IARC Paper

Mission - 8

Network of Autonomous Drones

Abstract

This paper is intended to demonstrate the techniques used by Team KRATOS in response to the challenge levied by the IARC MISSION -8. In this paper, we have explained the techniques adopted for successful performance to counter the mission challenge. Here we will come across autonomous stabilization of the drone and a swarm of drones, how they interact with one another, controlling them without electronic devices, here we did choose a voice command control system, possibility of manipulating autonomous swarm stabilization to human control for focusing the display over the boxes for critical code as explained in the mission-8 rules of IARC. Here the object tracking is done in a different manner apart from general on-board Image processing, we are transmitting the video to the nearby laptop and processing the object tracking there and required commands are sent back by means of Arduino wireless networking. One of the primary concentration of our work is over lidar, in generating data in degrees around the drone on top and bottom with magnetometer and gyroscope. Which defines it as one of the best obstacle avoidance system in performance of avoiding both stationary and moving aerial obstacles system with pointed rotary lidar. The use of various micro controllers for independent tasks which are time consuming was demonstrated using i2c bus

Introduction: The demonstration of UAV is designed with the swarming of drones based on the mission requirements of the IARC mission 8

A statement of the problem: Autonomous Swarm demonstration and utilizing them to one's requirements

- It is mentioned that the aerial robot has to identify the environment
- To avoid obstacles in its path
- It has to pass commands from one drone to another drone basing on swarm interaction
- It has to pass the live video of the boxes, environment by means of fpv
- One has to communicate only through non-vocal commands
- The propellers are to be enclosed for safety
- A kill switch to terminate the drone at any instant
- Has to survive at least 8 minutes

Conceptual solution to solve the problem

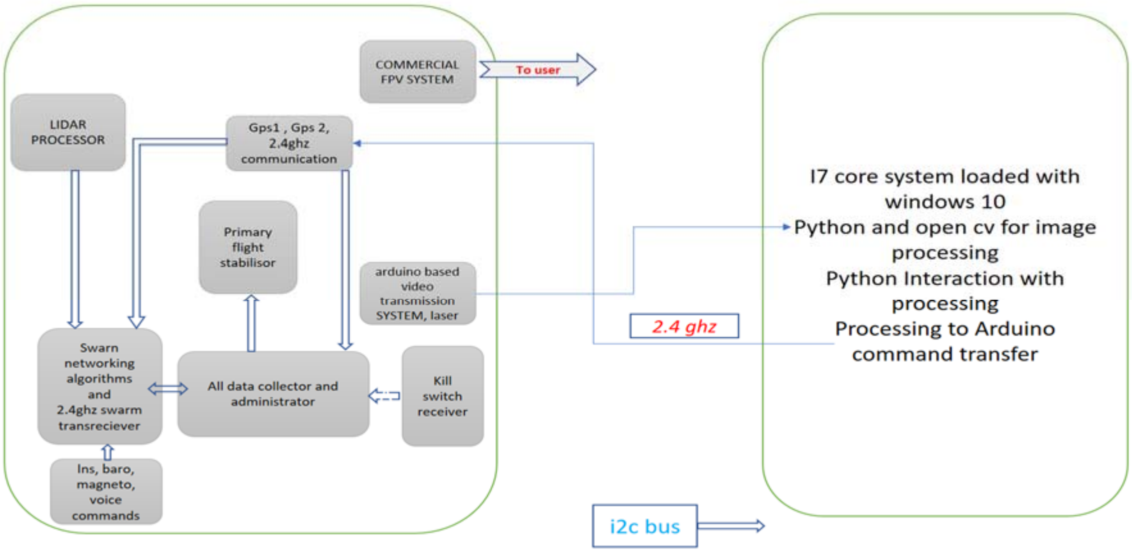
Here, first we start with the drone hardware. Our drones are of f450 quad family, they are equipped with 920 Kv motors and 1045 propellers, battery 0f 6500mah 3s Lipo battery, each motor produces 700gms of thrust while we utilize 500gms thrust for a normal mission stabilizing 1100 gms of the drone and 400gms of additional payload. This particular designed drone consists of multiple processors which communicates with each other via an i2c communication bus each assigned to a specific task as follows. Autonomous flight without human interference was being developed since 2017, and simulating swarm interactions.

Autonomous systems consist of a basic flight controller to auto stabilize pitch, roll, yaw when there is no command. This is further Linked with secondary microcontroller which is equipped with Mems three axis accelerometer, gyroscope, magnetometer, barometer, gps and processed lidar data to make it semi-autonomous with preprogrammed conditions. Mission planner is the third microcontroller which is equipped with gps, processed lidar data which runs mission 8 rules primarily to avoid obstacles and stabilize in position and trajectory formation as per voice commands. Fourth microcontroller deals with a mini TTL camera and transfers it to the ground station, processed visual data from ground station is sent back to the mission planner to make human worn helmet trackable and to shoot lasers at command

Swarm algorithms and its networking are being processed by a separate microcontroller which receives data from mission planner to position other drones and to manipulate their position on command and also transfer data that received from another drone to the mission planner. Here the swarm stabilization involves with a predefined pattern involving gps coordinates which were auto generated according to the master drone position by swarm algorithm where each drone can be independently controlled as an exception for pre-auto generated position commands once the new position is defined its error from auto generated coordinates will be considered as an offsets and will be lined up for further swarm positions

Obstacle avoidance is achieved by placing two pointed lidars on top and bottom of the drone which spins at 5hz continuously tracking the width of the drone in the trajectory suitable for passing through, also to support preprogrammed intelligence to avoid wanted interference by the killer drones. Video focus by each drone will be voice commanded to master drone by a team participant which transfers in swarm algorithm to all other drones and controls independently. Boundary awareness is not much focused since this operation is in a bounded walled room where the walls will be treated as an obstacle. Each drone is equipped with an FPV cam to transmit video simultaneously to team participant, whereas the master drone is equipped with two cams one for image processing and another for FPV. This mission planner is connected with a small microcontroller with a receiver which is virtually linked up with a kill switch, which terminates all functions and processes in case of safety.

Figure of control system architecture



Yearly Milestones

Stabilizing of quad copter achieved after months

Stabilizing of single quadcopter involved Arduino with mpu6050 as primary flight controller where it took a ton of time to stabilize with the proper PID tuning, this is taken from open source flight controller YMFC by Joop Brokking. It works as simple as reading pwm readings from the receiver using interrupts, reads Accel gyro values to measure pitch, roll involving simple complimentary for sensor fusion between gyroscope pitch, roll and accelerometer pitch, roll. Up next we added barometer to hold its altitude. Altitude hold function is simple, we used to measure the change in current altitude and actual altitude and then multiplied by proportional constant. Thus we obtained an altitude hold. But it used to oscillate due to minimum sensitivity (30cm) to Baro sensor. However, we managed the code to run at 250 Hz frequency. Then the ultrasonic sensor was added to the code, but it extended the time period of the code. So there we started to use multiple microcontrollers for multiple tasks, ultrasonic was connected to another micro controller where these two microcontrollers communicated threw the i2c communication finally with little delay in terrain change response the drone was hovered with minute oscillations

A team of two, has involved in creating Algorithms and programming self-stabilized drone and perform some semi-autonomous tasks like autonomous navigation to virtual gps points. Who in further with team contributed to swarm stabilization and autonomous intelligence

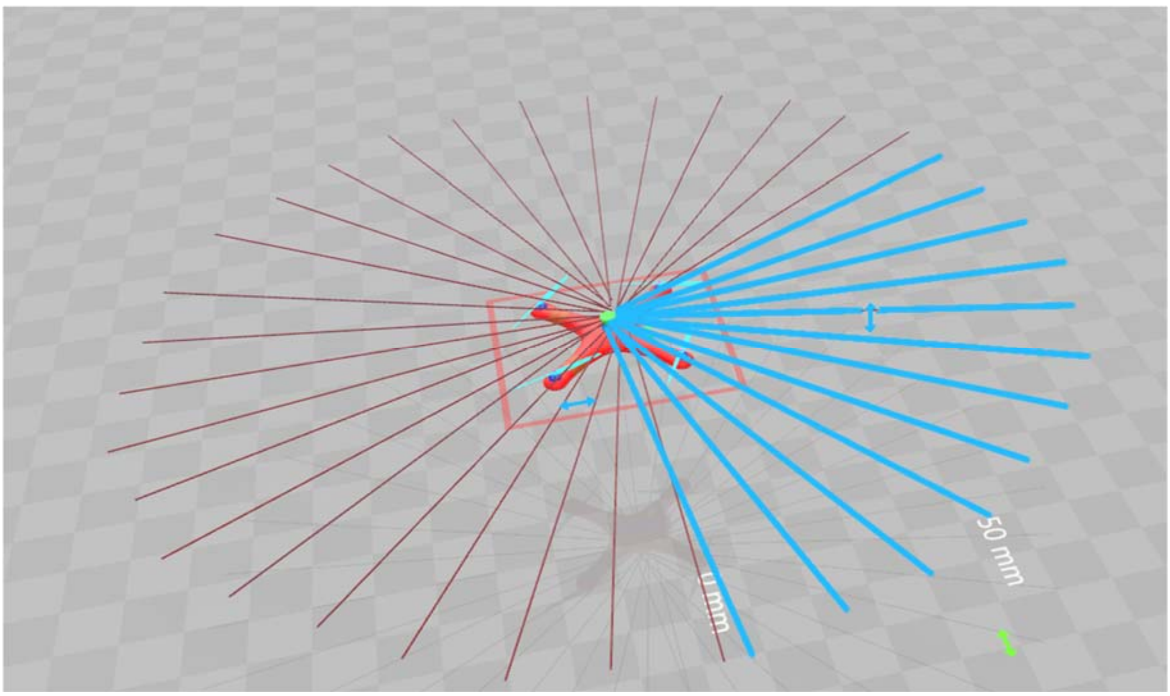
Navigating it to virtual gps coordinates however, with some errors

Swarm algorithms, construction and demonstration were still lagging behind the requirement by the time of writing of this journal.

Voice commands with basic configuration were implemented. And the further improved version development is under progress. Here we have used 15 commands structured control system. Start, stop, names of four drones, left, right, forward, backward, Ing. And their combination to control all four set of drones. Here even one drone collects commands it will transfer those to all remaining drones with their name thus swarm communication is demonstrated

Lidar designing and utilization over one requirement. Reality under construction and testing. Two lidars of around 20 gms each were mounted on top and bottom with angular frequency of 5 Hz linked with a magnetometer and a gyroscope to store data in north east south west coordinates with a resolution of app 6 degrees. Which is used to identify the obstacle and to plan the escape trajectory

Figure of lidar system:

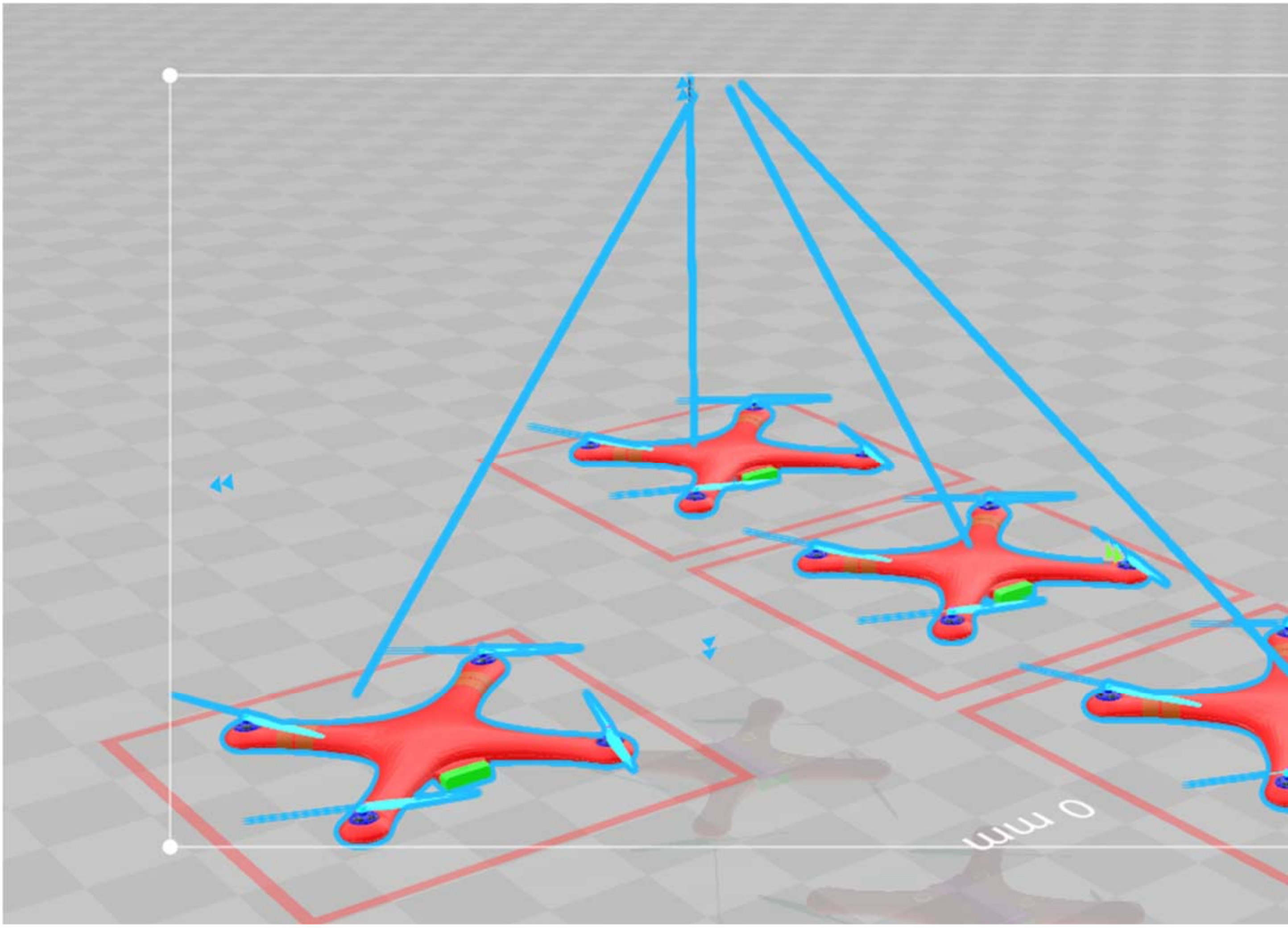


Air Vehicle

Motors: brushless electric DC Motors (920kv). Props: 10*45 propsType: quad copter with enclosed props. Guidance: gps, voice commands, specially designed Lidar. Nav: autonomous swarm algorithms with voice commands. The Stability Augmentation System is achieved by a 32bit micro controller only loaded with 3 axis stabilization system. Navigation is done with the help of gps, self designed lidar, voice commands

The Flight Termination System is achieved by the Multi micro controller system one specially assigned to terminate the drone complete working processes. Our drones carry 500gms of payload, including lidars, sensors, cams. Sensors were placed tightly in a 3d printed enclosure. Mission Sensors were lidars, voice recognizing sensors, optical flow sensors. Target Identification is done by OpenCV and python on ground station. Threat Avoidance by means of two Lidars linked up with magnetometer and gyroscope simulating virtual 2d (partial 3d) environmental data. Communications were the 2.4 Ghz open source modules for swarm networking with encryption and for secondary manual control. The additional power supply line is provided to all on-board sensors from the battery

Figure of overall control system:



All drones are linked up to same 2.4 ghz channel x, each drone is commanded by its (address, command). Thus swarm is controlled by one drone which is further controlled by human

Flight Preparations

Initialization involves with voice command. Vehicle power status is continuously monitored. All four propellers are enclosed with a lightweight carbon fiber fence. A safety kill switch linked with a main mission planner is used to terminate the drone performance under unplanned behavior or any damage. Parts and sensors are virtually equipped in the 3dBuilder 3d simulation software, and modified several times before actual plan. Testing were done to tune proper linear PID values for both independent and swarm drone stabilization

Conclusion:

The above mentioned system of drones can perform the following:

- An autonomous takeoff on voice command by master drone and swarm interaction take off of the other drones
- Team participant controls only one master drone and master drone controls all other drones
- Autonomous Obstacle avoidance system installed in each of the drones is capable of avoiding both static and moving mid air targets

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