DRDO SASE UAV FLEET CHALLENGE

IIT GUWAHATI

HARDWARE COMPONENTS

FLIGHT, CONTROL AND NAVIGATION

- Pixhawk Flight Controller and GPS module.
- Tarot 650 Sports Frame.
- EMAX motors, Carbon Fiber Propellers.
- 36AMP ESC's and 5200mAH Li-Po Batteries.

DETECTION , MAPPING AND COMMUNICATION

- Logitech 720p Webcam
- Nvidia Jetson Nano Computation Board.
- ALFA Long range Wi-Fi adapters for Nano.
- TP-Link Wi-Fi Router.

CONTROL AND NAVIGATION

- Pixhawk 4 Flight Controller Unit supports PX4 Autopilot Software
- Extended Kalman Filter(EKF) to estimate UAV states using PX4 Estimation and Control Library
- Rate, attitude, velocity and position PID controllers.
- Supports MAVROS communication which gives full access of drone over the network

TECHNICAL MODULES (SOFTWARE)

Swarm Communication Technology

Visual Coverage Planning

Target Detection

Target Localization

Visual Coverage

Proposed Solution: Linear Survey

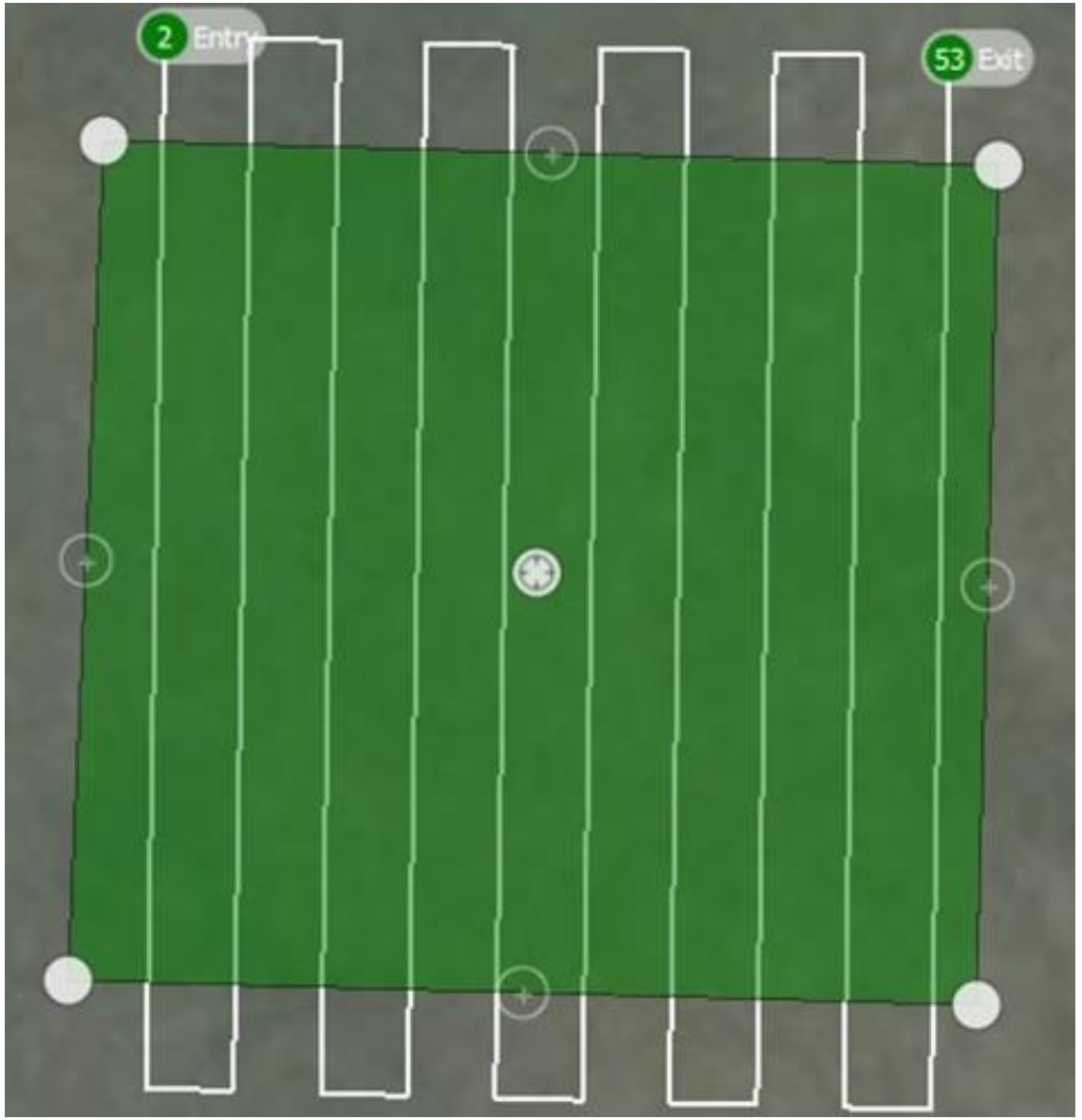
Decomposition: Equally sized rectangular coverage areas for each UAV.

Planning: Parallel line back-and-forth pattern for each coverage area.

Execution: Predefined geofences to perform linear survey at constant heights and speeds.

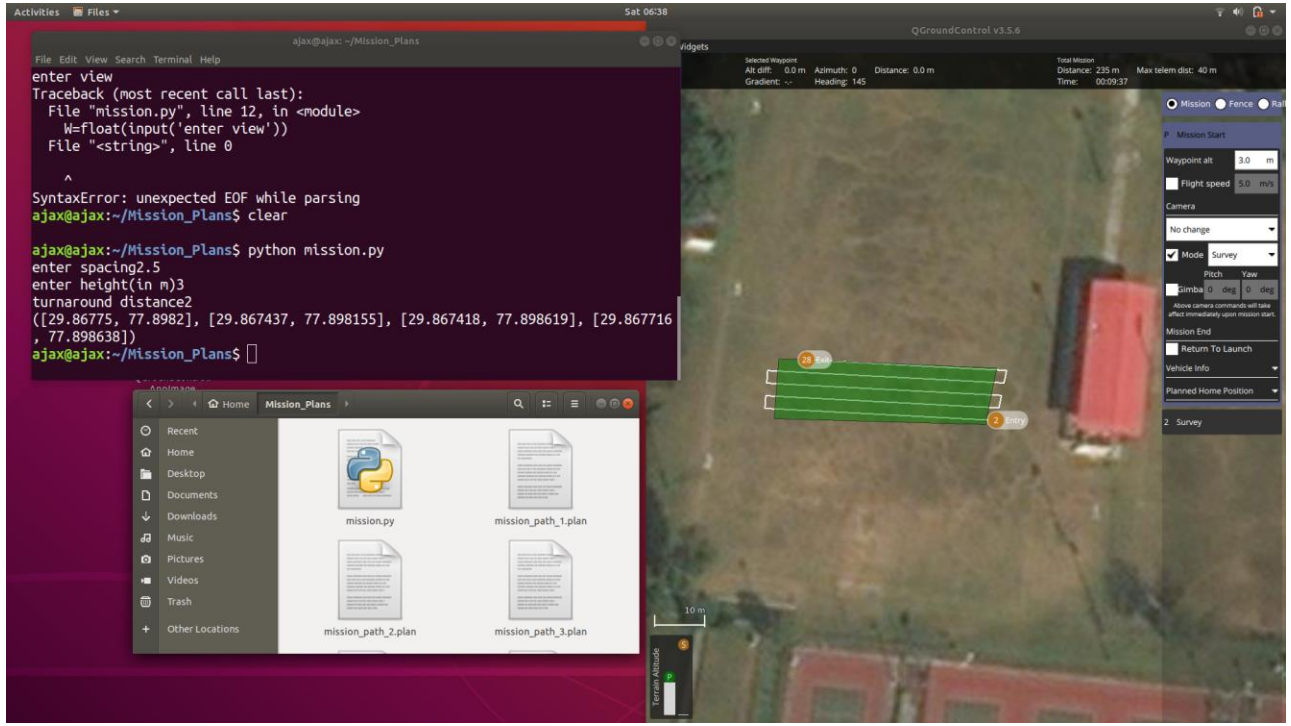
LINEAR SURVEY SEARCH PATTERN

- Preferable for large search areas with no prior information on target locations.
- Widely adopted in Mission Planner Software.
- The missions were planned using algorithm which auto generates mission setpoint plan and uploaded over Wi-Fi using MAVROS for each Drone



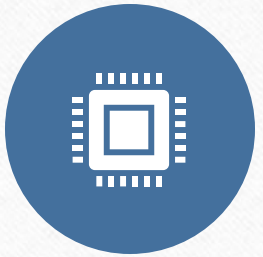
MISSION PLANNING ALGORITHM

- We need to give the Geofence coordinates of the area as input to the algorithm.
- It then divides area into 3 equal parts and plans the path for each drone.
- Then using MAV FTP mission push it uploads mission files into respective drones.
- Height, Velocity, Resolution and turnaround distance is also given input.



SWARM COMMUNICATION

Communication over Wi-Fi network.

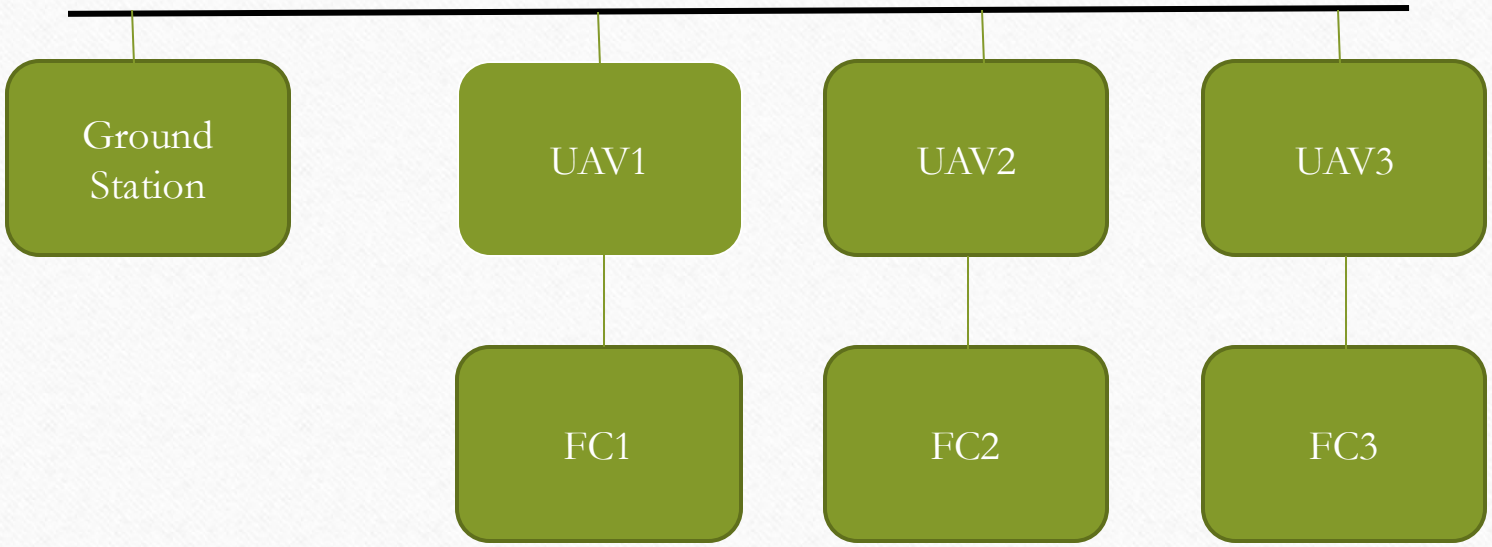


Communication through standard MAVlink protocol over a ROS network.

ROS MASTER on Ground Station.

ROS launch script for control and planning of all Drones to reduce manual inputs.

SWARM NETWORK OVER WI-FI



A FC consists of Px4 Flight Controller and GPS module

An UAV consists of Computation Board, Camera, Wi-Fi adapter

Centralized **Ground Station Unit(GSU)**.

The communication through **MAVLink protocol** over a Wi-Fi network hosted by the GSU.

A **single bash script** connects to the individual computation boards and arms all the UAVs.

Another command starts all the **control and navigation nodes**.

OBJECT DETECTION

Object Classifcation

- Challenges : **Feature learning** and **Localization**

You Only Look Once(**YOLO**)

- A single CNN for **classification** and **Localization**

WHY YOLO?

1. Lesser False Positives on **background**
2. Anchor boxes | Dimension Clustering
3. Multi-Scale Training | Fine-grained visual information

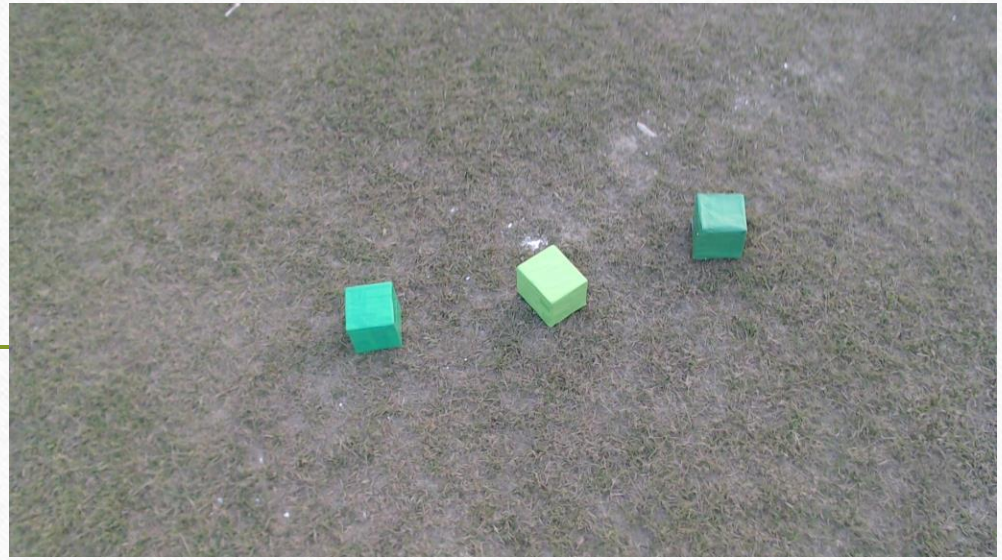
RESULTS

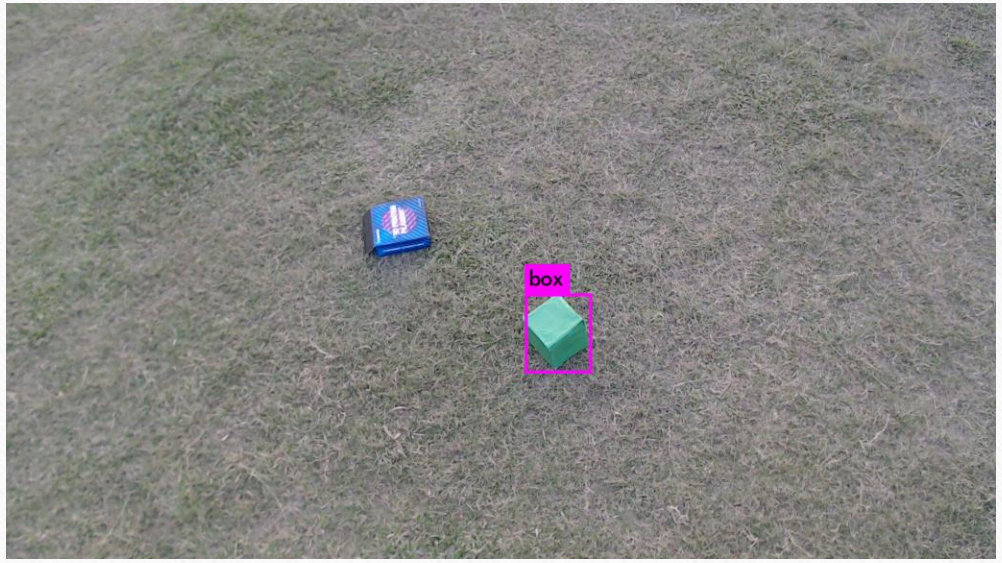
TS = 2050	Predicted (0)	Predicted (1)
Actual (0)	TP = 1204	FN = 44
Actual (1)	**FP** = 93	TN = 909

Precision	0.93
Recall	0.96
F1-Score	0.95

Average **IoU** = 71.04%

Toal boxes predicted = 1024 + 93

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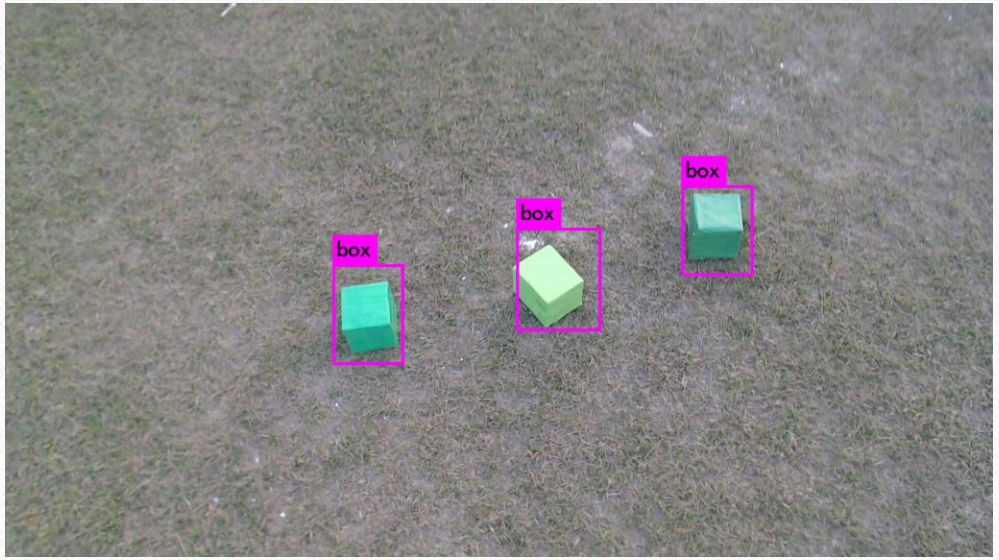
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FALSE POSITIVE FAIL-SAFE ALGORITHM

False Positive Detection errors pose greater threat to our proposed solution.

Extract **Histogram of Oriented Gradients(HOG)** features.

Kernel Partial Least Squares (KPLS-mRMR) to select 25/72 features.

Logistic Regression model.

Precision = 98% Recall = 95% Accuracy = 97%
This reduces the **False Detections** > 95% (i.e FP < 34)

TARGET LOCALIZATION

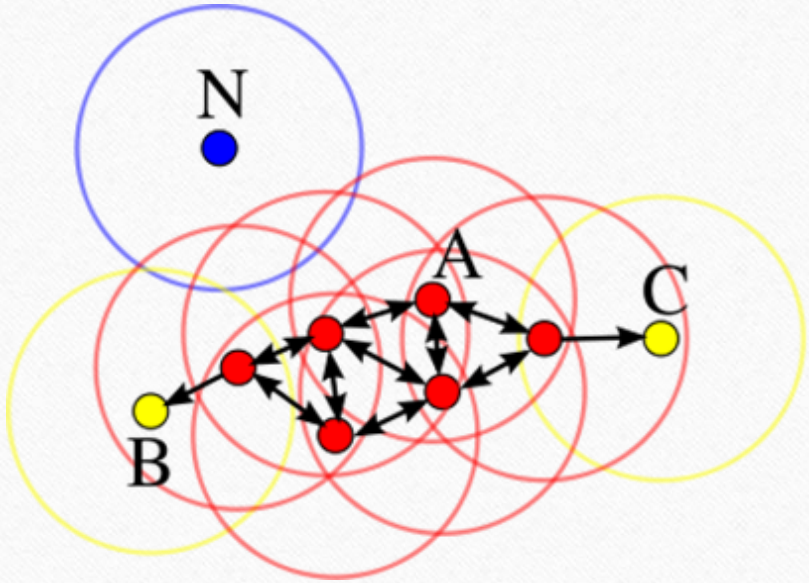
On successful detection, the UAV's GPS coordinates are sent to the **Clustering Node**.

A single Clustering Node for all UAV's **prevents re-detection errors**.

Noise is removed and **clustering centers** are plotted on the map.

CLUSTERING ALGORITHM

- **Density-based spatial clustering of applications with noise (DBSCAN)** to cluster the GPS data.
- **Robust to outliers** and **efficient in preventing low-density clusters** caused by random noise or false positive errors in detection.
- **Clustering parameters** can be tuned as a **function of height and detection frequency** to provide efficient differentiation of neighbor clusters.



COST ESTIMATE

- Pixhawk-16,000
- Frame-8,000
- Motors-4*3,000=12,000
- Nano-9,000
- Wi-Fi Adapter-3,000
- Battery-5,000
- Camera-2,000
- Propeller-2,000
- Total- 57,000 approx

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