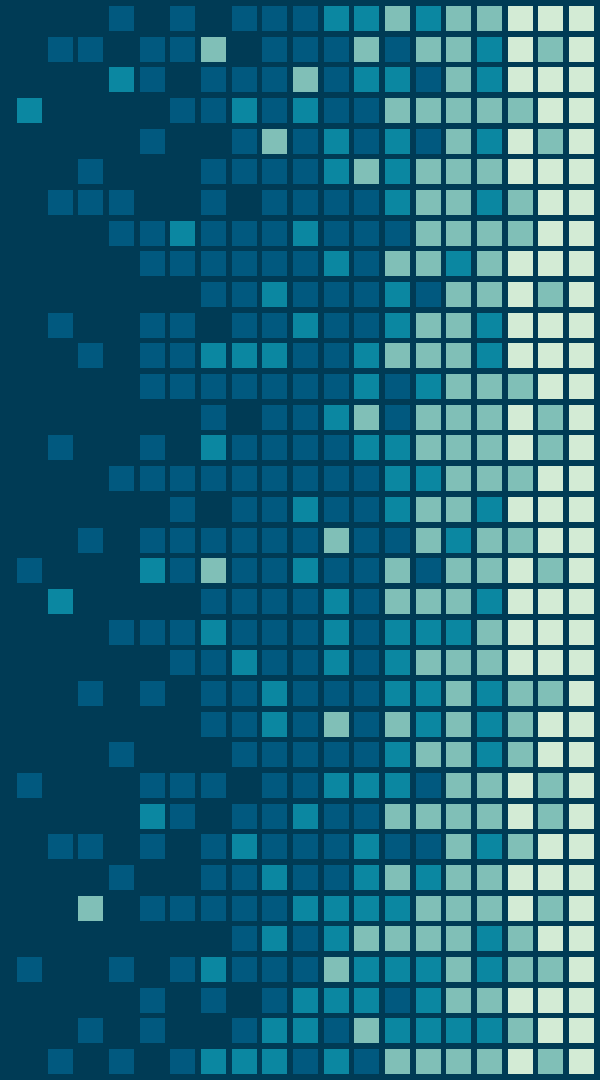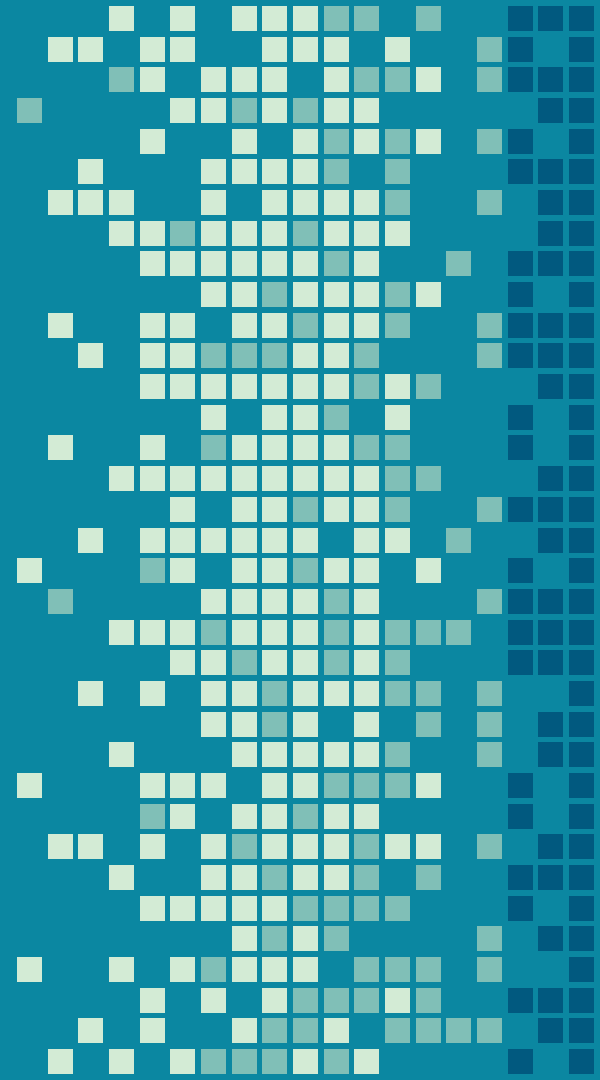# ECE 445
Final Presentation
Team 48

Phoebe Chen, Mary Rose Farruggio, Owen Thamban
Professor: Dr. Olga Mironenko
TA: Abhisheka Mathur Sekar

Introduction

Team 48

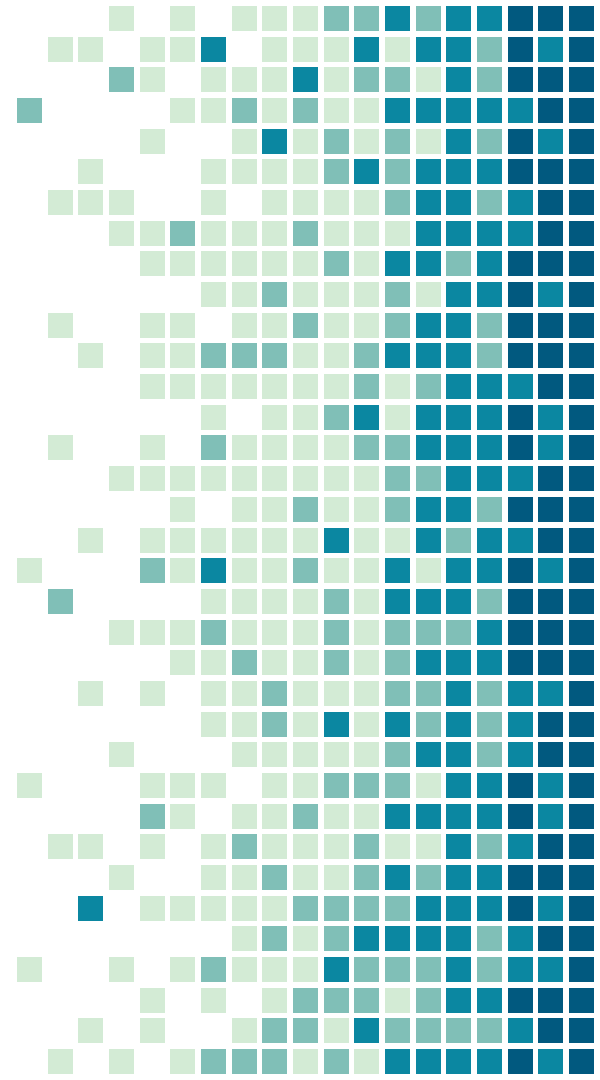## Electrochromic Bird–Friendly Windows

Phoebe Chen
Computer Engineer

Mary Rose Farruggio
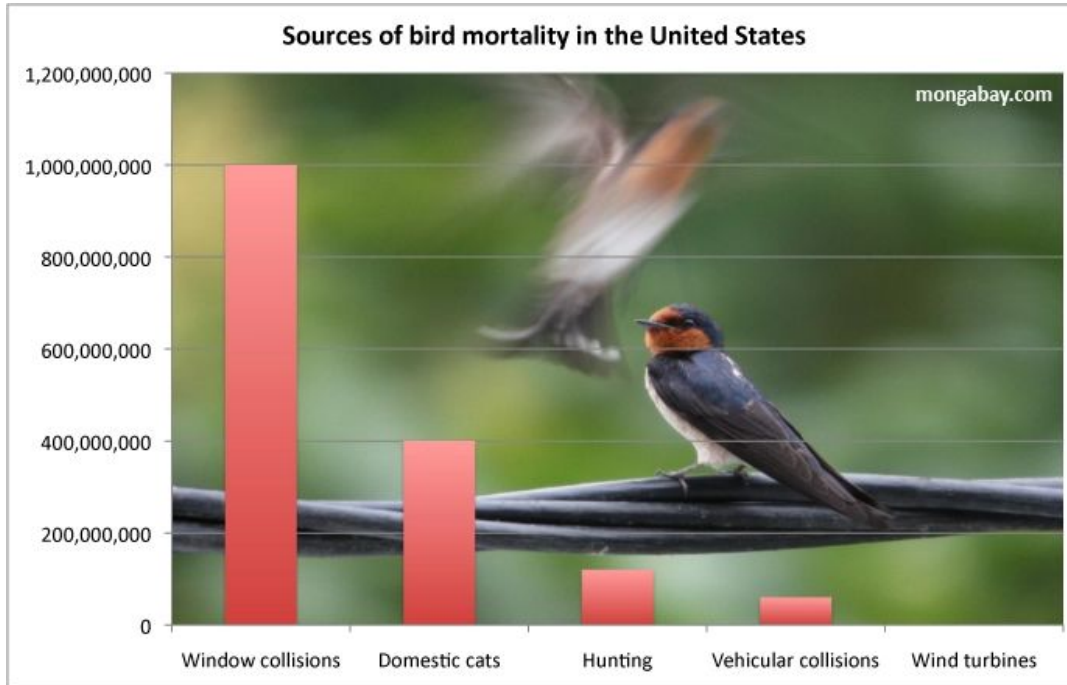Electrical Engineer

Owen Thamban
Electrical Engineer

Problem

- Approximately one billion fatal bird-window collision in America each year
- Current solutions significantly compromise visibility/aesthetic appeal
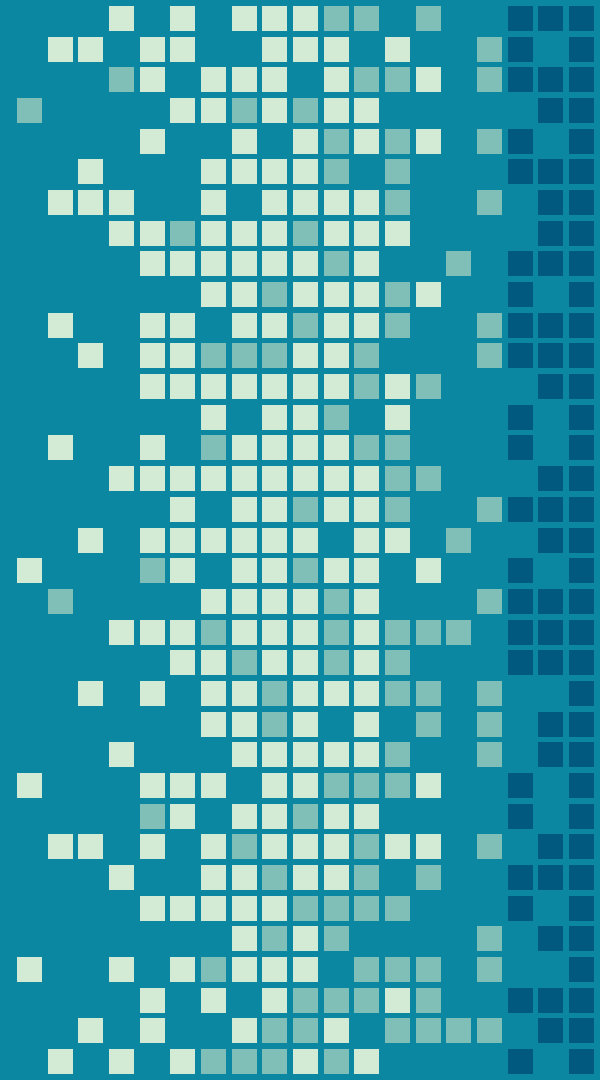 - →Adoption is low
- Conservation concern

Problem

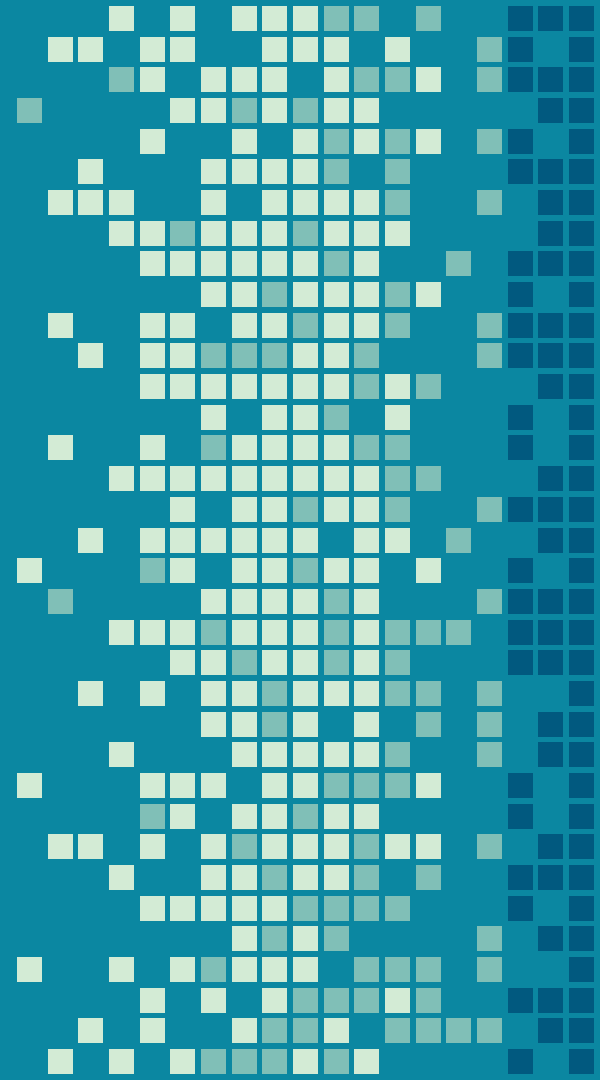Sources of bird mortality in the United States

Objective

To lower the rate of fatal bird–window collisions in an efficient manner while keeping the aesthetic appeal of the window
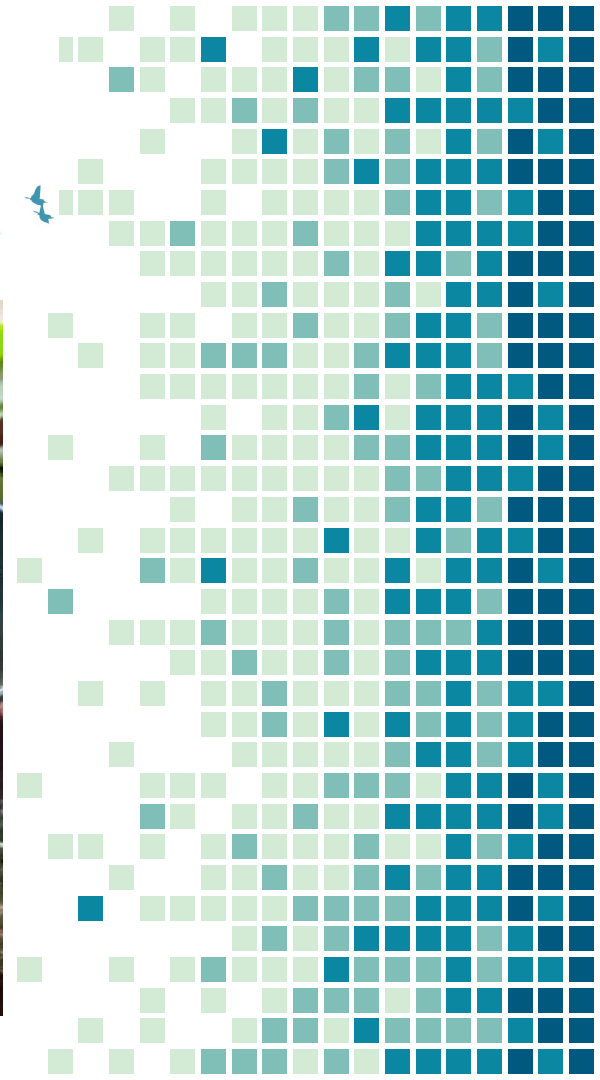
Solution Design

Initial Idea

- Need to make birds aware of the hazard -> Make window visible -> Electrochromic Materials
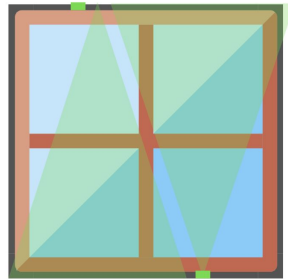- Detect Birds approaching and change opacity

Initial Idea

- Use ultrasonic sensors to detect birds approaching
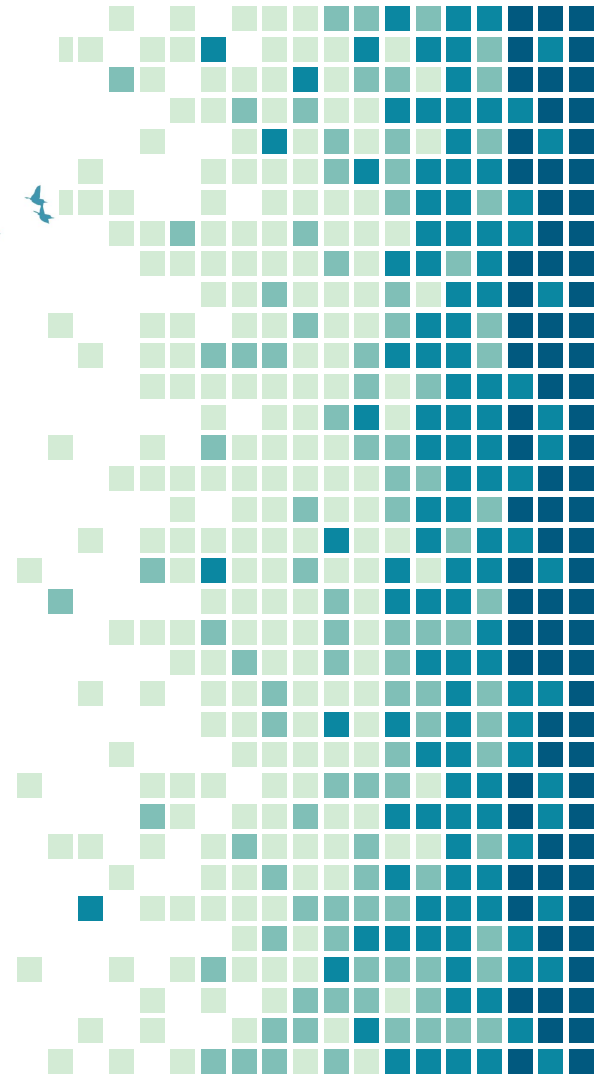- Change opacity of electrochromic panels when a bird is detected

Side View

Front View

Key

Ultrasonic Sensor

area of ultrasonic detection

Design Revision

- Fast flight speed and slow reaction time –> adjusted dimensions
- Aesthetically unappealing –>use hollow frame
- Can't distinguish between birds and rain, leaves, etc. –> add image processing

Side View

Key

Ultrasonic Sensor

area of ultrasonic detection

Front View

Side View

Camera

Key

= Ultrasonic Sensor

= area of ultrasonic detection

Front View
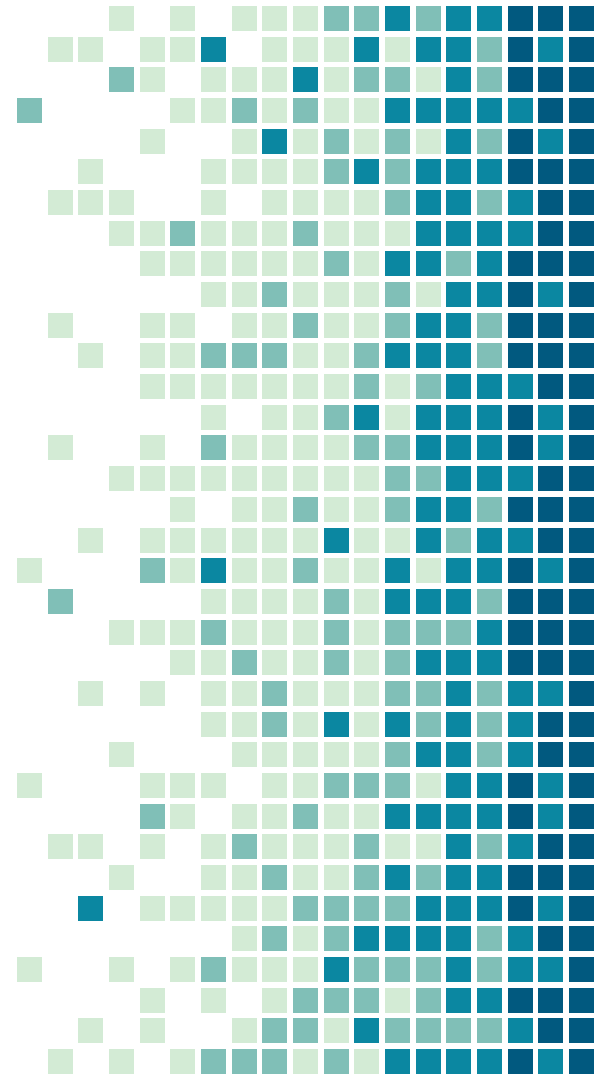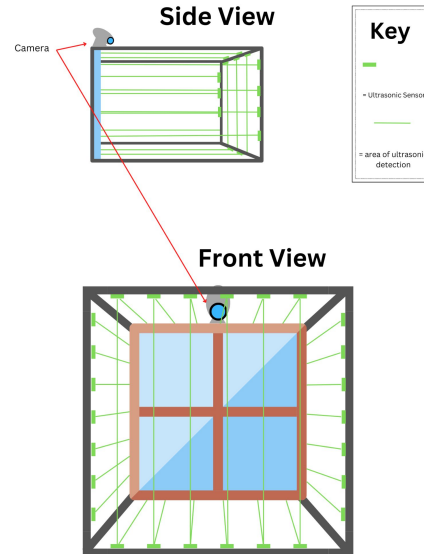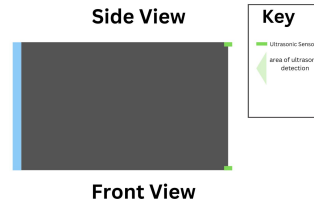
Design Revision

- Insufficient number of pins on microcontroller ->decrease sensors to minimum number necessary
- Limited field of vision->move thermal camera to frame's center
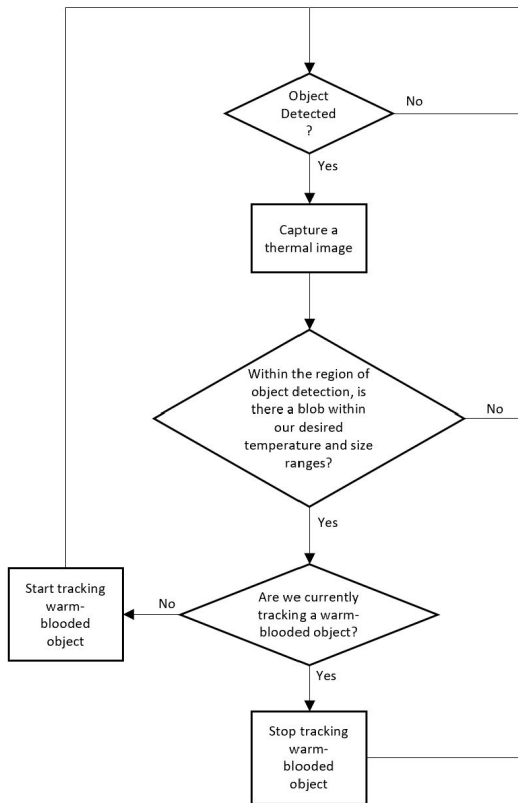
Side View

Camera

Front View
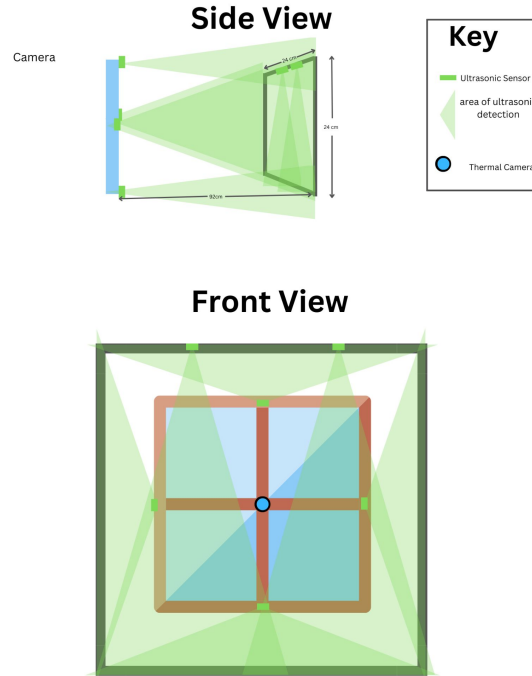
Key

Ultrasonic Sensor

area of ultrasonic detection

Thermal Camera

Image Processing

Design continued
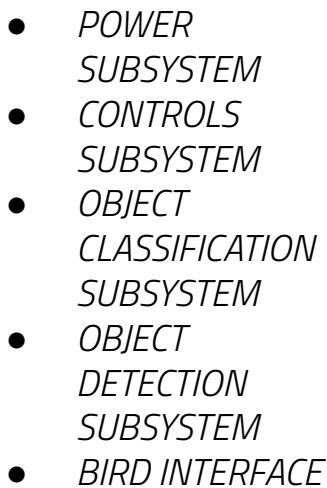
- *POWER SUBSYSTEM*
- *CONTROLS SUBSYSTEM*
- *OBJECT CLASSIFICATION SUBSYSTEM*
- *OBJECT DETECTION SUBSYSTEM*
- *BIRD INTERFACE*

Design continued

High Level Requirements

High Level Requirements

When the system is at rest the panels must be kept in their transparent state. The system is considered at rest before a bird is detected or after a bird has exited.
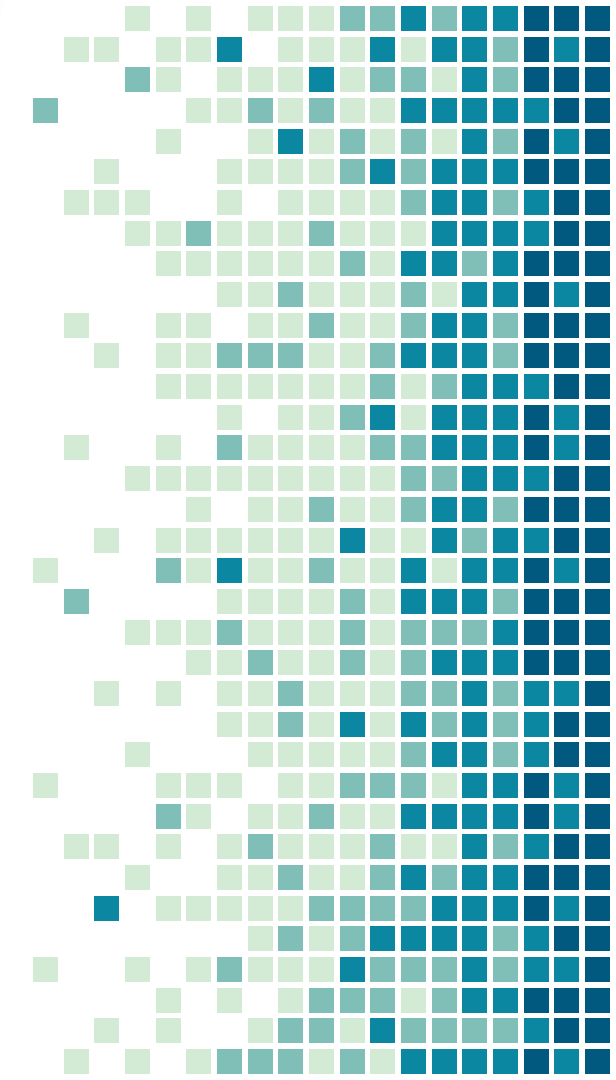
High Level Requirements

The system must be able to successfully detect an object traveling at 7.6 m/s or less of length ≥ 11 cm and width ≥ 19 cm (minimum length and wingspan of the seven birds with the highest rates of window collisions) entering or exiting through the front of the 24 x 24 x 58 cm rectangular prism encompassed by the frame in ≥ 80% of trials.

High Level Requirements

When the system determines that an object has been detected entering the frame–encompassed area, it must successfully transition one or more of the electrochromic panels from transparent to opaque.

Assumptions

- Majority head-on collisions

- One bird at a time

- Semi-species specific
  - White-throated Sparrow
  - Ovenbird
  - Common Yellowthroat
  - Dark-eyed Junco
  - Brown Creeper
  - Hermit Thrush
  - Black-and-white Warbler

Successes & Challenges
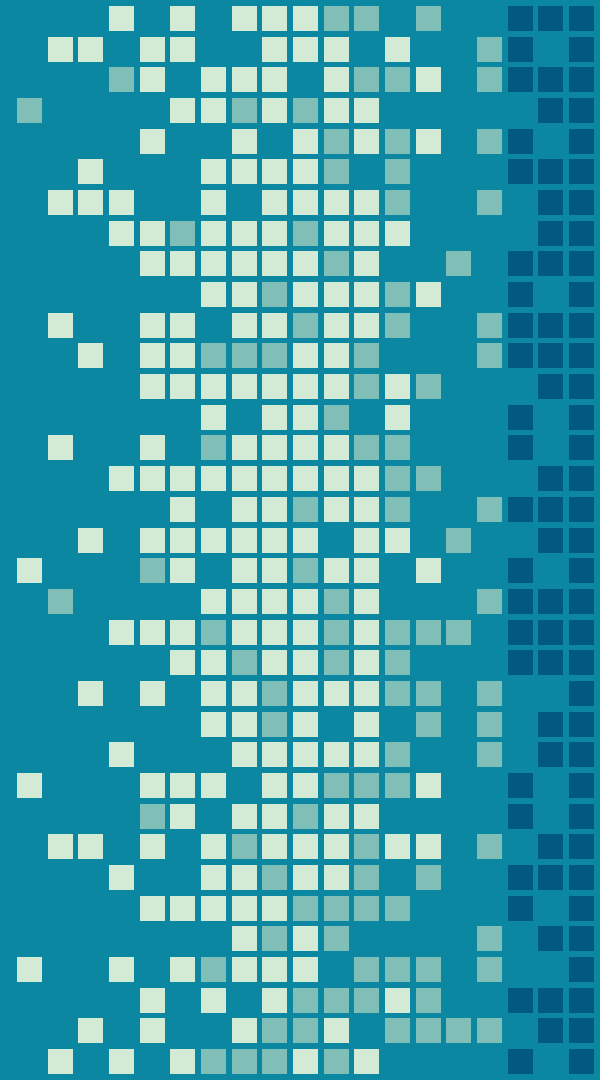
Challenges

- Physical design compromise
- High current draw from panels
- Ultrasonic sensor accuracy
- Microcontroller malfunction/switch to Arduino (less pins)
- Improvised digital switches
- Arduino limited current draw
- Not enough parts
- Integration
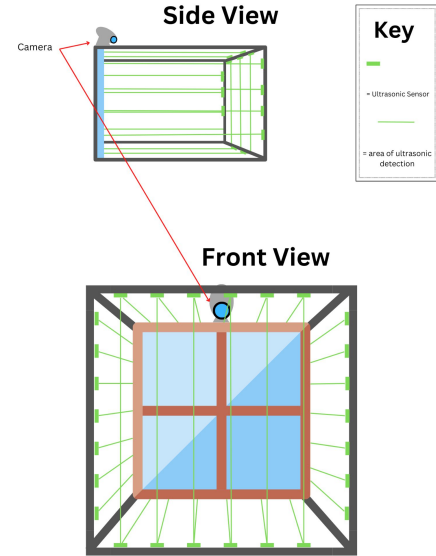
Side View

Camera

Key

- Ultrasonic Sensor

= area of ultrasonic detection

Front View

Successes

- Sturdy, portable, clean-cut frame
- Included DC/AC converters (altered parameters)
- Fast Ultrasonic Sensor/Microcontroller Response Time (7.85 m/s)
- Consistent detection under 58 cm (≥ 80% of trials)
- Full and location-specific panel transitions
- Accurate image processing/object tracking
- No panel damage

Results

Interface

CurT1 = 4.000 ms	CurV1 = 3.903 V	Period: --	Period: --
CurT2 = 4.000 ms	CurV2 = 3.903 V	Frequency: --	Frequency: --
Δt = 0.000 s	ΔV = 0.000 V	Peak-peak: 7.717 V	Peak-peak: 183.683 mV
1/Δt = Infinity		Mean: 251.507 mV	Mean: 2.934 V

500.000 µs/div   8000 Samples at 1 Msps   Stop
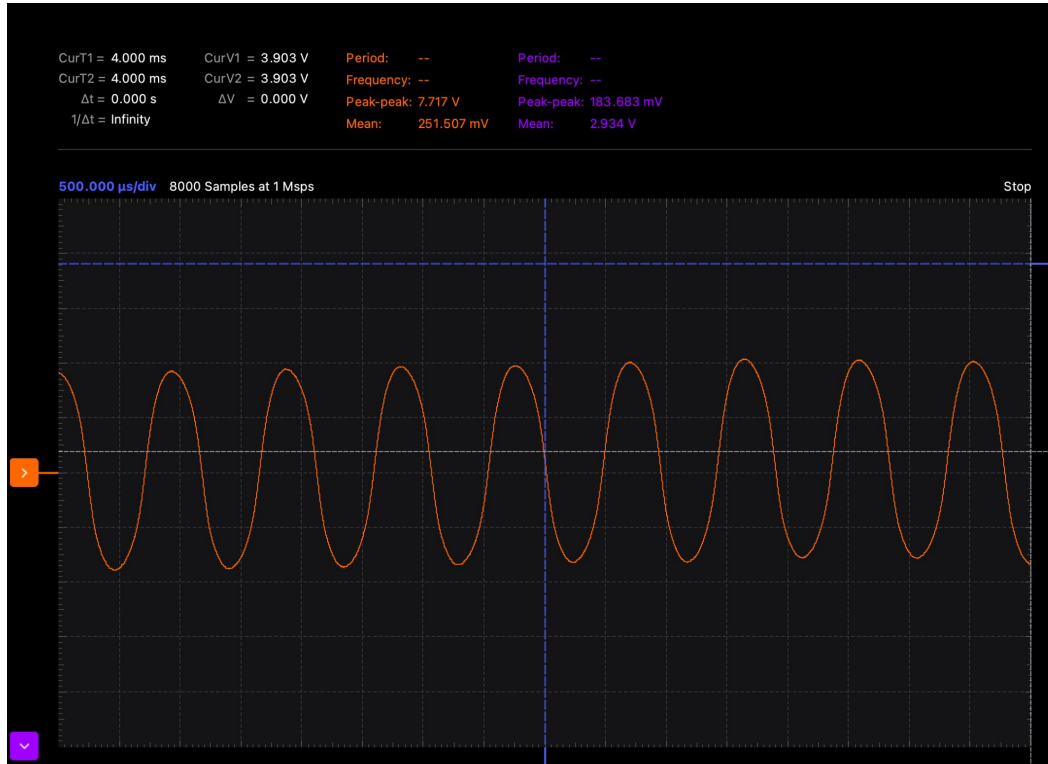
DC/AC Converter Input and Output
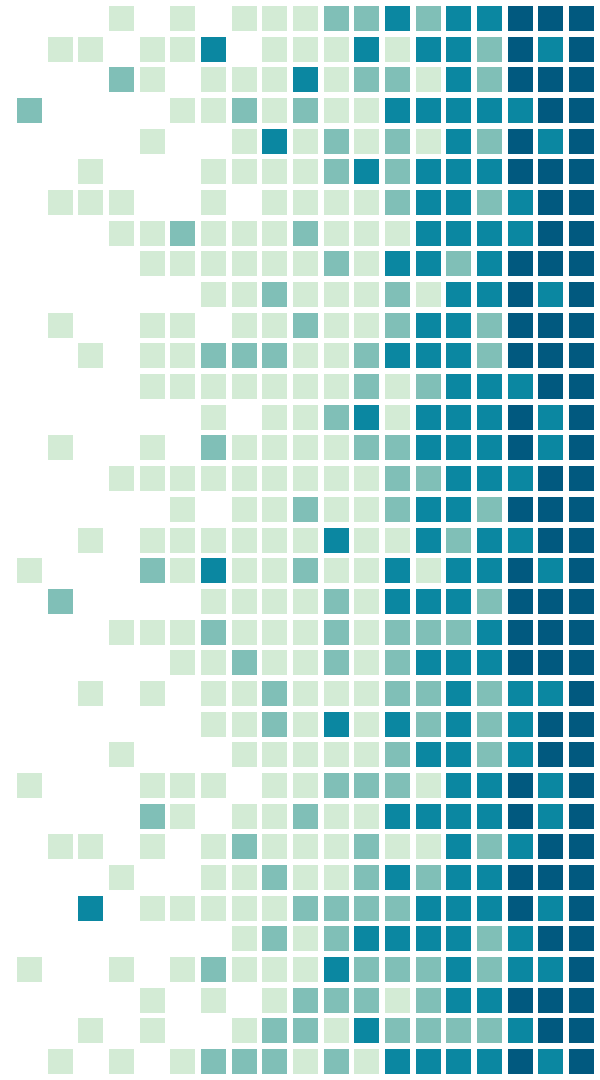
Detection/Interface
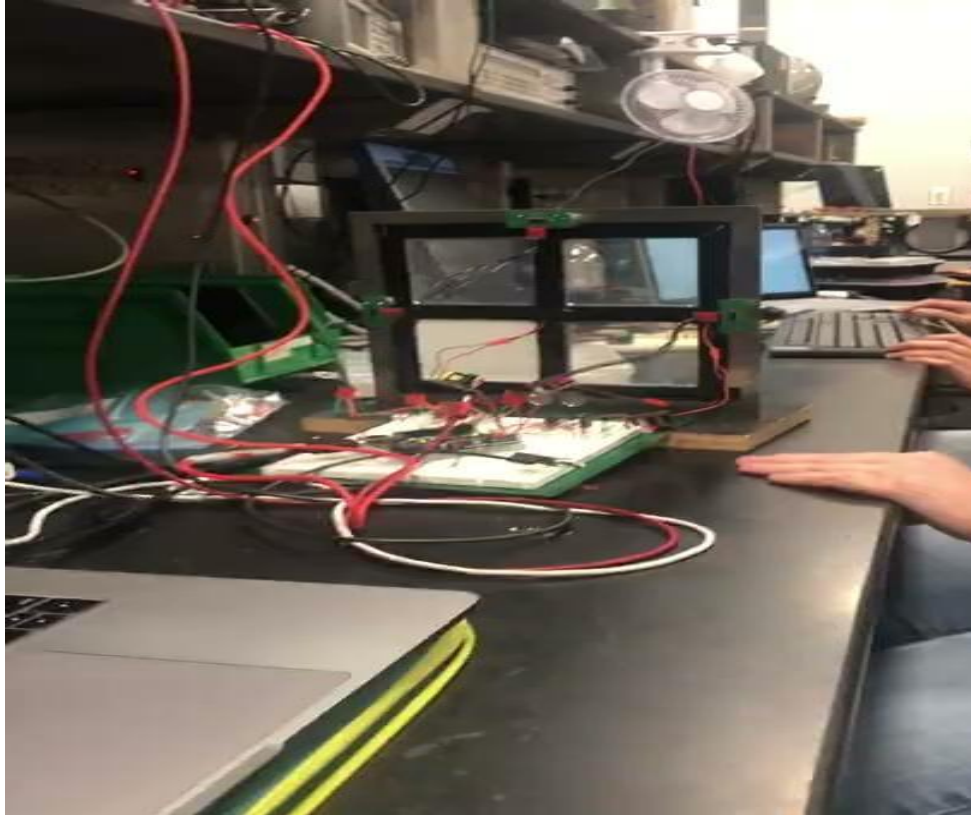
Performance: Ultrasonic Sensors

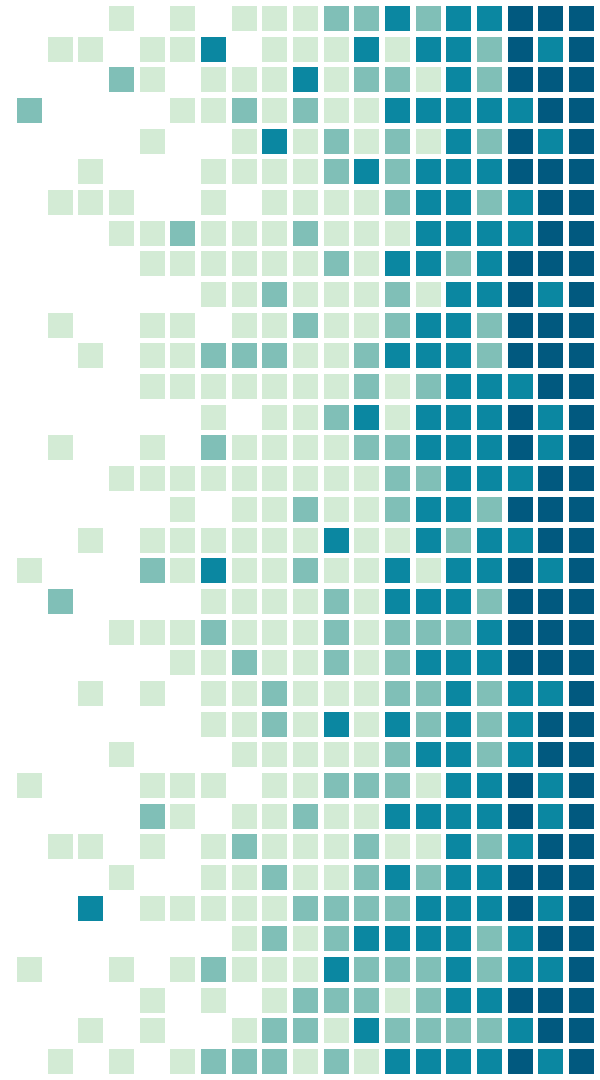| Ultrasonic Sensor 3		Ultrasonic Sensor 4		Ultrasonic Sensor 5	
Ruler-Measured	Sensor-Measured Distance	Ruler-Measured	Sensor-Measured Distance	Ruler-Measured	Sensor-Measured Distance
5	4.8	5	5.44	5	4.27
10	10.41	10	11.78	10	9.23
15	15.8	15	15.64	15	15.62
20	20.94	20	19.47	20	21.68
25	25.04	25	25.67	25	25.14
30	29.36	30	31.52	30	30.08
35	36.62	35	35.57	35	36.2
40	39.03	40	42.19	40	38.95
45	44.09	45	42.19	45	40.46
50	48.32	50	49.48	50	48.21
55	49.63	55	49.55	55	49.48
60	50.01	60	56.08	60 X	
65	50.11	65	42.21	65	
70 X		70 X		70	
75		75		75	
80		80		80	

Ultrasonic Sensor
Accuracy (cm)

Results: Classification
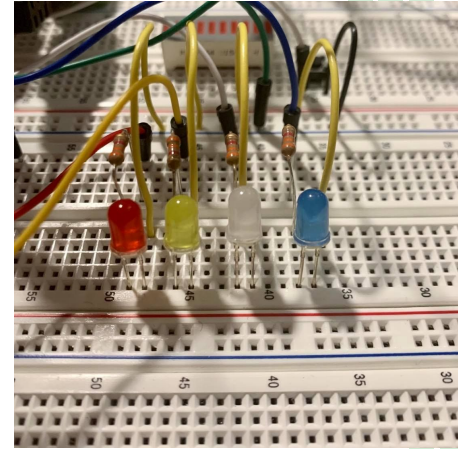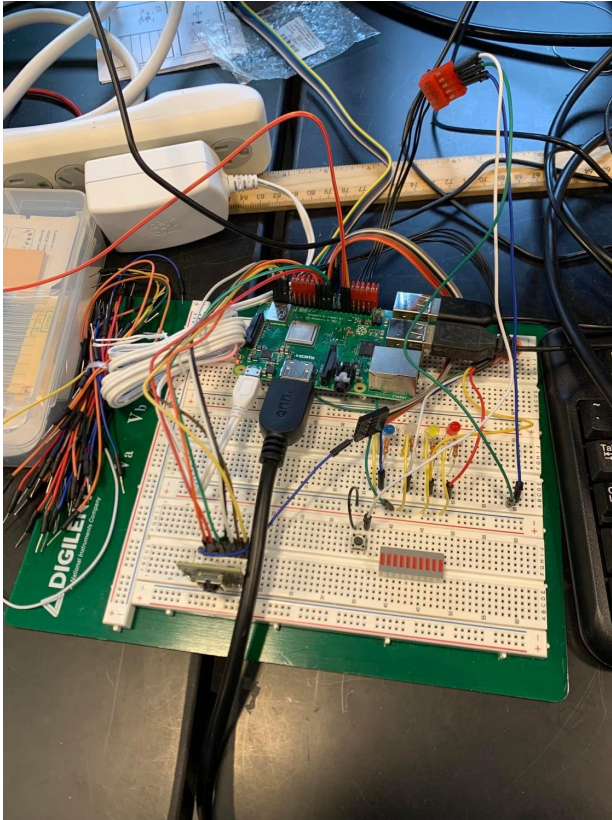
Conclusions & Takeaways

- Order many, many spare parts as early as possible
- Datasheet accuracy varies
- Make accountability a habit early on
- Unit test in short bursts
- Has potential for larger applications

Recommendations

- Economies of scale-> increase application size
- Testing with live birds
- Waterproof system for field applications
- Adapt parameters based on geographical location (temperature, threshold)
- Implement more efficient image processing algorithm
- Median Filter
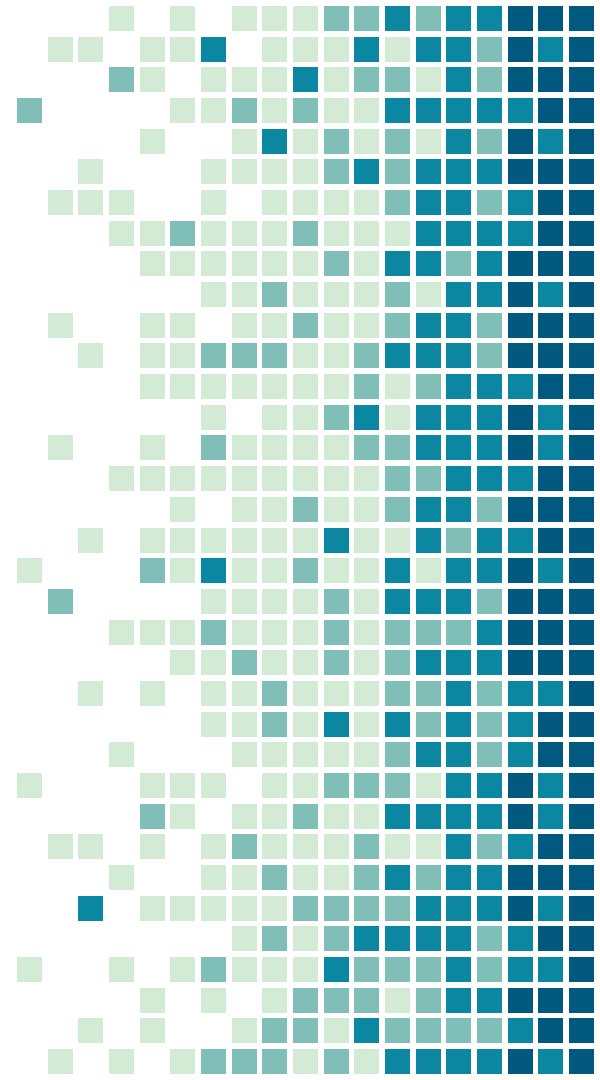
Questions?

Appendix

Block requirements: Control Subsystem

- The control subsystem must be able to calculate distances correctly based on input from the ultrasonic sensors. For measured distances below 20 cm, the accuracy of the 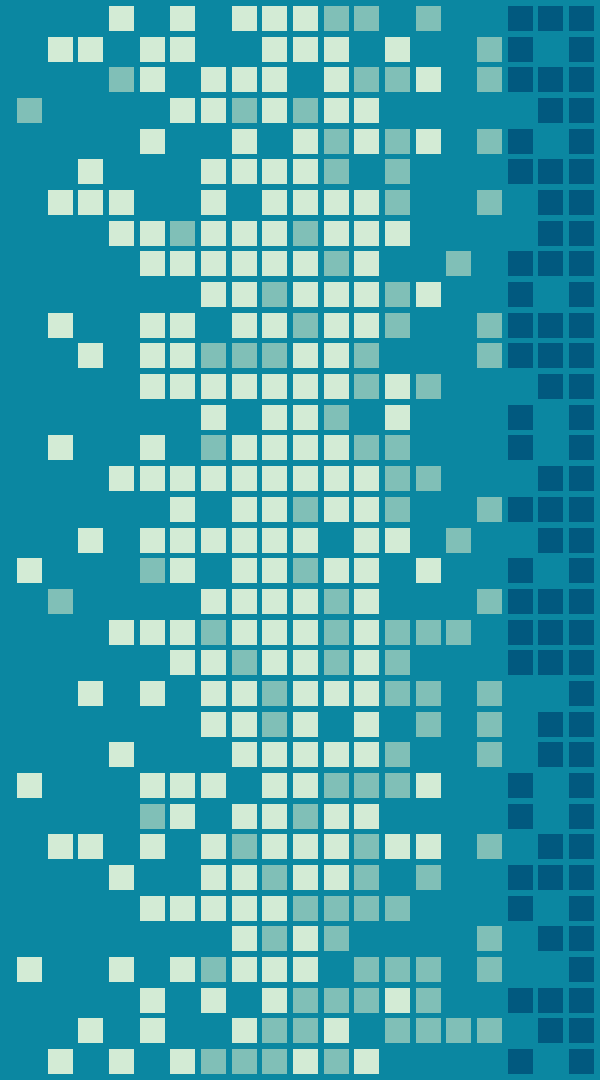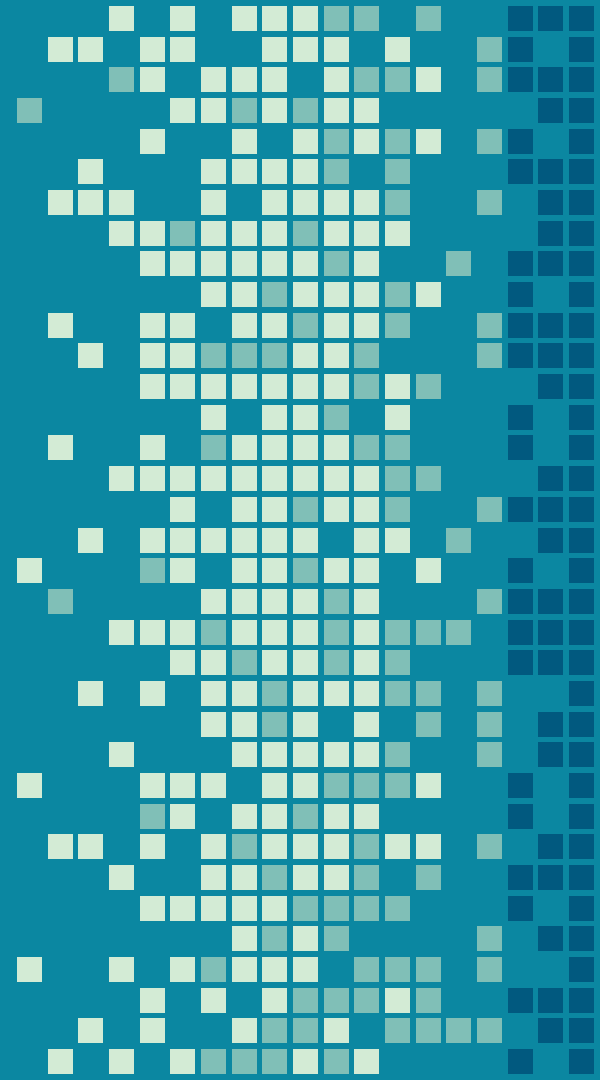calculated distances should be within 5 cm. For measured distances between 20-100 cm, the accuracy of the calculated distances should be within 10 cm.

- The control subsystem must be able to signal to the electrochromic panels to change opacity once an object is detected. I/O pins controlling the opacity should transition to a high voltage (2.7-5.5 V) in 95% of trials.

- The control system must be able to initiate image processing in the Raspberry Pi. The interrupt pin of the microcontroller feeding into the Raspberry Pi must go high (2.7-5.5 V) when an object is detected in 95% of trials.

Block requirements, Object Detection and Object Classification Subsystem

Object Detection

- For measured distances below 20 cm, the accuracy of the calculated distances should be within 5 cm in ≥95% of trials. For measured distances between 20-100 cm, the accuracy of the calculated distances should be within 10 cm in ≥95% of trials.

- The ultrasonic sensors must be mounted on the frame in such a way that they can accurately determine which electrochromic panel zones the detected objects are entering/exiting within the 3D frame area in ≥95% of trials.

Object Classification

  - The image processing can correctly identify warm blooded objects within the 58 cm x 58 cm x 92 cm frame space in ≥85% of trials.

Block requirements: Bird Interface and Power subsystems

Bird Interface

- The opacity must visibly transition between transparent and opaque in response to the microcontroller.

Power subsystem

- The opacity must visibly transition between transparent and opaque in response to the microcontroller.

- The voltage regulator must supply a DC input voltage 2.5-3.5V to the DC to AC converters feeding into the electrochromic panels at all times the system is operating.