Florida Light and Power

Image Recognition for Pad Mounted Equipment

Targets

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**Derivation of Metrics** Metrics were derived from the customer's needs. Each metric is relative to the corresponding need. Due to the nature of the project, some metrics are by nature binary: yes or no, on or off. For example, receiving power to either power or not power the beacon is not within the scope of the project. There are already systems in place that deliver power, but the design must be able to use it. There are also some conditional metrics that do not have a specific target value but more of a range. For example, installation time must be less than an hour. Any time under an hour is success, whereas over would be failure. There are some functions that have been split into different categories in order to keep track of two different metrics. For instance, receiving power and transmitting output are similar in nature, but are measured in voltage and binary values, respectively. Another special note to consider is that the measurements for the mock transformer will mimic the dimensions of the actual FPL transformer. That information is confidential and cannot be displayed on this form. The first critical target is that the beacon is being powered. Typically, a transformer will output 1.8V-3.3V to power a LED. This is the value that the beacon will use. To avoid obstruction, the beacon cannot be obstructed and must be recognizable by images within 50 feet. Receiving binary input is binary in nature, but still works off of the logic of either receiving 1.8V-3.3V, or not receiving voltage at all. Transmitting detectable output is strictly binary, which means that the software will represent the output as a yes or a no. Finally, detecting the transformer with the image recognition solution must be done with an 80% level of confidence. There are many factors that could negatively impact visibility of the beacon, so having a 100% guarantee is out of the scope of the project.

**Methods of Validation**

 The beacon’s visibility can be checked using a beacon prototype, coordinates, and a camera. Once sample images are taken from 50 feet away the team can simply look at the images to determine whether the beacon is visible. The beacon’s lifespan (and its impact on the transformer’s durability) can’t be completely determined within the project’s time span. However, the beacon can be left in different environmental conditions and stress-tested to confirm its durability. A multimeter can confirm the power supply’s voltage, but ultimately the best test will be whether the beacon works when connected to power. Camera coordinates can be compared with the object coordinates to measure image distance. Furthermore, once the images are run through the model most image recognition systems automatically output a confidence for each detection. Multiple FPL users can validate that the user notifications clearly indicate the output and the stored data can be manually checked for quality. A tape measure will be used to confirm the transformer dimensions and a FPL technician can time the installation.

**Discussion of Measurement**

Tools and individuals needed to validate measurements include: a high-definition camera, an infrared camera, a prototype transformer, water/hammer/outdoor environment, a multimeter, a model with confidence output, an FPL Power team, a tape measure, a stopwatch, and an FPL technician. To ensure the beacon receives power, a voltmeter will be used to measure the amount voltage transferred to the beacon. Before and after pictures will be analyzed to determine if any damage and any change in placement of the beacon on the transformer has occurred, to verify the beacon avoids obstruction. Visual observation of the beacon being on or off will be used to confirm that it receives binary input. A drone positioned at different elevations, will be used to verify if the beacon transmits a detectable output and detects the transformer and beacon.

**Critical Metrics**

The most critical metric is that the power received has a voltage sufficient to power the beacon. Since the beacon will receive power as the binary input indicating an error, there is no way for the design to know or indicate that an error has occurred without a sufficient power source. The second most critical metric is that the beacon avoids obstruction and is visible from up to 50 feet away. This is the farthest distance that drones will capture images from, and image recognition can’t be performed if the beacon isn’t visible. The third most critical element is receiving a binary input. This is measured in the same way as power since the power acts as the binary signal to power the beacon if an error has occurred. However, it is important to distinguish the two because the beacon should both receive the correct amount of power and then use it as input to indicate an error. This also connects to the fourth most critical metric: correctly turning the beacon on (or leaving off) to indicate an error. The beacon must turn on when an error occurs and should remain off until that event. Finally, the fifth most critical metric focuses on the image recognition model. The model needs to accurately detect the beacon to accomplish the project’s goal. A confidence rate of 80% or above will lead to accurate detections in a majority of cases.

**Summary and Catalog**

A summary of the targets and metrics for all minor functions are shown in the Catalog of Targets. The targets described in the catalog table below are required for completing a successful project and were chosen based on FPL’s requirements. Modification of transformers is limited, so some of the targets pertaining to the beacon system, can not be changed easily. As the project progresses it is possible that these targets may change based on simulations and real-world testing.

| **Catalog of Targets** |
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| **#** | **Function/Need** | **Metric** | **Imp.** | **Units** | **Ideal Value** |
| 1 | Avoids Obstruction | Beacon visibility | 2 | ft | 50 ft |
| 2 | Integrate with Transformer | Beacon and transformer lifespan | 6 | years | 30-50 years |
| 3 | Receiving Power | Voltage sufficiently powers beacon | 1 | V |  1.8V-3.3V |
| 4 | Receiving Binary Input | Voltage sufficiently powers beacon (Power acts as binary input) | 3 | V | 1.8V-3.3V |
| 5 | Transmit Detectable Output | Beacon is on or off | 4 | 0/1 | 1 |
| 6 | Receives image input | Image in range of beacon | 7 | ft | 50 ft |
| 7 | Detect Transformer and Beacon | Model confidence | 5 | % | 80% |
| 8 | Output Results | Model runtime | 11 | frames/s | 45 frames/s |
| 9 | Notify User | Human identification success | 9 | % | 100% |
| 10 | Store Results | Result and corresponding image on server | 10 | Mb | <100 MbB |
| 11 | Training images of transformer taken  | Number of images taken per function | 8 | # | 2,000 |
| 12 | Mock Transformer | Accurate Dimensions | 14 | in | Confidential |
| 13 | Inexpensive yet durable material | Beacon Cost | 12 | $ | < $100 |
| 14 | Straight forward beacon instillation | Instillation time | 13 | hour | < 1 hour |