EmberEye

Team: Kavin Kailash Ravie, Ishir Roongta, Gangadhar Nageswar, Jaskaran Singh Sodhi, Shashwat Chawla
Sponsors: Sebastian Scherer (AirLab), Andrew Jong
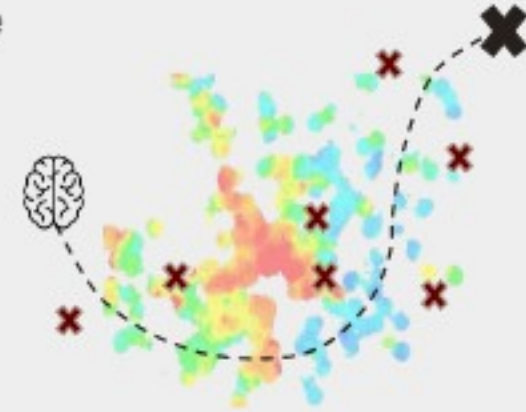**Advisors**: John Dolan, Dimitrios Apostolopoulos

Problem Statement

An aerial platform for subcanopy wildfire monitoring, that can assist firefighters by giving them real-time information about the spread of fire and help them plan safe entry/exit routes. The system is capable of:

- Operating in GPS-denied environments
- Relay map information back in real time with live camera feed
- Autonomously navigate the area while avoiding obstacles
- Rely on passive sensor data

Use Case
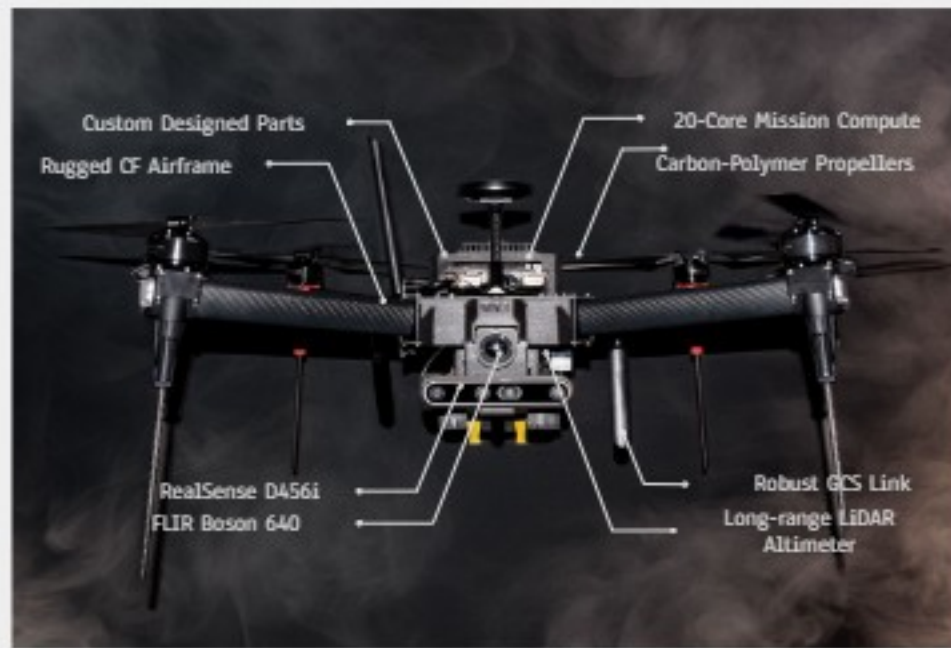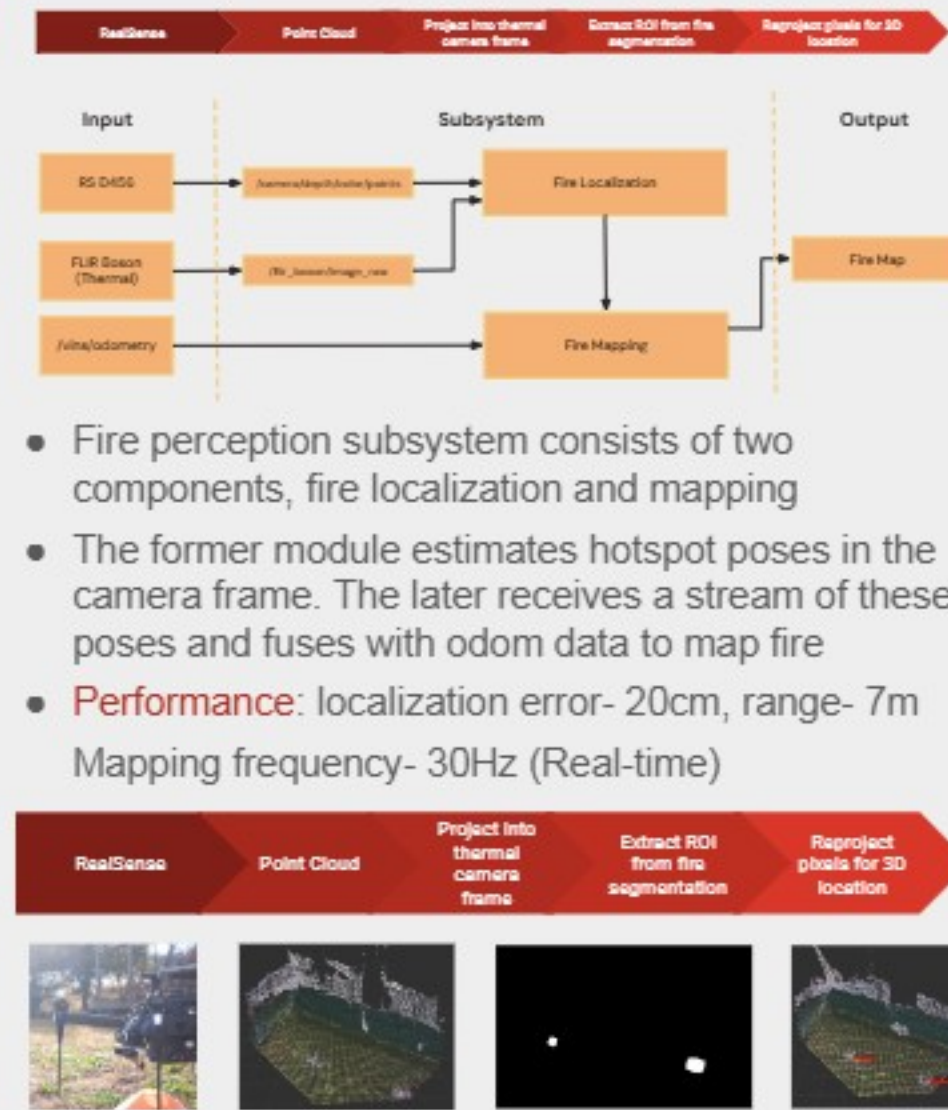

When   What   Why

Hardware

Phoenix Pro sUAS

Custom Designed Parts
Rugged CF Airframe
20-Core Mission Compute
Carbon-Polymer Propellers
RealSense D456i
FLIR Boson 640
Robust GCS Link
Long-range LiDAR Altimeter

- Fully custom-developed R&D sUAS Platform
- Powered by PX4 Autopilot
- 20-core x86 Onboard Compute
- FLIR Boson 640 and Intel RealSense D456
- Long-range Digital Datalink with Ethernet
- 16+ Minutes of Safe, Reliable and Robust Flight
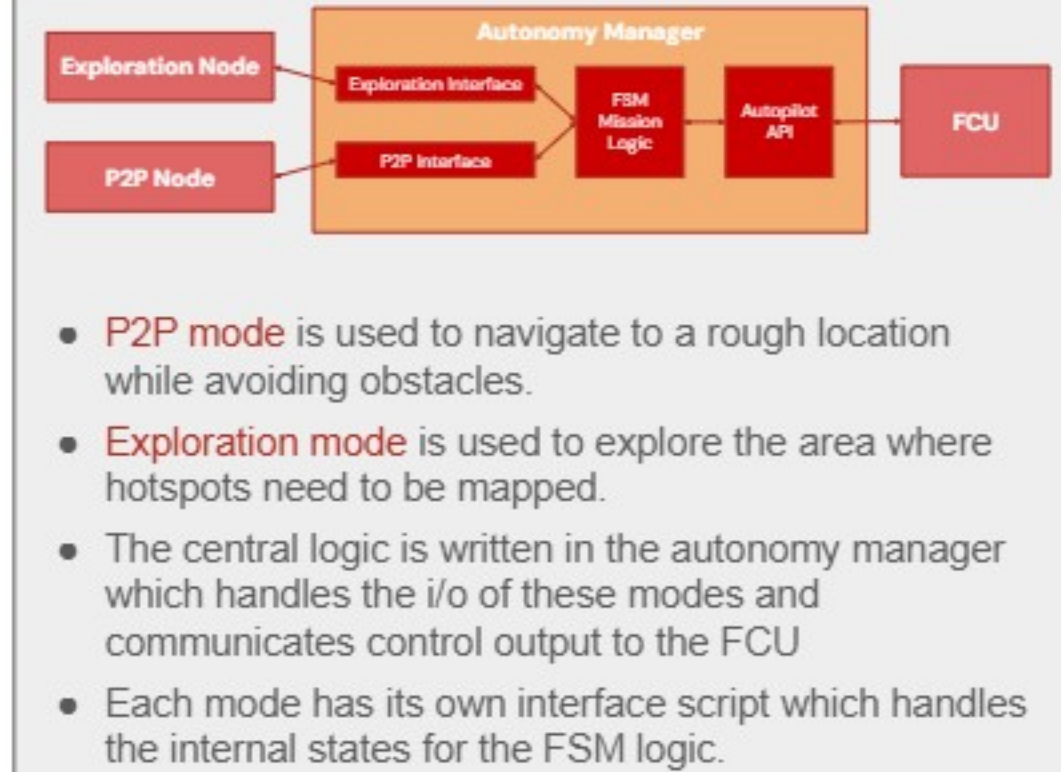
Fire Perception

- Fire perception subsystem consists of two components, fire localization and mapping
- The former module estimates hotspot poses in the camera frame. The later receives a stream of these poses and fuses with odom data to map fire
- Performance: localization error- 20cm, range- 7m
  Mapping frequency- 30Hz (Real-time)

RealSense → Point Cloud → Project into thermal camera frame → Extract ROI from fire segmentation → Reproject pixels for 3D location

State Estimation

Find IMU Gyroscope and Accelerometer Errors → Calibrate RealSense IR Cameras + IMU to get TF + Time-Offset → Use TF and dt values to run VINS with RealSense IR Cameras + IMU, then evaluate

- Estimates the pose (position and orientation) of the sUAS relative to its starting location.
- Utilizes data from 2 NIR cameras and an IMU, incorporating their calibration parameters and time synchronization.
- Robust to varied illumination variations in temperature and abrupt maneuvers.
- Performance: drift < 1% (100 meter loop), Frequency- 30Hz (Real-time)

Autonomy

- P2P mode is used to navigate to a rough location while avoiding obstacles.
- Exploration mode is used to explore the area where hotspots need to be mapped.
- The central logic is written in the autonomy manager which handles the i/o of these modes and communicates control output to the FCU
- Each mode has its own interface script which handles the internal states for the FSM logic.

Performance Requirements

- Localize itself at least at 10Hz
- Navigate trees with separation ≥ 5m
- Localize itself within a drift of 4%
- Have a Communications Range up to 150m
- Have flight time of more than 10 minutes
- Detect fires with accuracy ≥ 70%

Ground Control Station

2.4 Ghz ISM Spectrum | 20 Mbits/sec bandwidth | Ethernet | Command, Control & Video

Validated Performance

- Localized itself at 30Hz (GPS-denied)
- Autonomously navigated between obstacles with 4.0 meter separation
- Localized itself Within a drift of <1% over 100m
- Validated Comms range of 200m
- Validated Endurance of 16 Minutes
- Detected fires with accuracy ≥ 75%