

CUPBOARD CLOSER

Team 2:

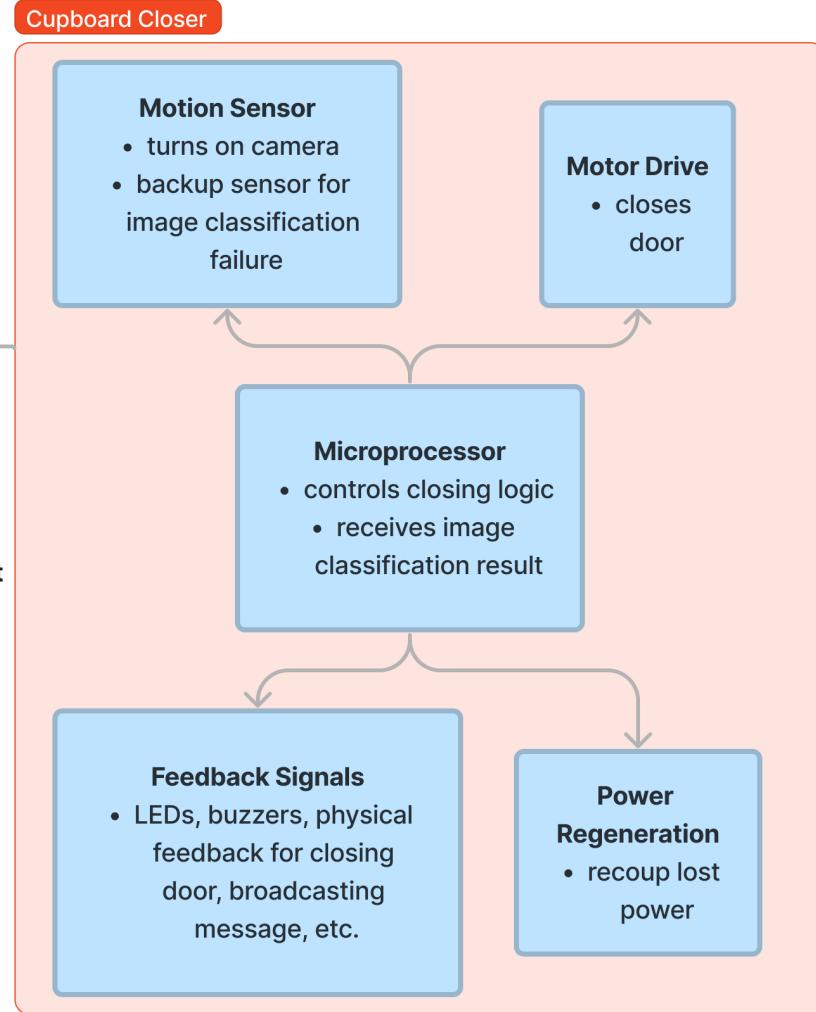
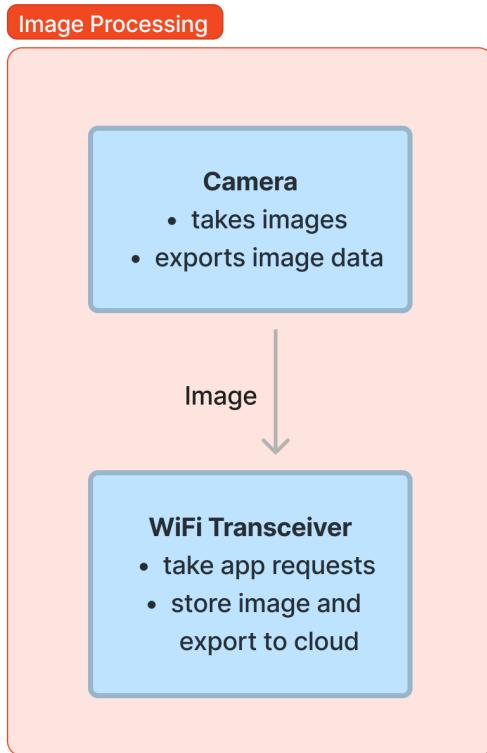
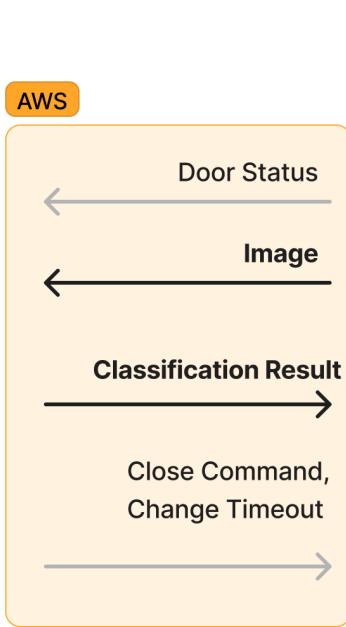
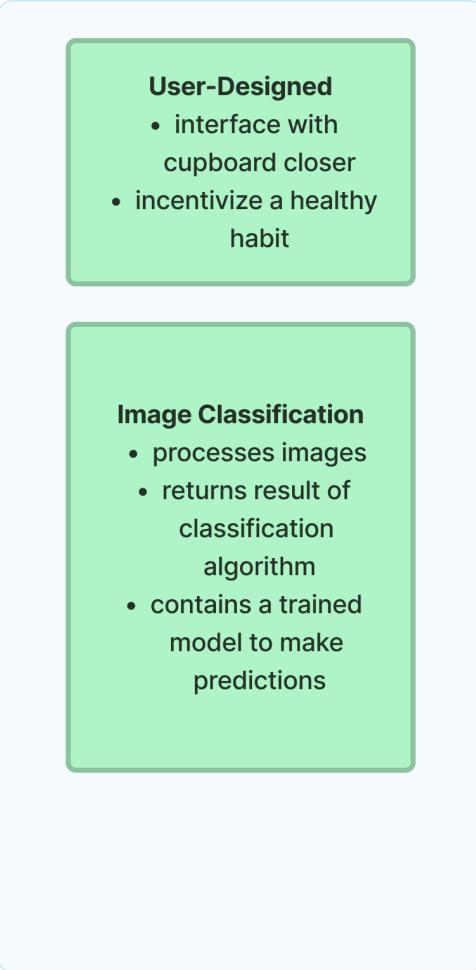
Maddie Love

Sierra Gordon

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Matt Spering

Companion App



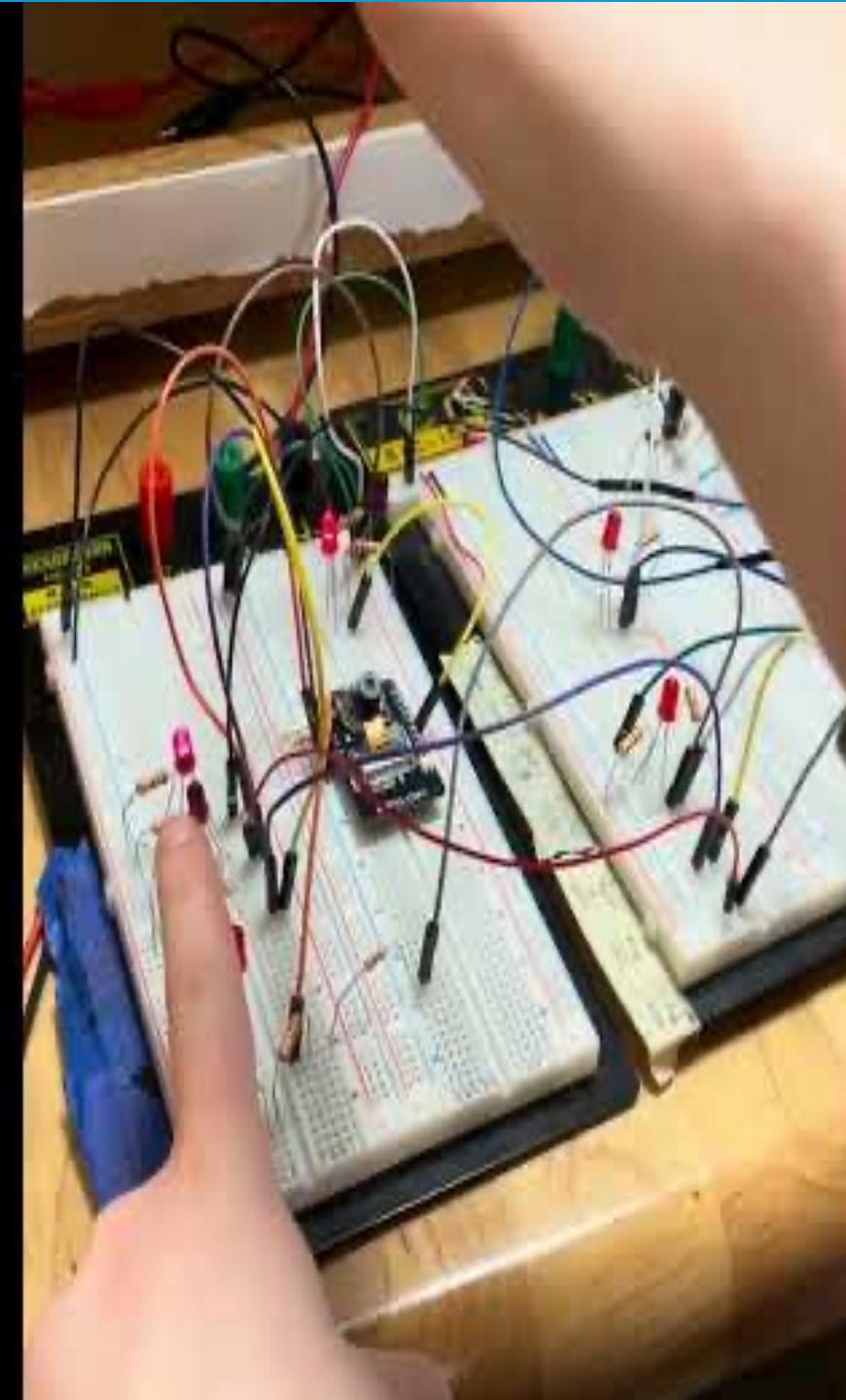
DESIGN OVERVIEW

COMPANION APP

- AWS Size Limits, could not offload image processing to cloud services
 - Including libraries
- Pivoted and created a Python executable instead of iOS app
- Current status of the cupboard device, as well as kitchen habit tracking
- Maintained AWS functionality

COMPANION APP

- Hand detection within companion app
- LED low for hand detection



COMMUNICATIONS TESTING

- AWS IOT MQTT Messaging
 - Timeout changes
 - Hand classification
 - Door open
 - Images
 - Image upload confirmation

ESP32 Timing

Present hand to ESP32-CAM, wait for a confirmation on the microcontroller

4.76s

AWS IOT Timing Results

Send an Empty AWS IOT Message (average over 50 messages):

0.5s

Sending an image from ESP to Companion App:

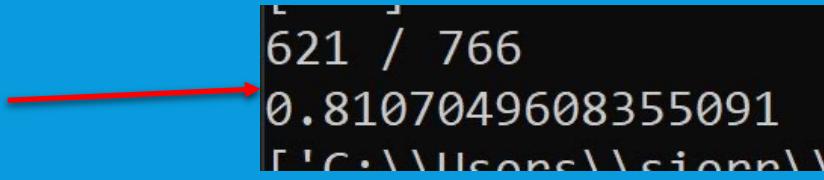
AWS Image Message	
Trials	Time (seconds)
65	0.733242688
76	0.626590061
65	0.794357318
100	1.304221478

IMAGE CLASSIFICATION

Trained new model with pictures taken with camera and different hands

Testing of image classification resulted in 81% accuracy

Timing Testing: For 35 trials, the average time to classify an image was 0.124 seconds.

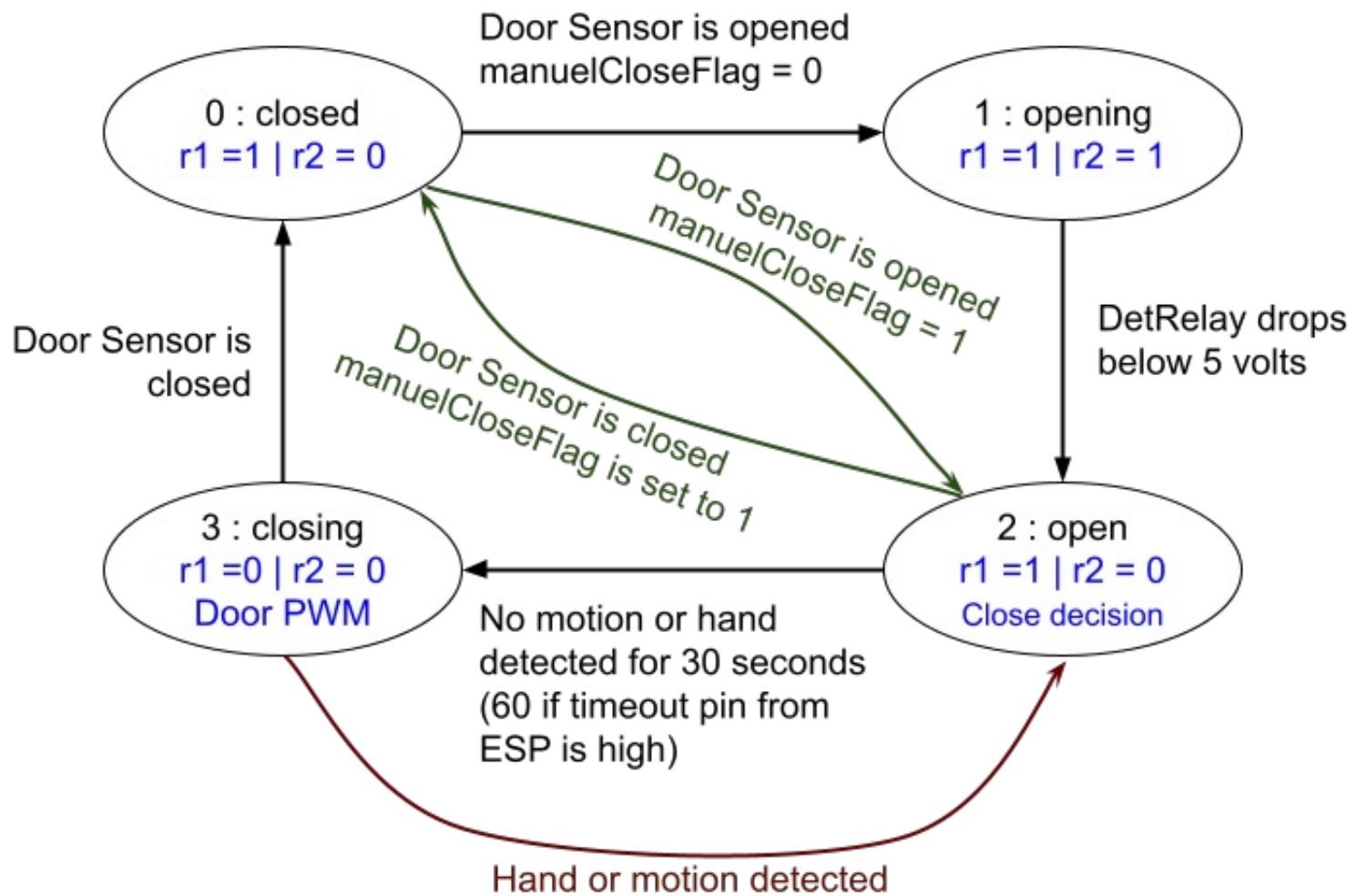


621 / 766
0.8107049608355091
C:\Users\sierr...

Integrated with communications to classify images. Qualitatively we found the program could classify better if it's closer and the orientation of the hand matters.

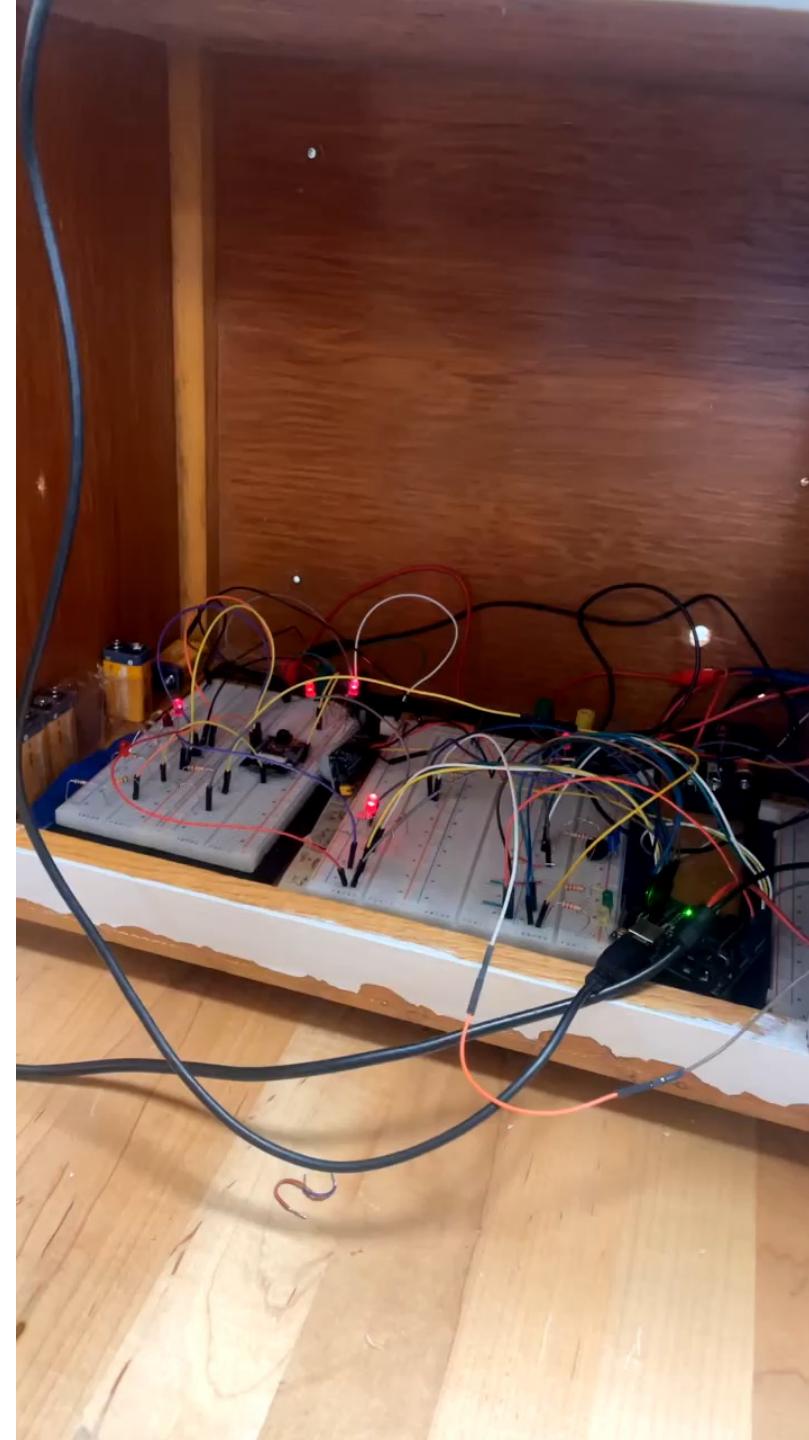
MICROCONTROLLER

- State 0: Nothing
- State 1: Regeneration
- State 2: Closing Decision
- State 3: Motor Drive
- r_1 and r_2 are relay settings for the motor and regeneration



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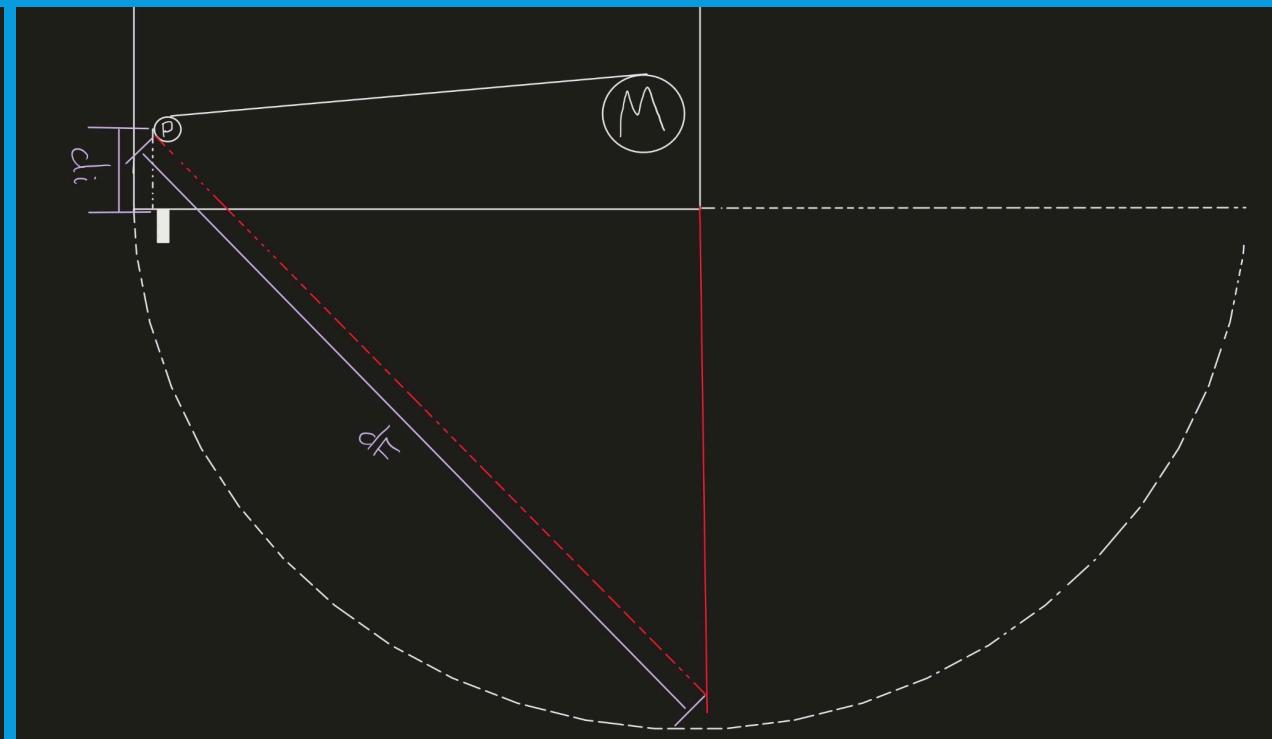
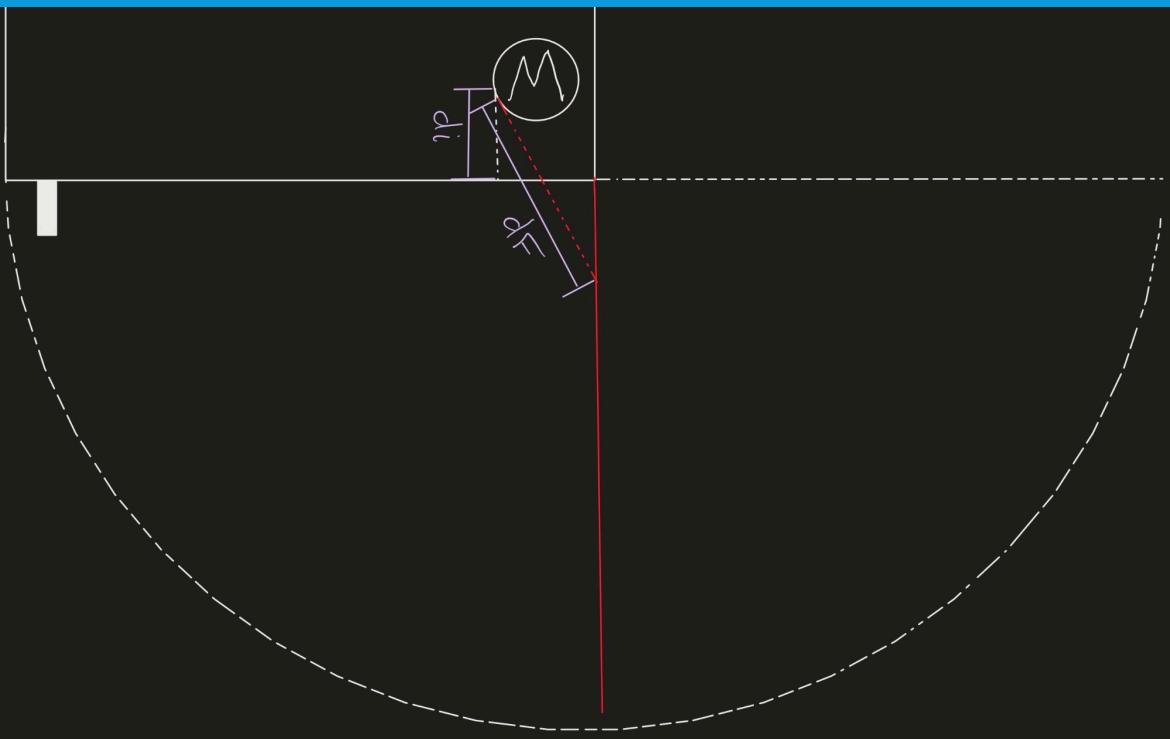
POWER REGENERATION – QUICK RECAP

- $V_o = K_e * \omega$
- Although a sufficient K_e was obtained, rotating the motor shaft at an adequate velocity proved to be very difficult.
- Variety of issues – size of moment arm, strength of cable, robustness of motor mount, amount of rotation.
- Overcoming these challenges required many iterations and redesigns.
- Charging circuit uses relays to route current to and from capacitor.

CHARGING THE CAPACITOR

- The amount of energy stored on a capacitor is equal to the amount of work done to charge it.
- The capacitor we are using is relatively large – 0.25 Farads – so the amount of work we need to do in order to charge it to a sufficient level is also relatively large.
- Recall that the work done on an object is the integral of the force applied multiplied by distance displaced – in order to do the greatest amount of work on the capacitor (and consequently give it the greatest amount of charge), we must maximize the number of rotations of the motor shaft. This is directly proportional to the amount of travel in the cable over the course of an open.
- Introducing a pulley was the solution here.

WALL MOUNTING



INCREASING SHAFT RADIUS

- It was prohibitively difficult to unspool the motor initially – the door would hardly open, and when it did, the cable would often snap.
- It quickly became obvious that increasing the radius of the moment arm was necessary.
- Many iterations before settling on a final solution.

BUILDING UP THE SHAFT



BUILDING UP THE SHAFT



BUILDING UP THE SHAFT



OPENING MECHANISM -TEST DATA

Trial #	Travel (in)	Duration(s)	Ang. Speed(rpm)	Meas. V. (V)	Calc. V. (V)	%Difference
1	21	1.51	124.8	19.40	25.59	31.93
2	20.5	1.26	146.1	22.71	31.02	36.61
3	11.75	0.78	135.3	21.03	29.2	38.86

16 more rows...

20	19	2.34	73	11.35	15.4	35.73
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Average % Difference: 35.73%

CIRCUIT DESIGN

- Controlled by a series of relays and diodes
- Capacitor discharges into our main power bus
- Test by measuring current out of battery, and out of capacitor

CURRENT SUPPLIED BY CAP- TEST DATA

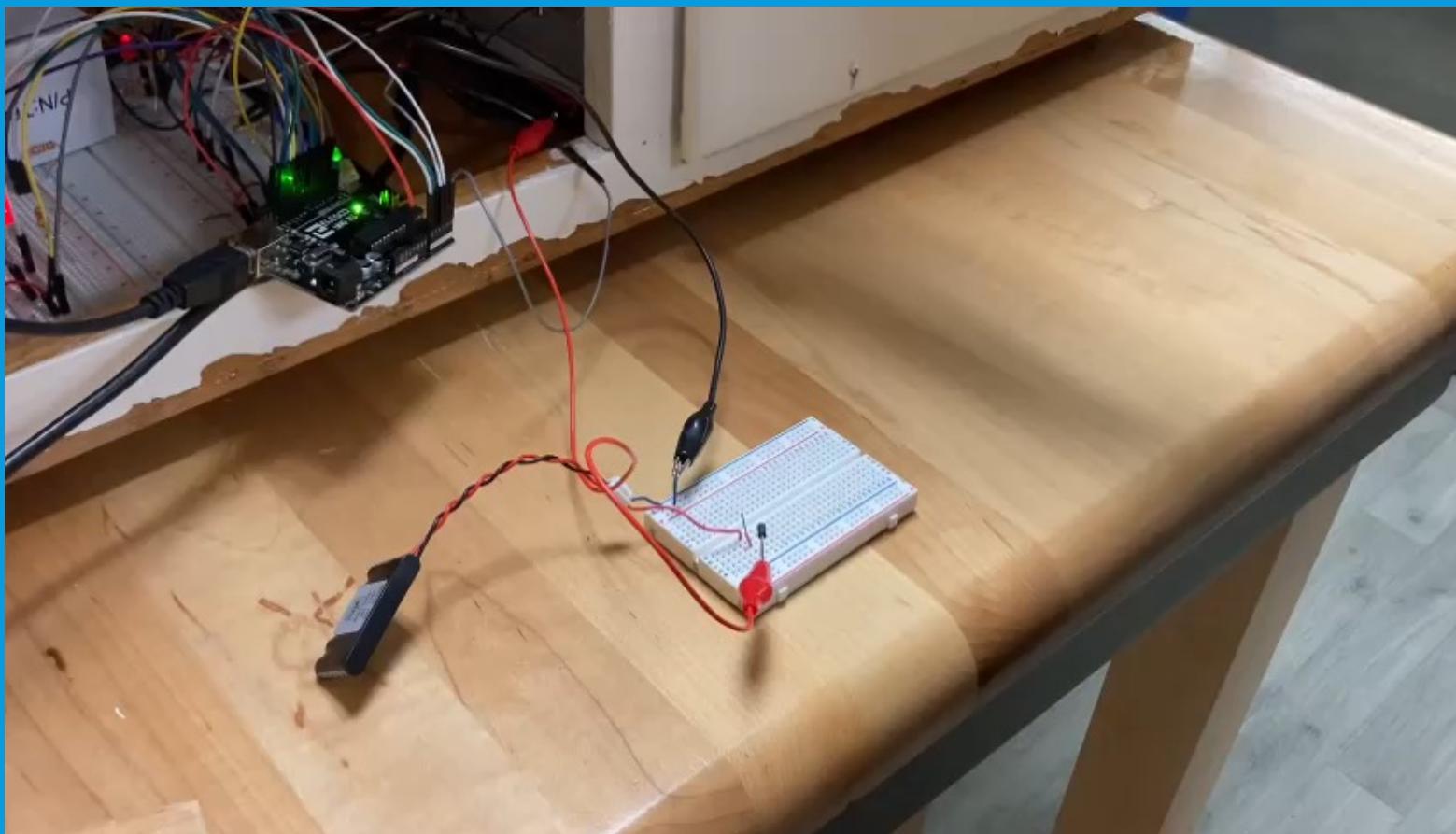
Trial #	Average Current Supplied (mA)
1	5.7
2	8.3
3	5.3

16 rows later...

20	7.0
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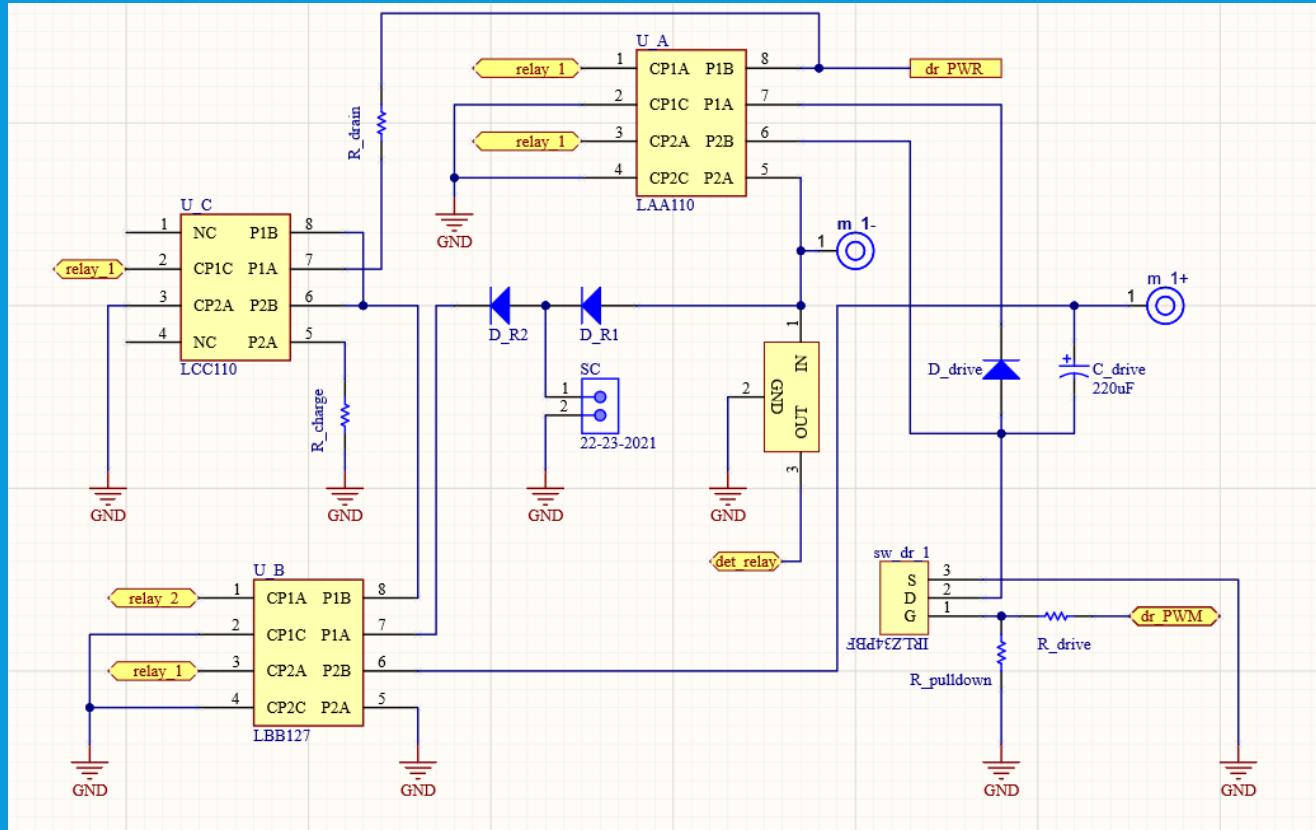
Average current supplied: 8.2 mA

SHORT VIDEO DEMO



MOTOR DRIVE AND POWER RELAY DESIGN

- Objectives:
 - Close the door using controlled PWM inputs to the gate generated by MCU
 - Switch relays to allow for regeneration action to take place during "Opening" state
- Design Elements:
 - DC motor drive with N-type MOSFET and protection diode to drive gear motor
 - PWM signal operating at conditions: 500 mHz and 50% duty cycle from digital MCU pin
 - Relay switch controlling power bus input to motor drive that disconnects from power during "Opening" state

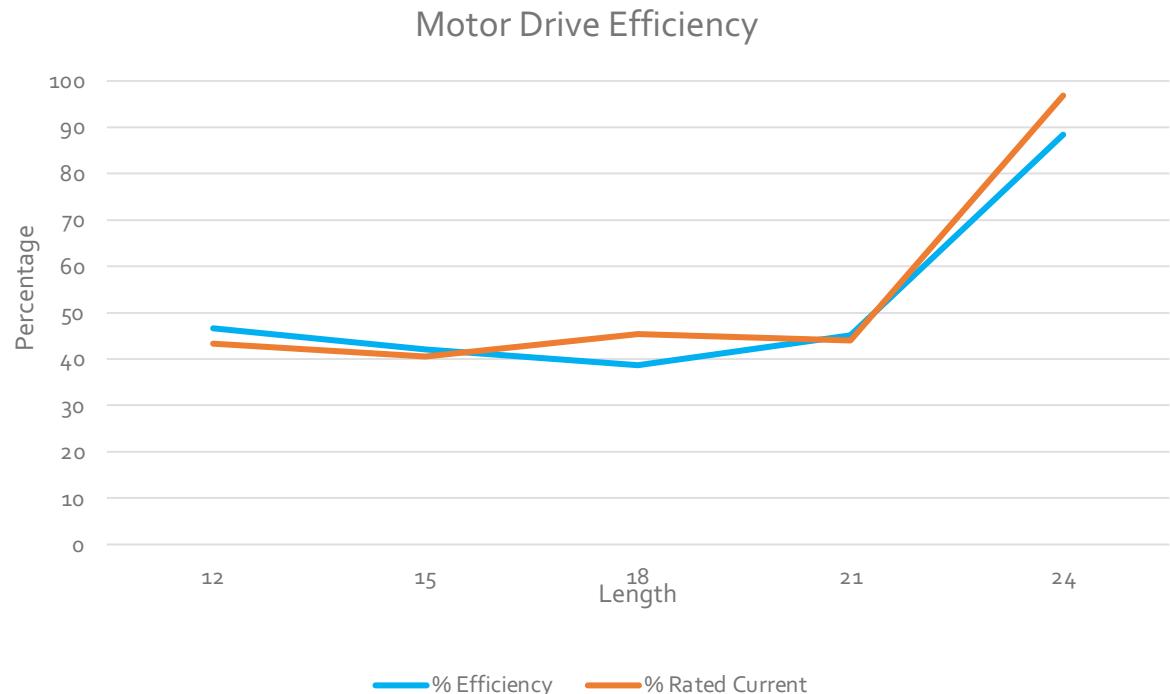


MOTOR DRIVE TESTING

- Tested using multimeters across motor (Voltage) and into motor (Current)
- Ten trials completed for each length of opening line for a total of fifty trials total
- Timing via stopwatch and rotations calculated from length of line off the pulley; Torque calculated from motor power and shaft speed
- Notable increase in startup power and therefore startup torque once door reached 2 ft. Threshold
- Notable correlation between percent rated motor current and percent efficiency of drive system

Averages for Varying Open Length (Motor Drive):

Length (in):	Voltage Peak (V)	Current Peak (A)	Power Peak (W)	Time On (s)	Energy (mAh)	Speed (RPM)	Torque (mN*m)
12	6.933	0.087	0.601	3.086	74.554	46.566	124.064
15	6.881	0.081	0.558	3.989	89.937	44.914	118.826
18	6.859	0.091	0.622	4.904	123.508	43.824	135.515
21	6.887	0.088	0.605	5.861	143.185	42.792	136.498
24	6.899	0.194	1.336	6.861	369.158	41.770	305.618



Averages for Varying Open Length (Battery):

Length (in)	Voltage Peak (V)	Current Peak (A)	Power Peak (W)	Time (s)	Energy (mAh)
12	7.975	0.162	1.289	6.713	150.789
15	7.958	0.167	1.325	8.341	192.841
18	7.957	0.202	1.608	10.074	282.749
21	7.952	0.169	1.342	12.053	282.323
24	7.947	0.190	1.511	14.182	374.655

BATTERY & POWER BUS TESTING

- Battery testing done similarly to drive testing using multimeter leads over and out of the battery leads
- Ten trials were completed for each length of opening to obtain comparison data to the drive system
- Completed prototype on breadboard fully powered off battery shown in video to the left with "Hand Detection" tied and motion sensor boxed to activate instantly

DEMONSTRATION

