

FPL Image Recognition for Pad Mounted Equipment

Team 304



Team Introductions



**Kent
Logue**

**Mechanical Design
Engineer**



**Jordan
Wilkerson**

**Mechatronic Design
Engineer**



**Sam
Hammermaster**

**Software Integration
Engineer**



**Erin
Murphy**

Project Manager

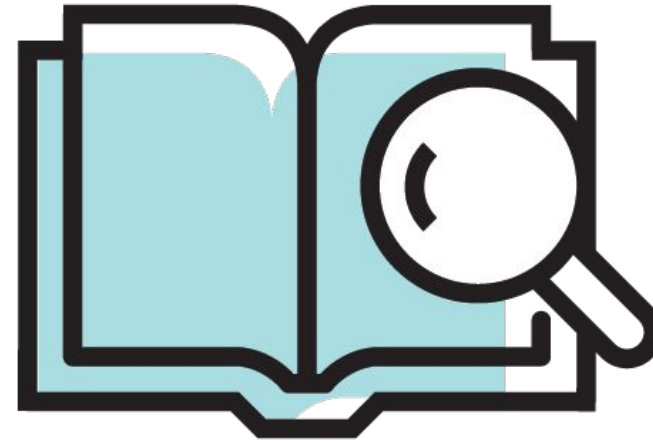


**Gage
Irwin**

**Computer Vision
Engineer**

Presentation Outline

- Problem statement
- Concept generation
- Concept Selection
- Models & Diagrams
- Future Work
- Summary



Sponsor and Advisor



Project Sponsor

Troy Lewis

Florida Power & Light

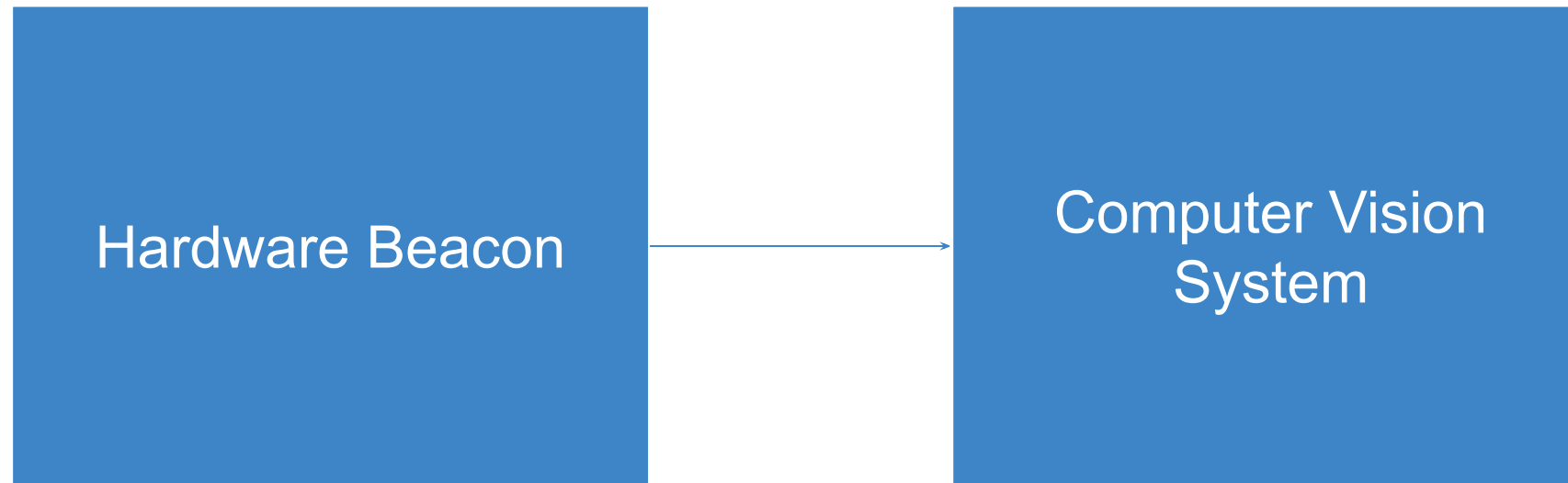


Project Advisor

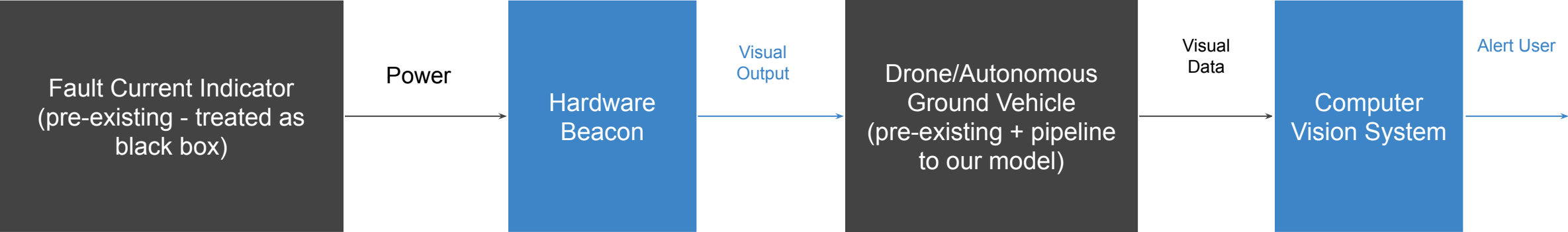
Dr. Rodney Roberts

FAMU-FSU College of Engineering

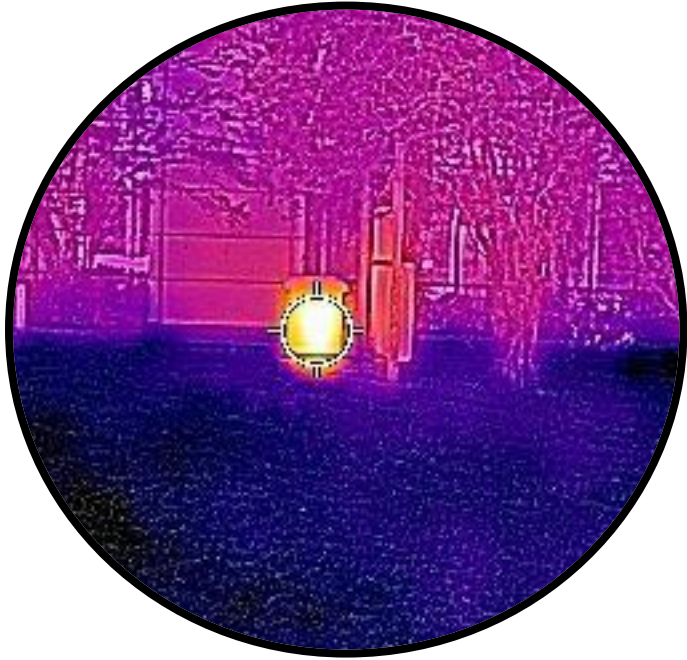
The Problem



The Problem



Key Challenges



Concept Generation



**100
Concepts**



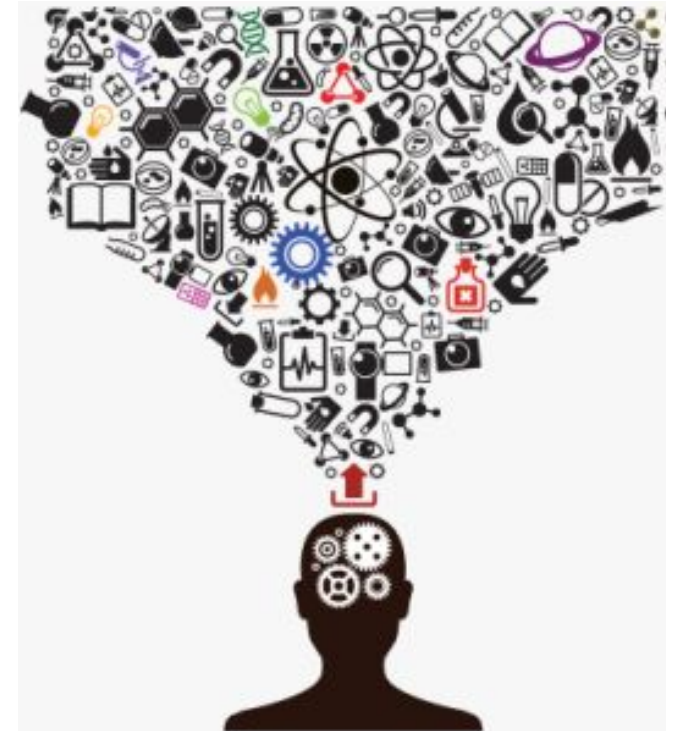
Biomimicry



**Forced
Analogy**

100 Concepts: Hardware

| Top Hardware Concepts | | | | |
|-----------------------|--------------|----------------------|-------------------|-----------------|
| Power Source | Binary Input | Attachment Method | Signal Type | Materials |
| Transformer | Power | Nuts & Bolts | Heater/Cooler | Stainless Steel |
| Battery | RF | Polyurethane Sealant | LED source | Aluminum |
| Solar | Signal Wires | Welding | Moveable Arm/Flag | Plastics |



100 Concepts: Software

| Top Software Concepts | | | |
|-----------------------|-------------------|---------------------------|-----------|
| Input Type | Computer Language | Cloud Platform | Algorithm |
| Images | MATLAB | Google AI | YOLOv4 |
| Videos | Python | Azure AI | YOLOv5 |
| Infrared | Javascript | Amazon Web Services (AWS) | |



Biomimicry

| Tree Function | Associated Function |
|--|--|
| Leaves (Change Color) | Beacon Identification (A light that changes colors) |
| Branches (Extend out of tree) | Beacon Functionality (An arm that extends out) |
| Bark (Weather protection) | Materials (Weather resistant) |
| Trunk (Connects the tree to the ground) | Beacon Attachment (A strong connection to the beacon and transformer) |



Forced Analogy

| Aircraft Carrier Function | Forced Analogy |
|--|--|
| Resistant to Ocean Environment (Rain, salty air, waves) | Resisten to Florida's Environment (Rain, salty air, hurricanes) |
| Control Station (Assesses problems with the ship) | Binary Control (Assess problems with transformer) |
| Communication System (Communicate with main land) | Beacon System (Communicate a signal to done) |
| Signal Flags (Communication between ships) | Pop up Flag (Communicate a signal to done) |



High Fidelity Design Concepts

Design Concept 1:

| Hardware | | | | | Software | | | |
|--------------|--------------|----------------------|-------------|-----------|------------|-------------------|----------------|-----------|
| Power Source | Binary Input | Attachment Method | Signal Type | Materials | Input Type | Computer Language | Cloud Platform | Algorithm |
| Transformer | Power | Polyurethane sealant | LED source | Plastic | RGB | Python | Google AI | Yolov5 |

High Fidelity Design Concepts

Design Concept 2:

| Hardware | | | | | Software | | | |
|--------------|--------------|-------------------|-------------------------|-----------------|------------|-------------------|----------------|-----------|
| Power Source | Binary Input | Attachment Method | Signal Type | Materials | Input Type | Computer Language | Cloud Platform | Algorithm |
| Transformer | Power | Rivets | External cooling device | Stainless Steel | Infrared | Python | Google AI | Yolov5 |



High Fidelity Design Concepts

Design Concept 3:

| Hardware | | | | | Software | | | |
|--------------|--------------|-------------------|-----------------|-----------------|------------|-------------------|----------------|-----------|
| Power Source | Binary Input | Attachment Method | Signal Type | Materials | Input Type | Computer Language | Cloud Platform | Algorithm |
| Transformer | Power | Rivets | Mechanical Flap | Stainless Steel | RGB | Python | Google AI | Yolov5 |

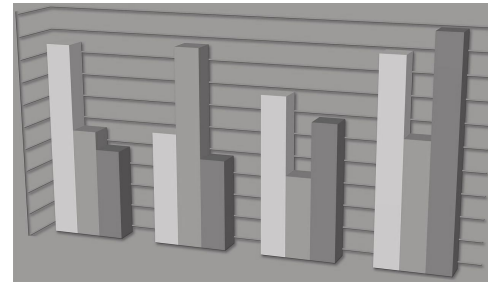
Concept Selection Approaches



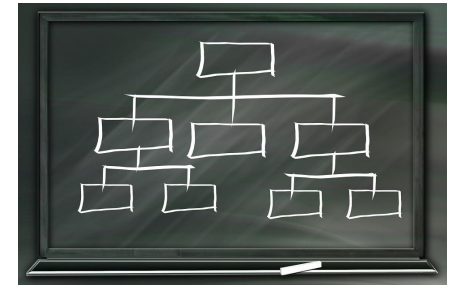
**Binary
Pairwise**



**House of
Quality**



Pugh Charts

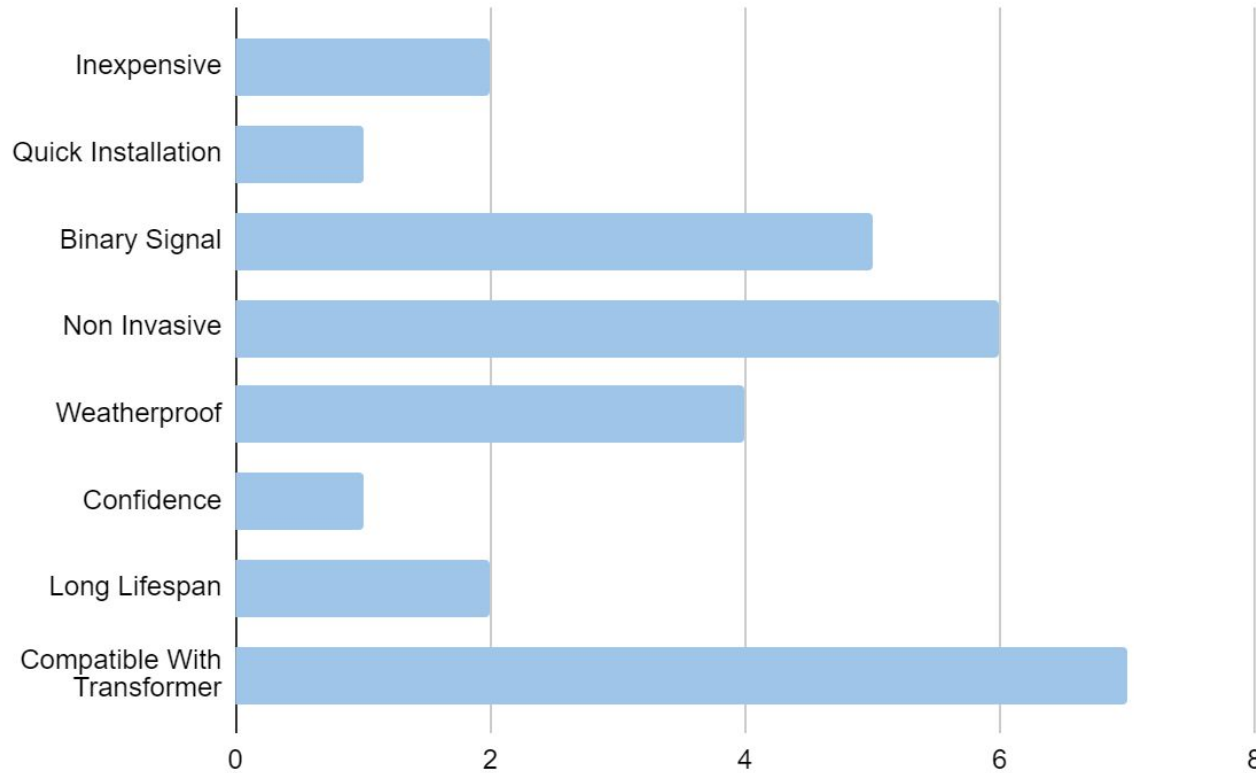


AHP

Binary Pairwise

| Inexpensive | Quick Installation | Binary Signal | Non Invasive | Weatherproof | Confidence | Long Lifespan | Compatible With Transformer | Sum |
|-------------|--------------------|---------------|--------------|--------------|------------|---------------|-----------------------------|-----|
| - | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| 0 | - | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | - | 0 | 1 | 1 | 1 | 0 | 5 |
| 1 | 1 | 1 | - | 1 | 1 | 1 | 0 | 6 |
| 1 | 1 | 0 | 0 | - | 1 | 1 | 0 | 4 |
| 0 | 0 | 0 | 0 | 0 | - | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 0 | 0 | - | 0 | 2 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | - | 7 |

Binary Pairwise



From the Binary Pairwise we were able to determine the most important customer needs

House of Quality

| House of Quality | | | | | | | | | | |
|-----------------------------|--------------------------|----------------------|-----------------|------------------------------------|---------------------|------------------|---------------|----------------------|------------------|-------------------|
| | Units | ft | years | V | 0/1 | % | frames/s | % | Mb | hrs |
| Customer Requirements | Importance Weight Factor | Visibility of Beacon | Beacon lifespan | Voltage sufficiently powers beacon | Beacon is on or off | Model confidence | Model runtime | Notification success | Storage capacity | Installation time |
| Inexpensive | 2 | | 3 | | | 9 | 9 | | 3 | 3 |
| Quick Installation | 1 | | | | | | | | | 9 |
| Binary Signal | 5 | 3 | | 9 | 9 | | | | | |
| Non Invasive | 6 | | | | | | | | | |
| Weatherproof | 4 | 3 | 1 | | | | | | | |
| Confidence | 2 | 9 | 1 | 9 | 9 | 9 | 9 | | | |
| Long Lifespan | 1 | | 9 | | | | | | | |
| Compatible With Transformer | 7 | 1 | | 3 | 3 | | | | | |
| Raw Score | 334 | 52 | 21 | 84 | 84 | 36 | 36 | 0 | 6 | 15 |
| Relative Weight % | | 15.57 | 6.29 | 25.15 | 25.15 | 10.78 | 10.78 | 0.00 | 1.80 | 4.49 |
| Rank Order | | 2 | 4 | 1 | 1 | 3 | 3 | 7 | 6 | 5 |

From the importance of the customer needs we also calculated the ranking of importance of our targets and metrics.

Pugh Charts

| Selection Criteria | Concept 2 | Concepts | | |
|------------------------------------|-----------|----------|---|---|
| | | 1 | 5 | 6 |
| Voltage sufficiently powers beacon | Datum | + | + | S |
| Beacon is on or off | | + | + | S |
| Visibility of Beacon | | - | + | + |
| Model confidence | | S | S | S |
| Model runtime | | S | S | S |
| Beacon lifespan | | - | - | S |
| Installation time | | S | + | - |
| # of pluses | | 2 | 4 | 1 |
| # of minuses | | 2 | 1 | 1 |
| # of same | | 3 | 2 | 5 |

| Legend | |
|--------|--|
| 1 | Transformer-powered plastic LED attached using a polyurethane sealant. Corresponding image recognition system that takes in RGB video uses trained YOLOv5 to make detections |
| 2 | Stainless steel external device that cools with transformer power and is attached with rivets. Computer vision system analyzes infrared videos using YOLOv5 |
| 5 | Mount an external LED on the top of a stainless steel lever attached using rivets and powered by the transformer and infrared video input with YOLOv5 algorithm |
| 6 | External cooled rod made of stainless steel (or same metal as transformer) and infrared video input with YOLOv5 algorithm |

Analytical Hierarchy Process (AHP)

| Normalized | | | | | | | | | | |
|------------------------------------|----------------------|-----------------|------------------------------------|---------------------|------------------|---------------|----------------------|------------------|-------------------|-----------------------|
| Pairwise Matrix (Normalized) | Visibility of Beacon | Beacon lifespan | Voltage sufficiently powers beacon | Beacon is on or off | Model confidence | Model runtime | Notification success | Storage capacity | Installation time | Criteria Weight (W) |
| Visibility of Beacon | 0.08 | 0.23 | 0.03 | 0.21 | 0.31 | 0.16 | 0.37 | 0.16 | 0.19 | 0.19 |
| Beacon lifespan | 0.02 | 0.05 | 0.06 | 0.04 | 0.13 | 0.07 | 0.01 | 0.16 | 0.14 | 0.08 |
| Voltage sufficiently powers beacon | 0.75 | 0.23 | 0.28 | 0.21 | 0.13 | 0.07 | 0.37 | 0.16 | 0.10 | 0.26 |
| Beacon is on or off | 0.08 | 0.23 | 0.28 | 0.21 | 0.31 | 0.16 | 0.07 | 0.21 | 0.14 | 0.19 |
| Model confidence | 0.01 | 0.02 | 0.09 | 0.03 | 0.04 | 0.16 | 0.07 | 0.12 | 0.14 | 0.08 |
| Model runtime | 0.01 | 0.02 | 0.09 | 0.03 | 0.01 | 0.02 | 0.01 | 0.00 | 0.01 | 0.02 |
| Notification success | 0.02 | 0.23 | 0.06 | 0.21 | 0.04 | 0.16 | 0.07 | 0.16 | 0.14 | 0.12 |
| Storage compacity | 0.01 | 0.01 | 0.04 | 0.02 | 0.01 | 0.12 | 0.01 | 0.02 | 0.10 | 0.04 |
| Installation time | 0.01 | 0.01 | 0.06 | 0.03 | 0.01 | 0.07 | 0.01 | 0.00 | 0.02 | 0.02 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1 |

AHP

For each selection criteria we made a pairwise matrix to compare the final 4 concepts.

The values calculated from each were then input to the final rating matrix.

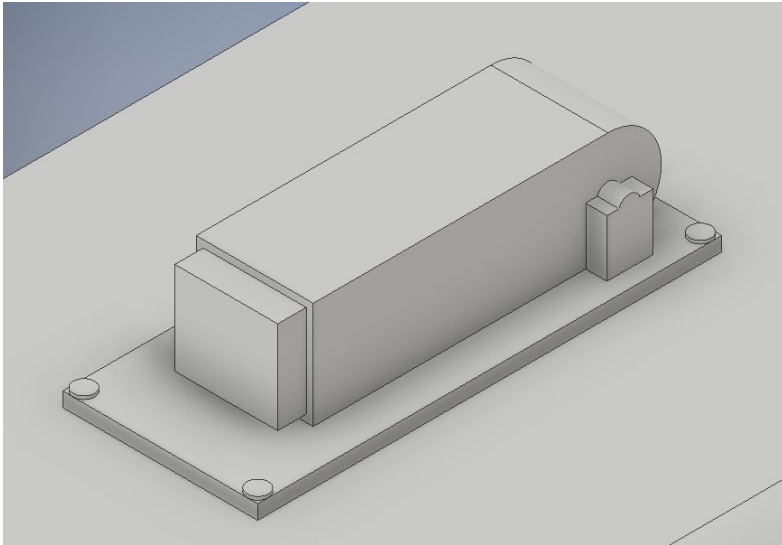
| Final Rating Matrix | | | | |
|------------------------------------|------|------|------|------|
| Selection Criteria | 1 | 2 | 5 | 6 |
| Visibility of Beacon | 0.31 | 0.08 | 0.52 | 0.08 |
| Beacon lifespan | 0.1 | 0.37 | 0.17 | 0.37 |
| Voltage sufficiently powers beacon | 0.42 | 0.08 | 0.42 | 0.08 |
| Beacon is on or off | 0.22 | 0.09 | 0.59 | 0.09 |
| Notification success | 0.22 | 0.09 | 0.59 | 0.09 |
| Installation time | 0.12 | 0.41 | 0.41 | 0.07 |

Selected Concept

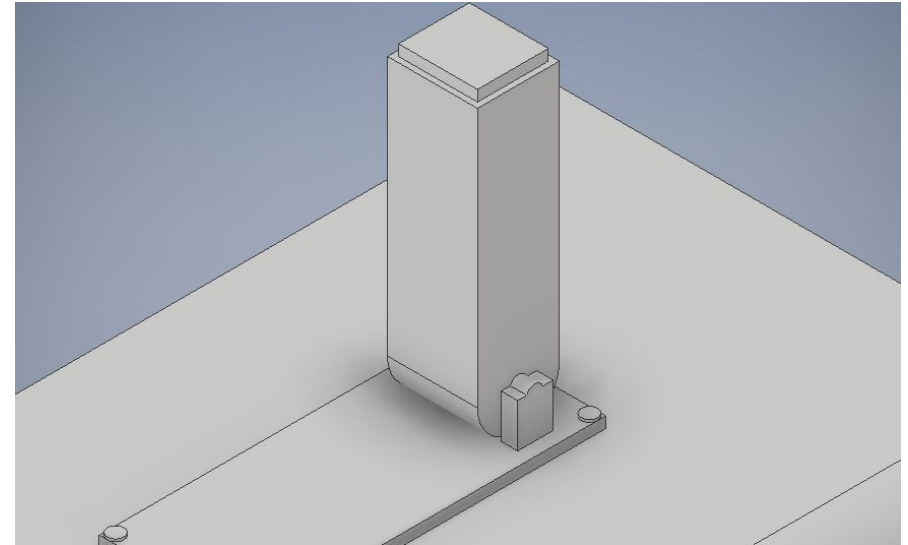
| Final Rating | |
|--------------|---------------|
| 1 | 0.2467 |
| 2 | 0.1017 |
| 5 | 0.4127 |
| 6 | 0.0949 |

| Legend | |
|--------|--|
| 1 | Transformer-powered plastic LED attached using a polyurethane sealant. Corresponding image recognition system that takes in RGB video uses trained YOLOv5 to make detections |
| 2 | Stainless steel external device that cools with transformer power and is attached with rivets. Computer vision system analyzes infrared videos using YOLOv5 |
| 5 | Mount an external LED on the top of a stainless steel lever attached using rivets and powered by the transformer and infrared video input with YOLOv5 algorithm |
| 6 | External cooled rod made of stainless steel (or same metal as transformer) and infrared video input with YOLOv5 algorithm |

Selected Concept - Rough Sketch



Lever - down



Lever - up

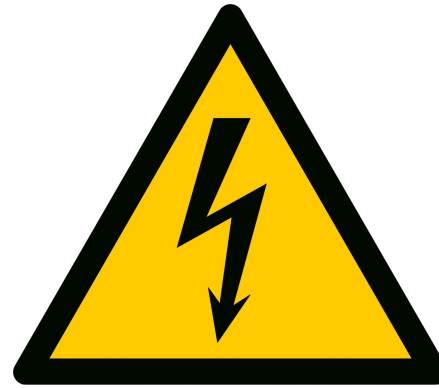
Selected Concept Pros



Emits a light



**Changes shape
of transformer**



**Uses minimal
power**

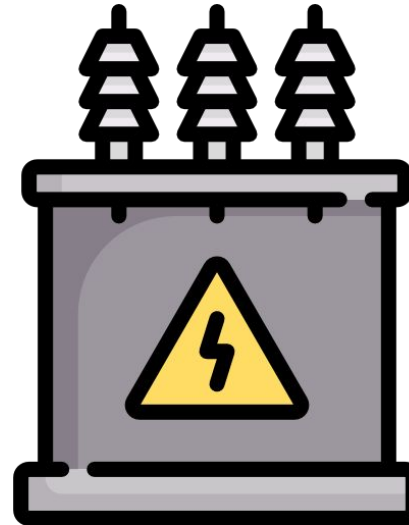


**Alerts residents
of power outage**

Selected Concept Cons



**Potential
mechanical failure**

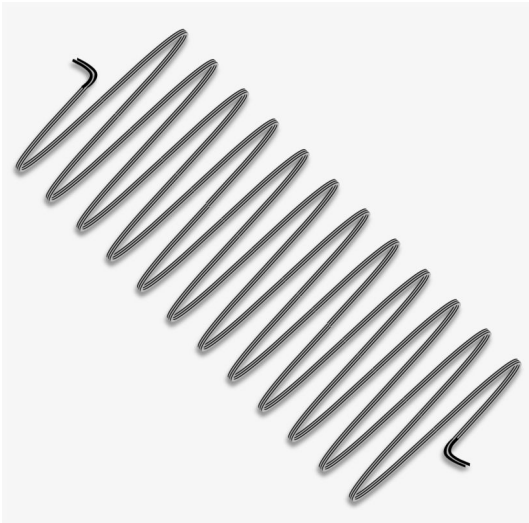


**Can be accessed
externally**



**Must drill through
transformer**

More Design Choices



Spring mechanism
for release

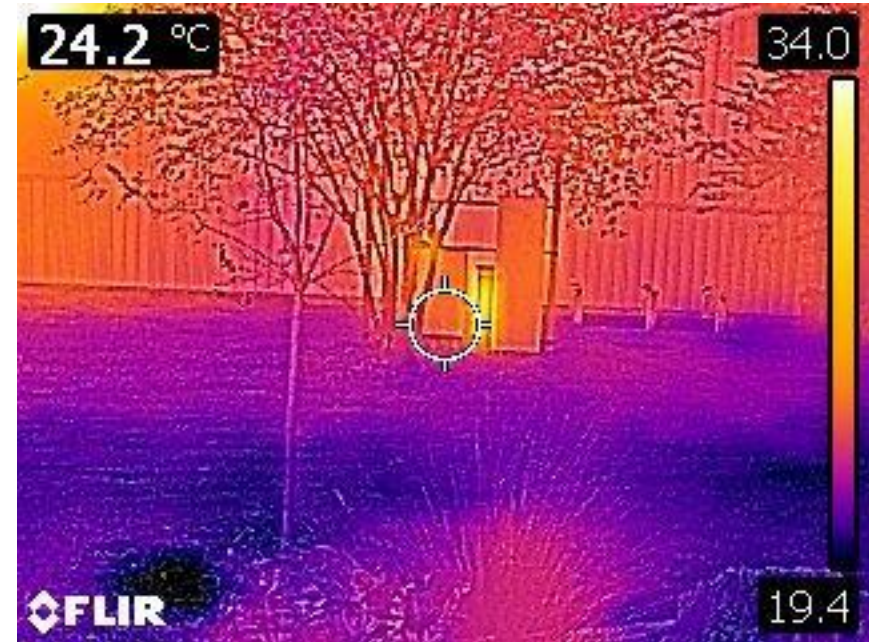


Easy reset



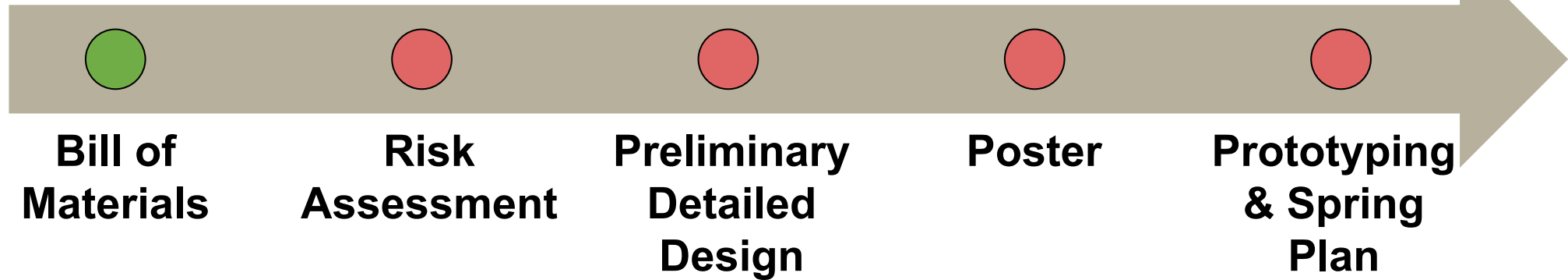
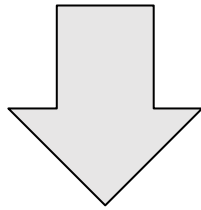
Locking mechanism
to prevent reset

Distance Factor



Future Work

Currently Here



Summary

- Thank you FPL and NextEra Energy
- Problem Overview
- Concept Generation Methods + Results
- Concept Selection Approach
- Selected Concept
- Upcoming work



Project Scope



Objective



Assumptions



Key Goals



Markets

Objective



Develop a hardware beacon that indicates faulted FPL pad mounted equipment, and a method of identifying the beacon with machine vision.

Hardware Assumptions



Binary

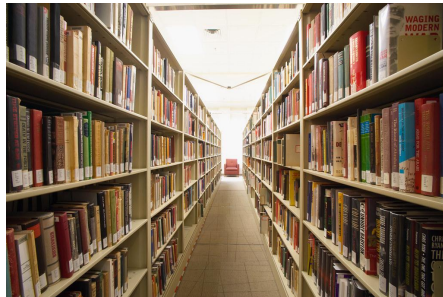


Varying sizes

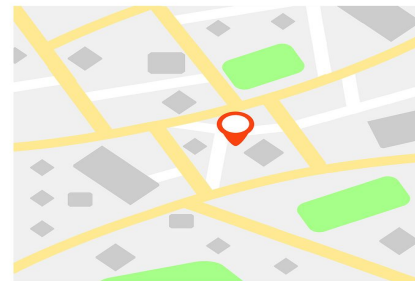


Obstructions

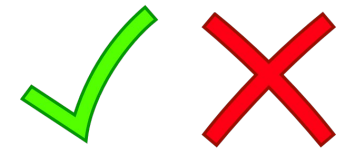
Software Assumptions



**Photo
Library**

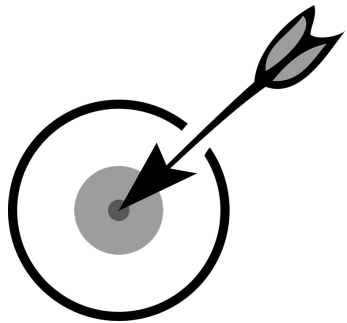


**Given
Location**



Identification

Key Goals



**Accurate up
to 50 feet**



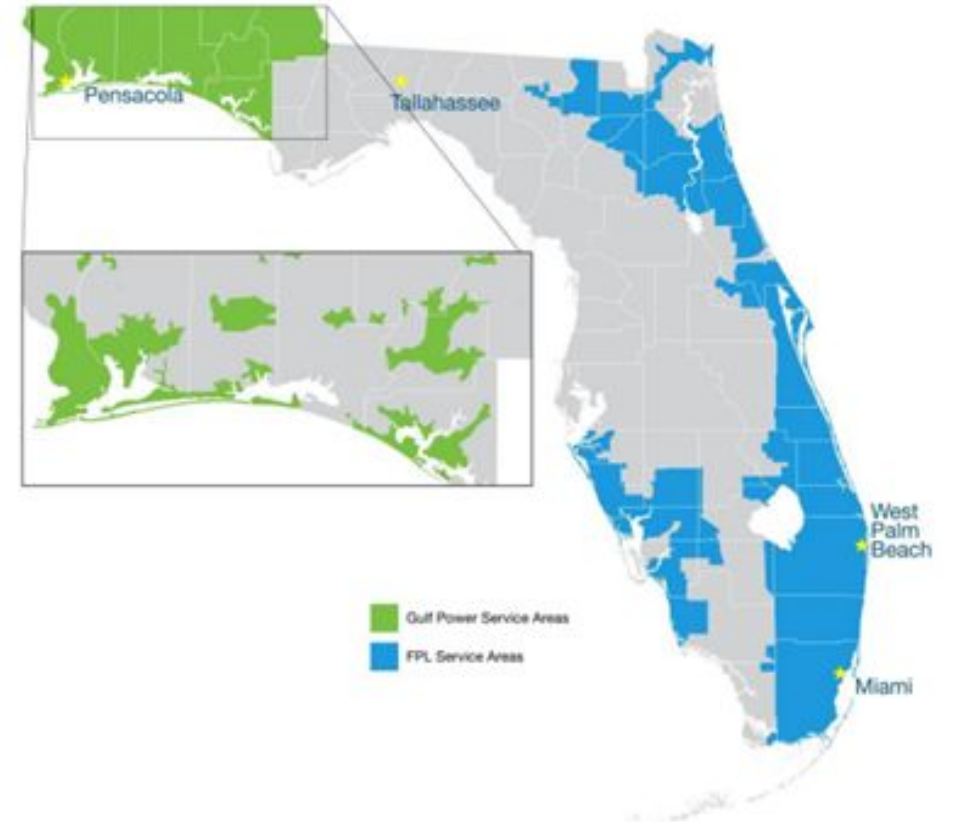
**Securely
Mount**



**Develop
System to
Identify**

Markets

Florida Power & Light services
approximately 5.6 million customers



Stakeholders



Florida Power & Light (FPL)

Smart Grid & Innovation



NextEra Energy

Stakeholders



Senior Design Coordinator

Dr. Oscar Chuy

FAMU-FSU College of Engineering

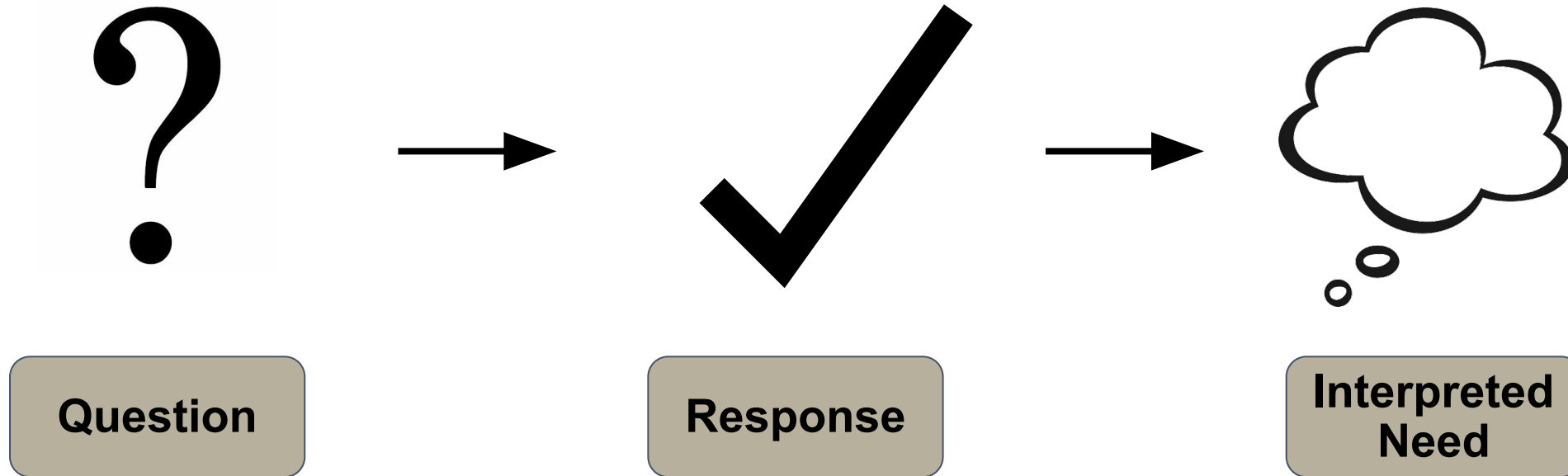


Project Advisor

Dr. Rodney Roberts

FAMU-FSU College of Engineering

Customer Needs



Customer Needs: Hardware



Inexpensive



Quick Instillation



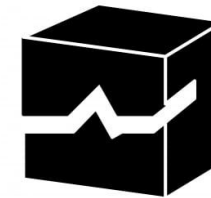
Receives Power



Weather
Resistant

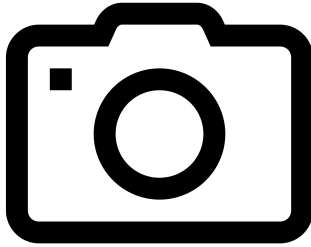


Water Tight

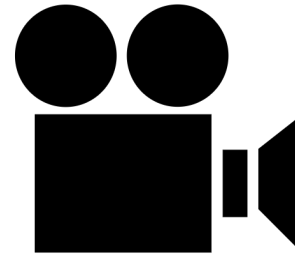


Cannot Interfere

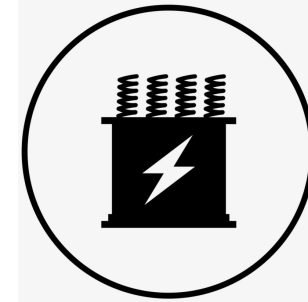
Customer Needs: Software



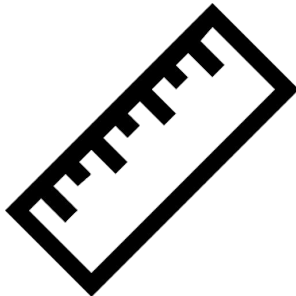
Works with pictures



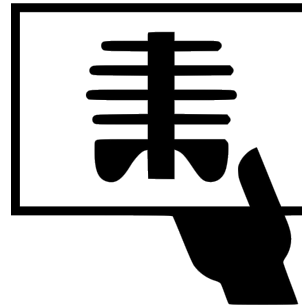
Works with video



Recognizes transformer and beacon



Can detect within 50 feet

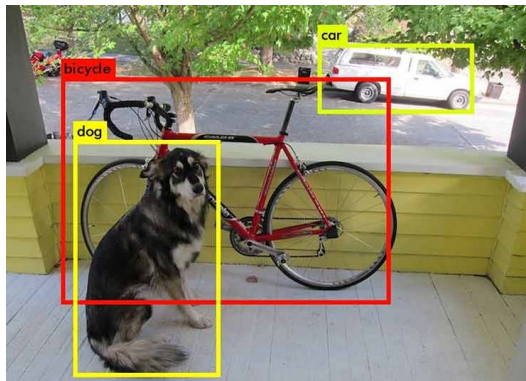


Can see through obstructions



Compatible with AWS

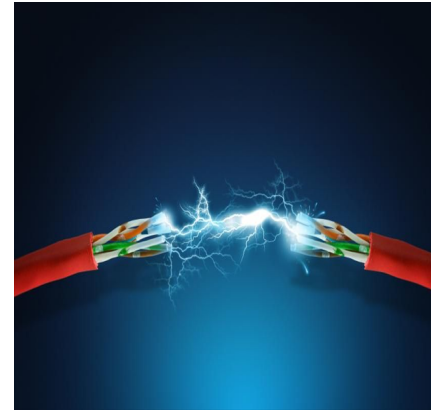
Functional Decomposition



Detection



Communication

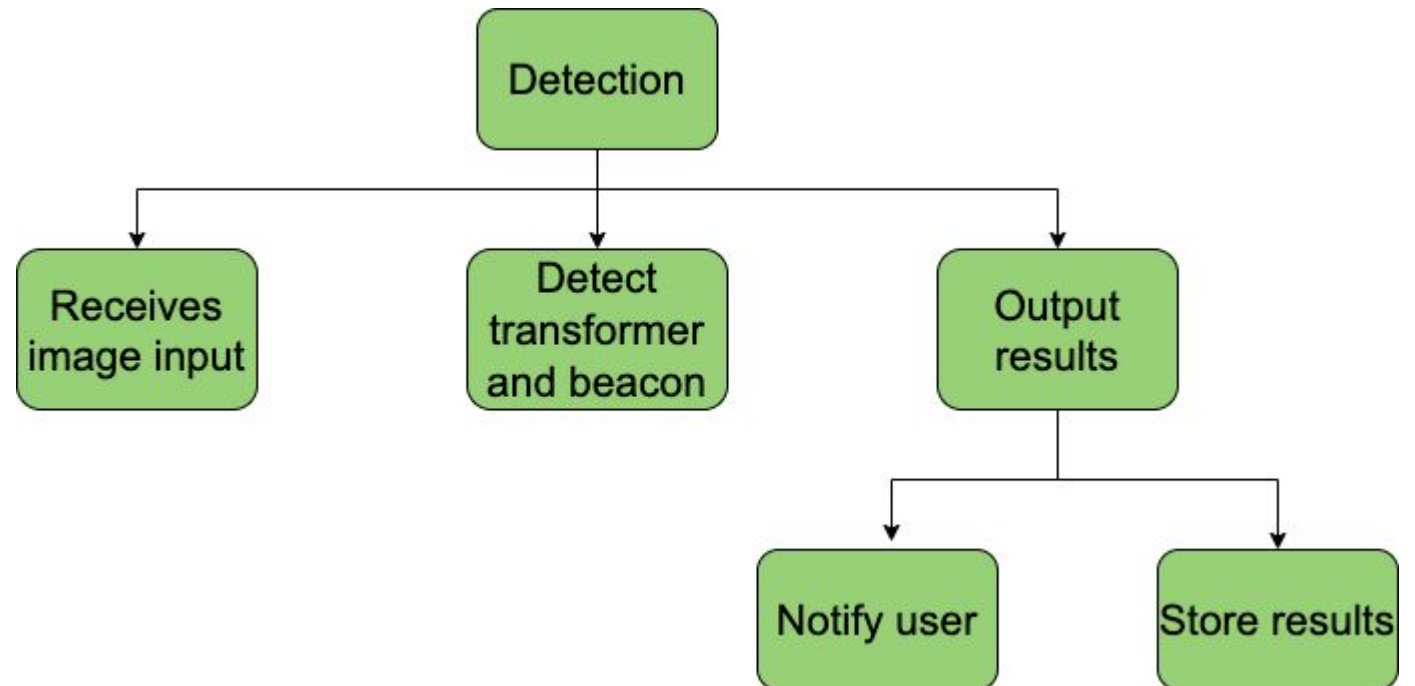
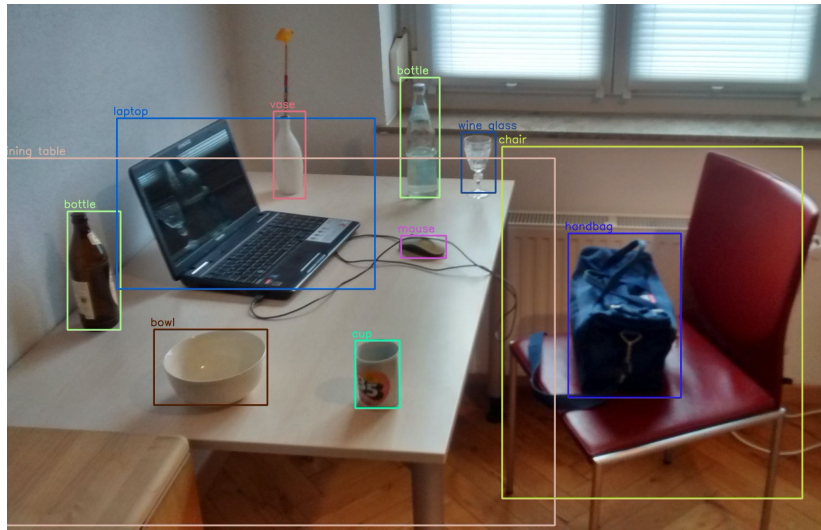


Power

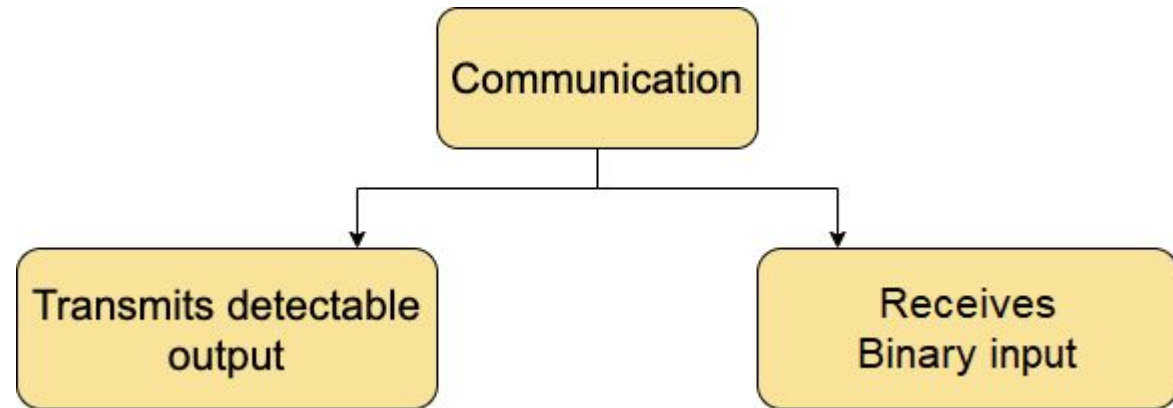


Attachment

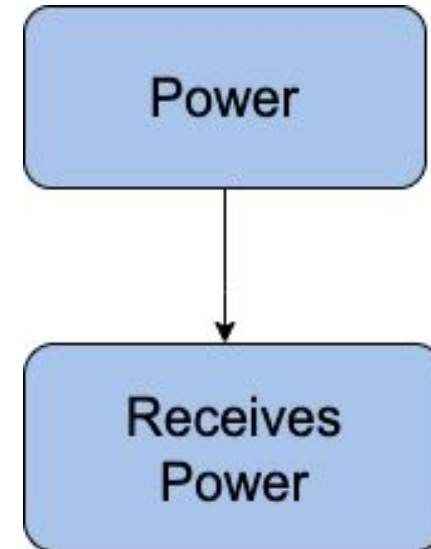
Detection



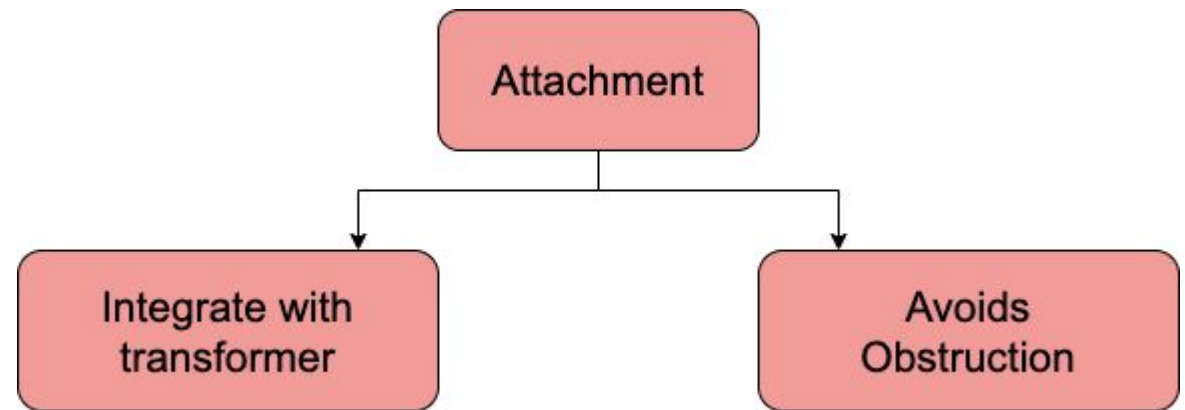
Communication



Power



Attachment



Questions?



Reference

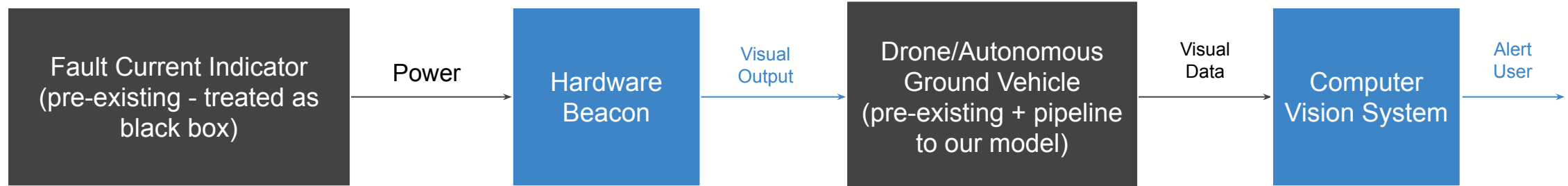
Hurst, R. W. “Padmount Transformers Explained.” *The Electricity Forum*, Electricity Forum, <https://www.electricityforum.com/td/utility-transformers/padmound-transformer>.

“FPL | Smart Technology | Drones.” FPL, *Florida Power & Light Company*, <https://www.fpl.com/reliability/drones.html>.

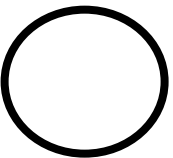
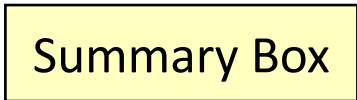
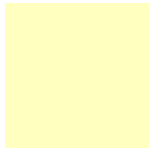


FAMU-FSU
Engineering

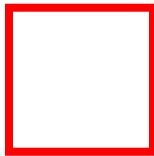
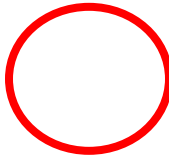
Design Pipeline (Potential Questions)



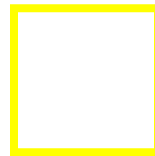
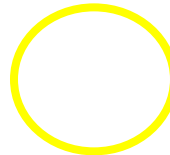
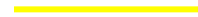
Standard Shapes



Text box 1



Outlined Text Box



Approved Logos



FAMU-FSU
College of
Engineering



FAMU-FSU
Engineering



FAMU-FSU
Engineering




FAMU-FSU
College of Engineering



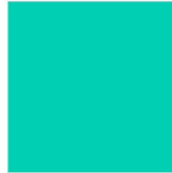
FAMU-FSU
Engineering

Color Palette



PANTONE®
2299 C

2299 C
Color values:
RGB 164 210 51
HEX/HTML #A4D233
CMYK 41 0 84 0



PANTONE®
2239 C

2239 C
Color values:
RGB 0 207 180
HEX/HTML #00CFB4
CMYK 59 0 39 0



PANTONE®
2199 C

2199 C
Color values:
RGB 0 187 220
HEX/HTML #00BBDC
CMYK 77 0 16 0



PANTONE®
1788 C

1788 C
Color values:
RGB 238 39 55
HEX/HTML #EE2737
CMYK 0 88 82 0




PANTONE®
647 C

647 C
Color values:
RGB 35 97 146
HEX/HTML #236192
CMYK 96 54 5 27




PANTONE®
7535 C

7535 C
Color values:
RGB 183 176 156
HEX/HTML #B7B09C
CMYK 10 11 23 19




COE Dk Gray

75% Black
Color values:
RGB 64 64 64
HEX/HTML #404040
CYMK: 0 0 0 75



COE Md Gray

50% Black
Color values:
RGB 128 128 128
HEX/HTML #808080
CYMK: 0 0 0 50



COE Lt Gray

25% Black
Color values:
RGB 191 191 191
HEX/HTML #bfbfbf
CYMK: 0 0 0 25



APA Tables

| Category 1 | Category 2 | Category 3 | Category 4 | Category 5 |
|------------|------------|------------|------------|------------|
| Item 1 | | | | |
| Item 2 | | | | |
| Item 3 | | | | |
| Item 4 | | | | |

| | Category 2 | | | Category 3 | |
|------------|---------------|---------------|--|---------------|---------------|
| Category 1 | subcategory 1 | subcategory 2 | | subcategory 1 | subcategory 2 |
| Item 1 | | | | | |
| Item 2 | | | | | |
| Item 3 | | | | | |
| Item 4 | | | | | |

