Fire Detection System (FDS)

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Introduction

According to CalFire, 2020 was California's record-setting year with over 10,000 fires and over 4 million acres burned. This was the driving factor into developing a fire detection system, specifically for homeowners living in remote areas or with large open land. The goal was to create a consumer accessible product that could be implemented on these homeowners' property.

Overview

The overall goal is to provide a low scale solution to fire detection/prevention. The objective is to use computer vision deployed on a single board computer to detect fires around a wide-open property in conjunction with wireless soil moisture sensors using inexpensive microcontrollers. A singular camera will be mounted on preprogrammed servos to capture all angles.

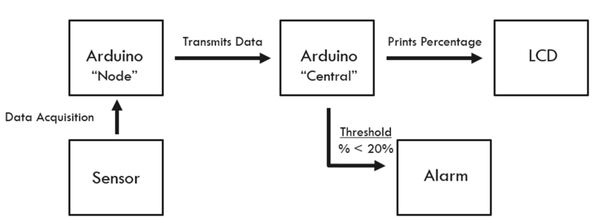
Wireless Sensor Network

Central Node

- Powered by plug-in in home
- Displays moisture levels from surrounding nodes onto LCD screen.
- Below set threshold level, triggers alarm
- Button to silence alarm

Sensor Node

- Range 135m
- 5000 mAh Battery ~ 11 Days
- Transmits every 6hrs



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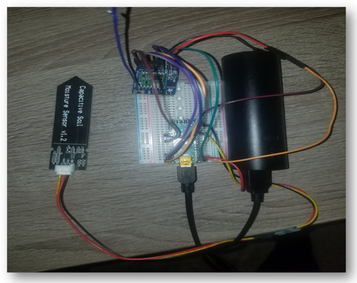
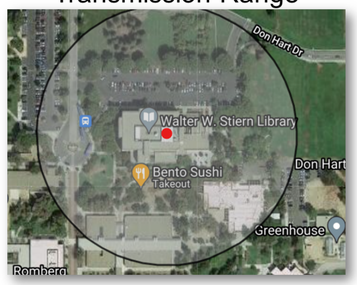
Central Node

Sensor Node



Transmission Range



Fire Detection

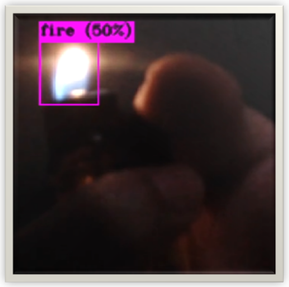
Object Detection

A Raspberry Pi is used for a live camera feed and object detection. The camera in use is a Raspicam with the absence of an IR filter to help see fires. The proprietary libraries from Raspicam can be brought into a function using OpenCV (Open Source Computer Vision Library), which can be used in other computer language interfaces. A neural network is required to be trained to recognize fires and eliminate false positives. Over 500 images of fires and pictures without fire are annotated for training. The annotation process was time consuming, requiring each image to be annotated by hand (see below image).

Neural Network

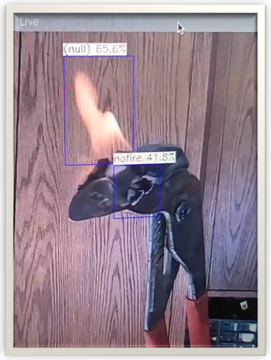
Over the initial course of implementing a neural network from scratch, it was decided it would be much better for the detector to use a newly released iteration of You Only Look Once (YOLO), a convolutional neural network framework of a single shot detector that is said to have the best accuracy per throughput (measured in frames per second). Most of the work in this area was allocated towards creating a dataset that used in neural network training. Fires are difficult to recognize at a distance since it can be confused with similar colored objects and lighting. Another caveat is that the simplified model will be reduced in accuracy when ported onto the resulting program on the Raspberry Pi, which cannot run the YOLOv4 Tiny neural network as is. To mitigate this and improve performance, another neural network inference framework, NCNN, was used in conjunction to simplify the original model to its format due to its focused design for use in mobile CPUs.

Results



Fire Detection in YOLO from Webcam (desktop implementation)

Fire Detection with YOLO -> NCNN with Raspicam



Raspicam Mounted with implemented fire detection and camera servo

Conclusion

In this work we proposed a fire detection system, that takes advantage of the compactness of a single board computer and object detection software to assess the risk of fires in real time. Along with soil moisture tracking as another preventative measure. Our results show that it is feasible to create a small-scale fire detection system capable of detecting fires and giving early warning to the owner.