SMAC-FIRE

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Goal

We demonstrate the ability to modify an existing open-source drone and its communication system to be optimal for wildfire mapping. We use drones as relay stations to forward messages to each other to increase their area of coverage, while reducing costs by using less expensive drones and a single ground station [1].

Introduction

California is a state prone to fires. Every year, there are thousands of fires which burn hundreds of thousands acres of land.

Firefighters work endlessly to extinguish these fires and are constantly having to put their lives on the line because of it. Lines of sight can be greatly obscured due to the smoke around the area, making it difficult to pinpoint the source of the fire and where to put forth most of the effort [2].

SMAC-FIRE (Closed-Loop Sensing, Modeling and Communications for WildFIRE) is an NSF-funded research project which attempts to design a network of airborne drones and wireless sensors that can help map wildfires and predict their progression, and thus support firefighters on the ground [3].

Figure 1. Aurelia X6 Drone with Raspberry Pi, Directly Connected to Ground Station Laptop Running Mission Planner

Drone Communication

We have been using an open-source drone to be able to modify its capabilities, as well as its open-source communication system.

For fast and reliable interactions between drones, we are using Raspberry Pi's that communicate with each other via Wi-Fi dongles [4].

We use the MAVLink protocol to communicate with the ArduPilot control interface of the drone. This has been verified by using a shipped drone communication software (Mission Planner) with our ground station laptop to control the drone.

We thus connect Raspberry Pi's to the drones to relay messages between them using MAVLink, and attempt to increase the drones' communication ranges and areas of coverage by using stronger antennas, thus reducing the need for too many drones to cover greater areas when monitoring wildfires.

Figure 2.a. Relay Station

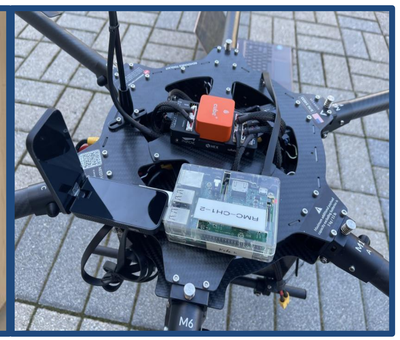

Figure 2.b. Raspberry Pi + Antenna Relay Station on Drone

Results

- ✓ We have verified the drones communicating using the MAVLink protocol.
- ✓ We coded the Raspberry Pi's to communicate with each other using the Wi-Fi dongles – establishing connection, sending, and receiving messages.
- ✓ We have shown the Raspberry Pi's connecting to the drones and communicating with them, and with each other, while connected to the drone.
- ✓ We created an SVM to aid with detecting wildfires in JPEG images.

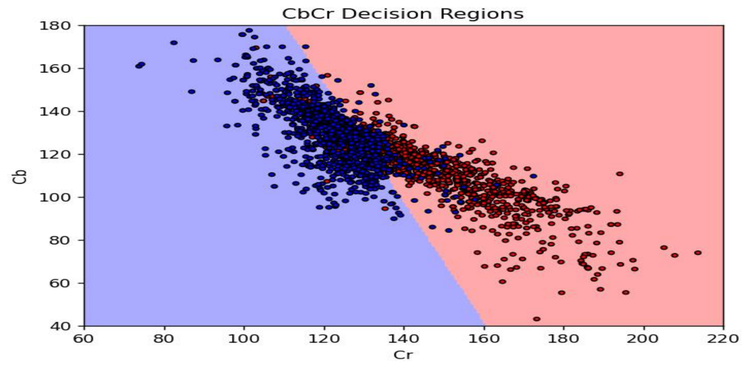

Figure 3. Decision Regions to classify images based on wildfire content

Image Processing

To minimize the image transmission bandwidth usage of the drones, as well as their power usage, it would be beneficial to transmit only the pictures that contain wildfire information.

Since most cameras record photos in the compressed JPEG domain, we found a way to use a Support Vector Machine to analyze information present in the compressed DCT domain of the JPEG files. This saves computational power by processing the images in the JPEG domain, rather than decompressing them and then processing them, or just transmitting and relaying the images when they do not contain necessary information.

We compared the chromaticity components of over 2000 images with and without wildfires present and found an SVM that helps with the binary classification problem of the images, shown in Fig. 3. The blue-difference and red-difference chroma averages of each image were plotted. Dots in the red region represent images that are more likely to contain wildfire content, while those in the blue region are less likely. The boundary line equation is: $\mathbf{C_b = -2.79C_r + 488.43}$

Acknowledgements and References

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[3] L. Swindlehurst, A. Eltawil, T. Banerjee, Z. Kassas, J. Coen, and H. Jafarkhani, "SMAC-FIRE: Closed-Loop Sensing, Modeling and Communications for WildFIRE," *Center for Pervasive Communications and Computing*, 2022. Available: https://cpcc.uci.edu/research.php.
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