D.R.D.O. SASE'S
UAV FLEET CHALLENGE

MID EVALUATION REPORT

INTER IIT TECH MEET 8.0

IIT PATNA

INTRODUCTION

To spot a target amongst a clutter of different objects spread randomly over a grassy land and subsequently communicate the location of the target to their remaining two drones using swarm technology

DRONE MAKING

Hardware equipment used-

- 10T 1400KV Brushless DC Motors
- 30A Brushless Electronic Speed Controller
- Flight Controller (Pixhawk PX4 Ardupilot PIX 2.4.8 32bit)
- PPM Encoder Module
- Pixhawk Power Module V6.0
- 11.1V 2000mAh Lithium Polymer Battery
- Ublox GPS Module with Compass
- Raspberry Pi 4.0
- USB Web Camera
- FlySky 2.4 GHz RC Controller
- F450 Quadcopter Frame

Softwares used-

- Dronekit - Provides High Level APIs for development of applications for UAVs.
- MAVROS - MAVLink extendable communication node for ROS with proxy for Ground Control Station. We are using this for establishing communicating between Drones about information of the detected green cube.
- Ardupilot Mission Planner - Mission Planner is a full-featured ground station application for the ArduPilot open source autopilot project. It is a configuration utility and dynamic control supplement for our autonomous vehicle. We are using it for calibration.
- OpenCV Python - OpenCV is an open source computer vision and machine learning software library(for Image processing)

IIT PATNA

FLIGHT PATH & TRAJECTORY

The drone will be maintaining a height of approximately 2m from the ground as to also, avoid obstacles and to get a bigger picture of the cube while detecting it using the cameras placed on the drones.

The drones will be assigned a particular region in which they have to detect the cube placed only in those regions. In particular, we decided to assign parallel patches of the whole arena according to the number of drones used. The arena will be divided into 3 lanes and each drone will be given one lane. They will be synchronised using telemetry and will navigate in the same way in each lane. At all times they will be at a distance of around 13m from each other, in this way we will be avoiding the collision of air boundary of any two drones at a time and also, smooth functioning of our task will be ensured. The detection of 5 cubes should finish before any drone enters the other drone's area.

We choose this instead of any other search protocols like that of encircling drones around the boundaries or assigning quadrants as to avoid the possibilities of collision at the air boundaries, especially in the case when the drone will arrive eventually at the centre.

We are aiming at a simple trajectory which makes sure that the drones don't collide and the whole arena is covered with the minimum time taken and yet efficiently.

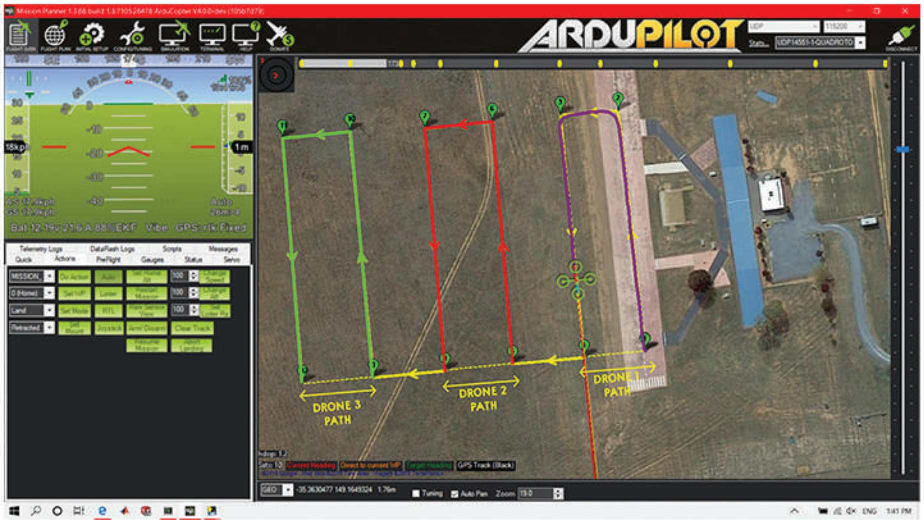


Image above is a simulation of a drone across the field for searching the cube, simulated in Mission Planner.

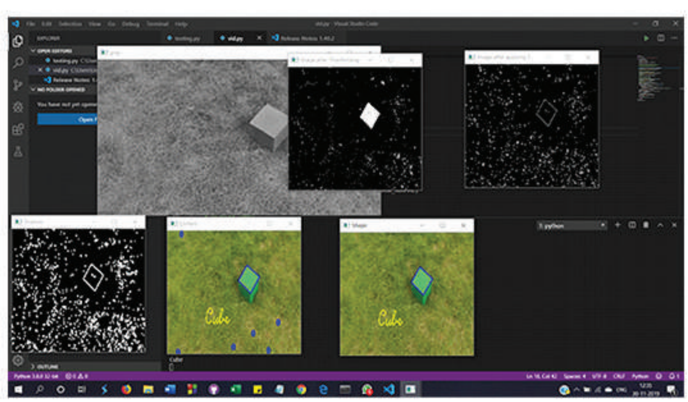
IMAGE PROCESSING IMPLEMENTATION (OBJECT DETECTION)

• Motion blur reduction: The live feed which we will be receiving from our cameras might be wavy because of the vibrations of drone being transferred to the camera. This creates a big problem to move along with the task of detecting cube. So our first concern would be making those images clear enough to accomplish the cube detection task.

• Contour detection: After making the image clear, we will proceed with the next objective of detecting the contour of the object out of that image. The techniques we would be using in this step include color thresholding, noise reduction and low band pass filter to remove high frequency signals from the grass.

• Canny Edge Detection: Now we would be focusing on detecting the edges in the object to ensure that it is a cube. Along with detecting the edges in the object, we would also find the aspect ratio of edges with the help of mathematical operations based upon the geometrical location of camera respective to object. If the aspect ratio is nearly equal to one we can rule out other 3-d objects like a cuboid. We can use this result in a further step to conclude our object to be a cube.

• Harris Corner detection: Now we would be treating the intersection points of the edges as the corner points of our object. Based upon the number of corner points we would be determining the object. There are three possibilities in case of a cube, either one face, two face or three faces which would visible to the camera at a time, accordingly the number of corner points detected would respectively be four, six and seven. This narrows down our computation to three test cases of the number of corners and the respective number of edges.



The image on the side depicts the numerous outputs of image processing of the cube.

SWARM COMMUNICATION

Communication Hardware

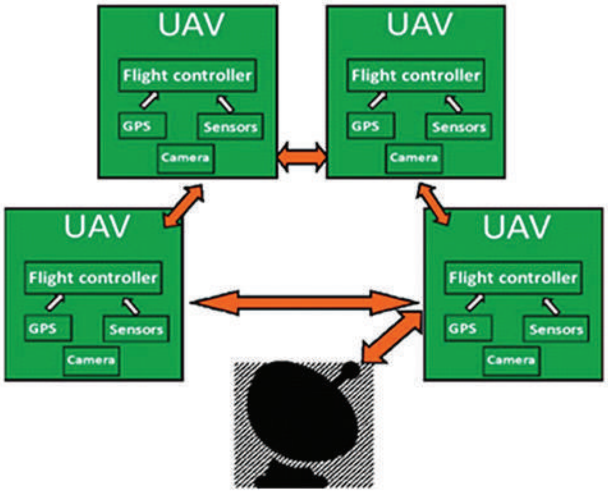
We are using in-built WiFi communication of Raspberry Pi 4. Our UAVs are alloted regions of the arena such that they cannot go away more than 15m (approx) from each other. So it is safe to use WiFi communication but for scalability purposes we may use 4G LTE modules for long range communications.

Network Topology

We are using Flying Ad-hoc Network (FANET) architecture to co-ordinate communication between all UAVs in . In a FANET all UAVs are part of a network of communications
that is established between the UAVs. This network allows for real time communications between UAVs. Direct communication between UAVs forces distributed decision making as is no necessity for an infrastructure-based decision engine. This also provides built in redundancy as the entire swarm is not dependent upon an infrastructure to execute the desired task of detection of . This is the primary advantage of FANETs.

Communication Data

During communication, the current coordinates of the UAV, roll pitch and yaw angles and images of detected cubes (if any) will be shared to other UAVs and ground station. Using the roll, pitch, yaw, current GPS coordinates of a drone and images of the cube detected we are estimating the location of the target green cube in the arena.



FANET NETWORK TOPOLOGY