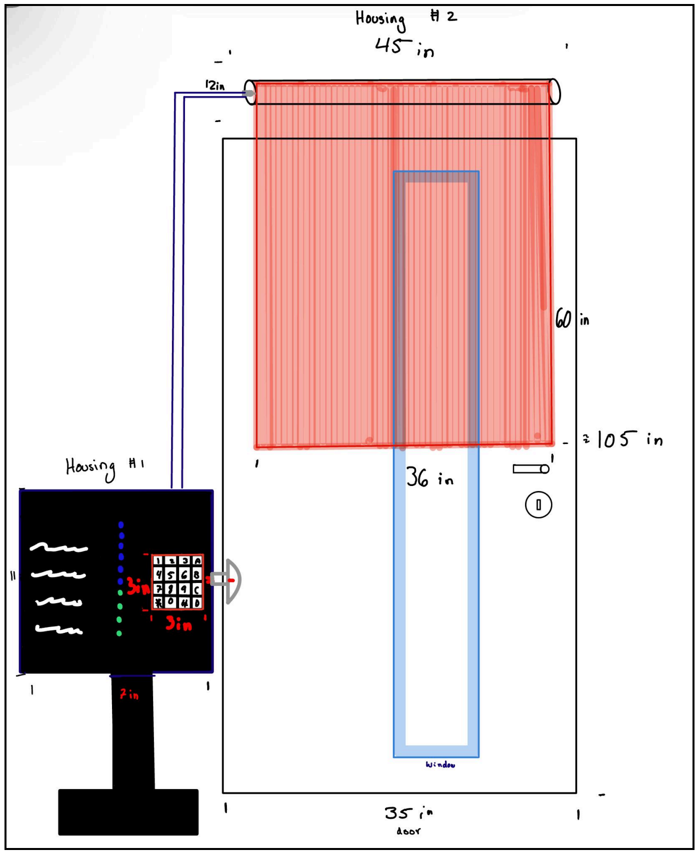
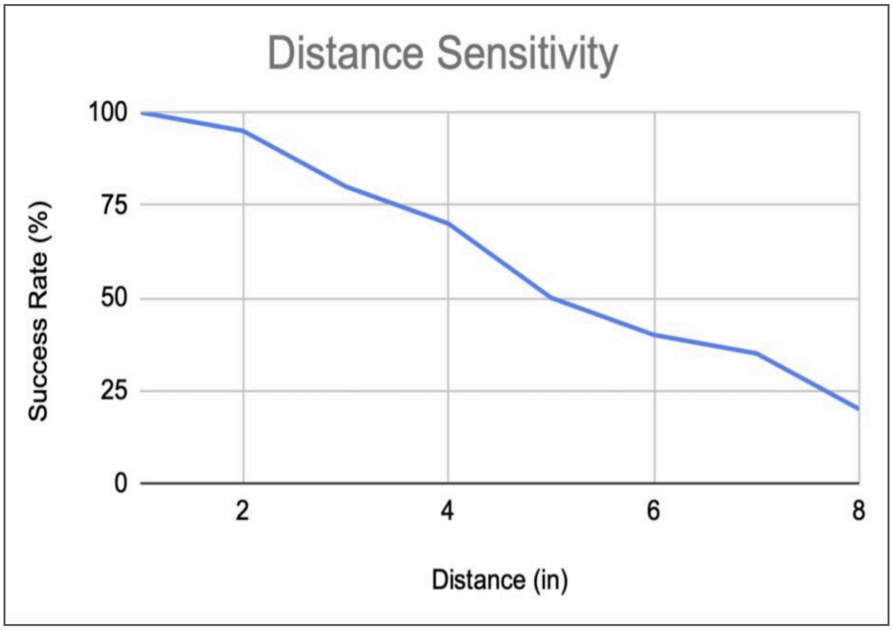


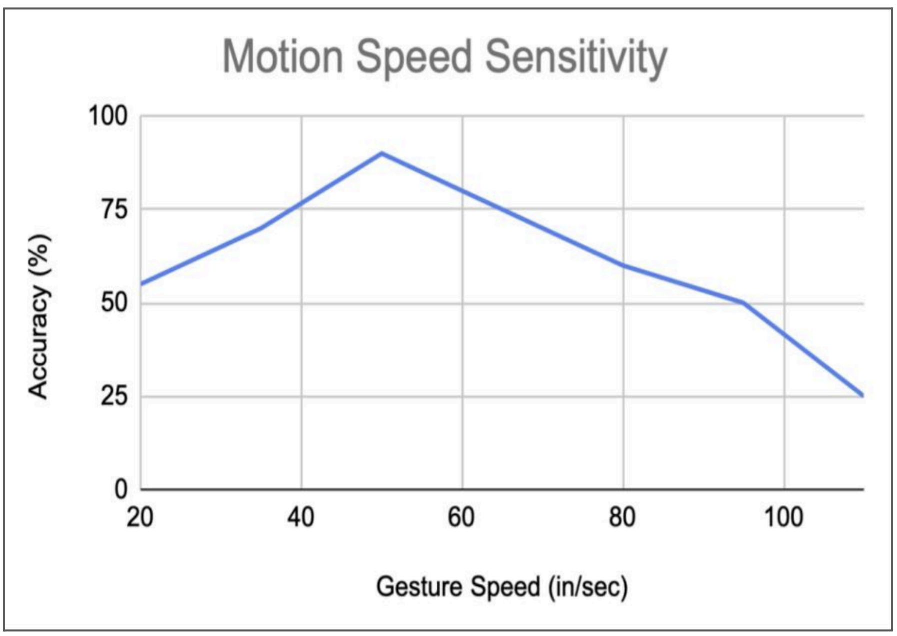
Figure 4: Hand Drawings

Transmitter	Draw (mAh)	Battery Capacity at Discharge Rate (mAh)	Run - Time (hrs)
Sensor / Keypad / LED	90	500	5.555555556
12V Motor	60	250	4.166666667
12V Motor Idle	15	500	33.33333333
Transmitter / Receiver	**Draw (mAh)**	**Battery Capacity Discharge Rate (mAh)**	**Run - Time (hrs)**
Arduino Uno	50	500	10

Table 5: Power Budget Calculations



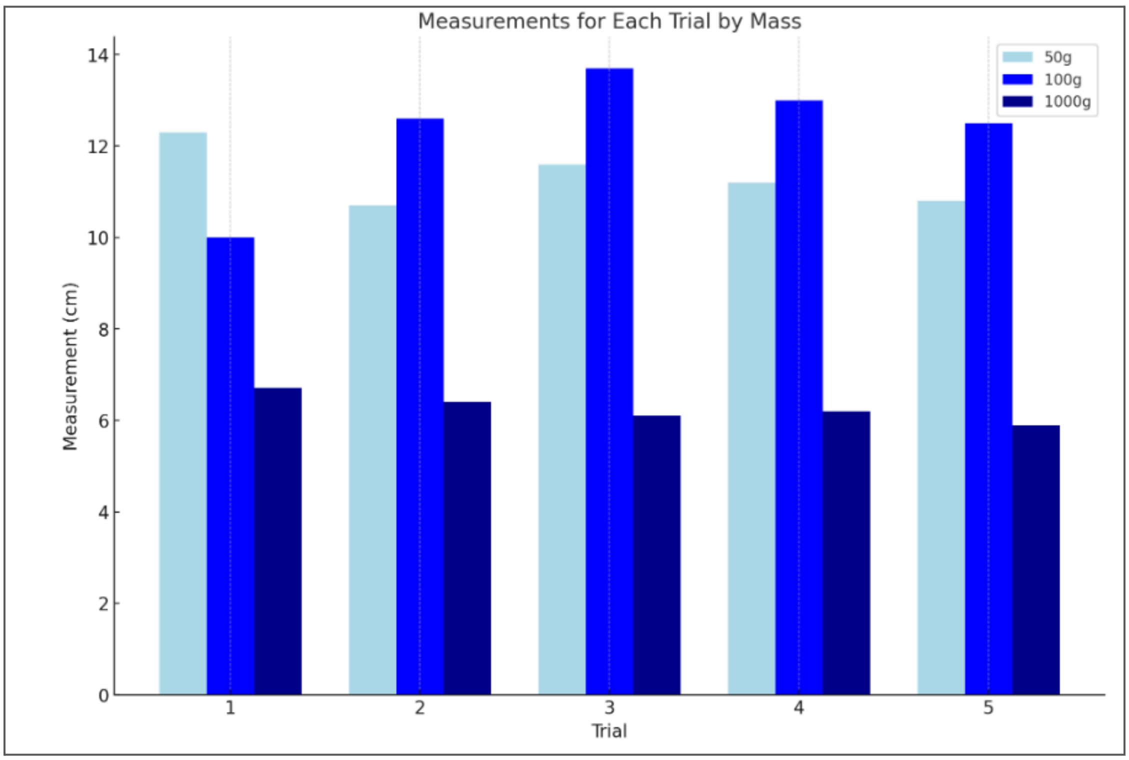
Graph 1: The Success Rate of the Sensor at Varying Distances



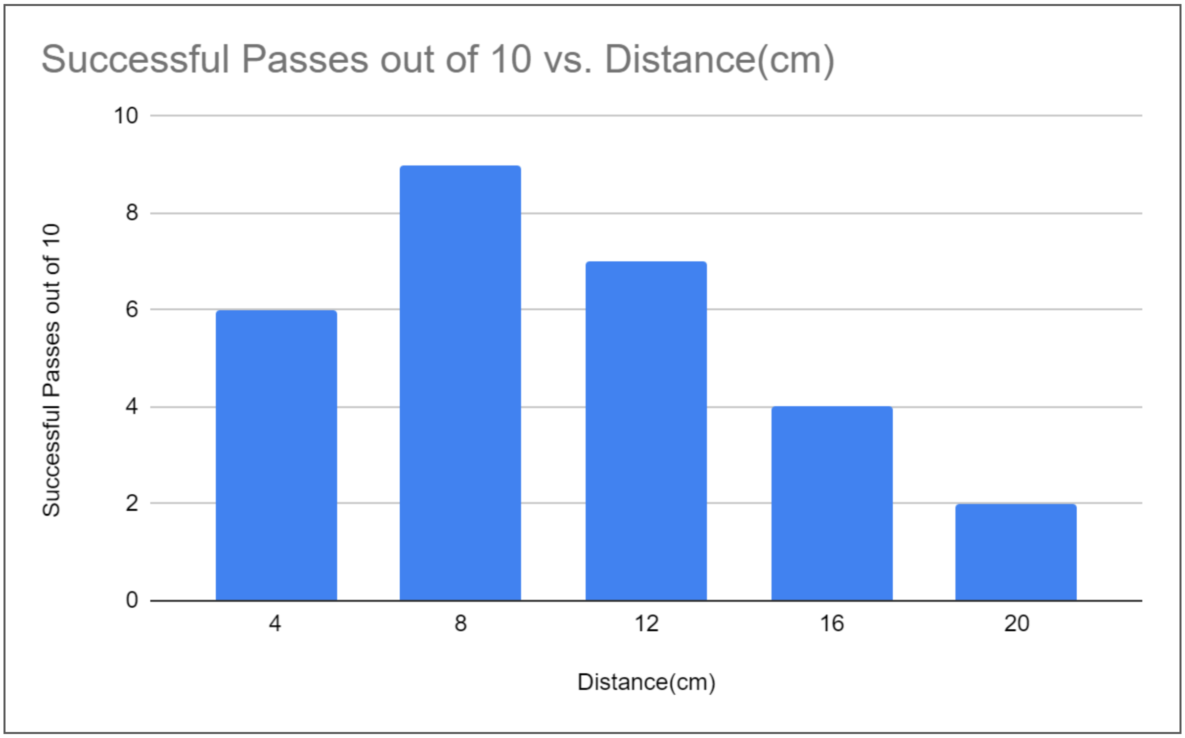
Graph 2: The Accuracy of the Sensor at varying Gesture Speeds

Trials	**50g**	**100g**	**1000g**
1	12.3cm	10.0cm	6.7cm
2	10.7cm	12.6cm	6.4cm
3	11.6cm	13.7cm	6.1cm
4	11.2cm	13.0cm	6.2cm
5	10.8cm	12.5cm	5.9cm
AVG	11.32cm	12.36cm	6.26cm

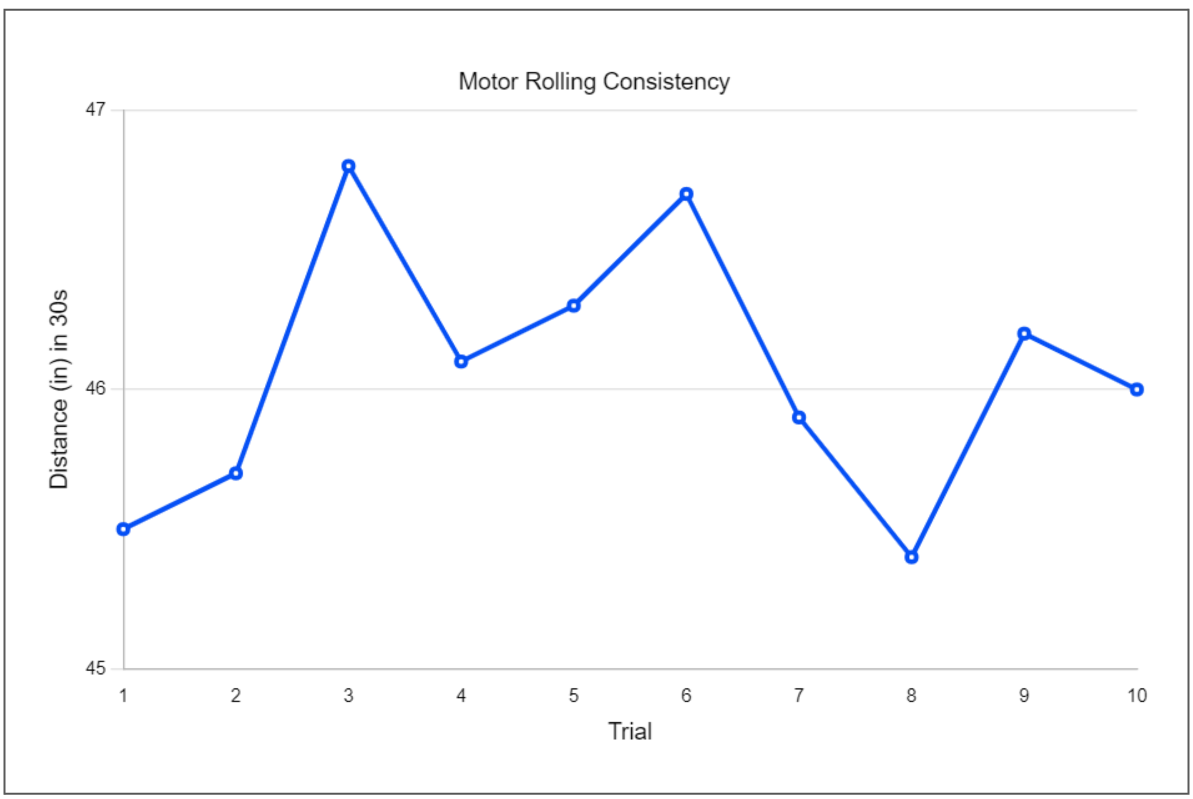
Table 6: Testing of the Motor's Capability to Lower Certain Weights



Graph 3: Visualization of the Motor's Success in Lowering Weights



Graph 4: Successful Passes of the Sensor at Varying Distances



Graph 5: The Success of the Motor in Moving the Curtain Varying Distances