Aerial Squadron technical paper for International Aerial Robotics Competition 2019

Team Reconnaissance

C.Aasish, Nandhini, Sanjeevi, Sabarish, Mohan Rishikesh, Ganesh Kartik, Ajay Krihna, Aakash,

ABSTRACT

The Team Reconnaissance is a team from India presents an indigenously developed Aerial Squadron a fleet of autonomous aerial robots as the candidate for the 8th mission of the AUVSI International Aerial Robotics Competition (IARC). In this paper we briefly describe the technical layout of our aerial robots that are designed for IARC competition. It is a custom designed quadrotor system that will explore the unstructured environment. The swarm of aerial robots is controlled using gestures. Obstacles are serious threats in this mission and are avoided by the installation of Light detection and ranging sensor (LiDAR) fitted on board. Our fleet of aerial robots runs human tracking algorithm to detect and track humans. Our swarm of flying platforms are designed man safe and we ensure this with our custom designed aerial quadcopters. The 3d printed ducts protect the aerial platform making direct contact with obstacles and it ensures that this design has no harm to humans while making interactions. We believe our swarm intelligence strategy and effective communication systems would help us to be a tough contender for this event.

Technical report:

Problem statement:

This competition theme requires an unmanned vehicle to safely explore an indoor environment without hitting an obstacle, it should be the Man-machine interaction and control system and Fused sensory enhancement of a human operator by a fleet of aerial robots. The quadrotor should have also the Swarm interaction and the Head-to-head interaction with opposing aerial robots.

Conceptual Approach:

Our team has designed an Unmanned Aerial System (UAS) that is of a compact design so that it is portable and easy to deploy. The total aerial system consists of a customized quad-copter based carbon fibre platform. This flying platform is equipped with different kinds of avionics systems.

Swarming of drones is tough and for this mission we have worked on synchronising multiple aerial platforms. Each and every aerial robot of the fleet is equipped with on-board computers and has constant communication with each other and the Ground control station. The flying aerial robots works with Wifi and with our software development package, we take complete control of the copter with the embedded code.

AIR VEHICLE:

The Unmanned Aerial Vehicle employed for this mission requires a design sophisticated enough to accommodate hidden electronic ducted fan aimed for a safe aerial flying of the robot, with the necessary payload for the checklist of the mission requirements. Confined to the rules and the checklist we've come up with this unique design. This structure has four arms where the fans sit along with the electronic speed controller and the main flight controller board adheres to the UAV’s fuselage. The control communication is done

Aerial platform design

through a non electric interface, precisely gesture control

For the simplified version of the ultimatum, we have come up with a simple model where the unmanned aerial vehicle is employed with four BLDC motors connected to 30amps of electronic speed controller each, integrated together to the Ardupilot flight control board. The base objective of the simplified model is to create a safe flying of the drone. Four propellers were fitted to each of BLDC and mainstream functioning of a normal quadcopter is followed. The task of safety aspect was accomplished through the foam which was cut and crafted in order to create a duct covering each of the dc motors.

We have focussed much on the structural design of copter and wanted to be unique. We have brought in the concept of dyson fan indicating bladeless propulsion. We are still working on this conceptual design and hoping to achieve better results. Upon successful results, we will be ensuring a safe aerial platform. Athe initial duct designs and test models are shown in the figures.

Test models

Propulsion and Lift System:

The propulsion modelling of our prototype for this mission is accomplished through four ducted arms containing EDF’s at each arm. Each arm is designed in such a way that, the air force-sucked in, is made to produce thrust by letting it out through a cylinder with a small opening in the bottom side of the hollow structure. The endurance of this machine is approximated just enough to support the mission timings.

Duct designs

The EDF's are of 70mm diameter each connected to a 40amps electronic speed controller integrated to a flight control board. The RPM of the fan is regulated using a built-in controller.

The ducted fan is to be aligned in the right side of the arm as per the picture. This ducted fan has 12 blades with a calculated weight of 175g on an approximation, run by a motor of 2845Kv.

Through flexible manufacturing systems and All-composite injection moulding processing, this fan has high rigidity and toughness leading to a wear-free action also these is dynamically balanced

Ducts used in test models

This completes the propulsion and the design system of the prototype. For the simplified model, we didn't actually use these ducted fans in here. Instead, we used normal BLDC merged with propellers as mentioned earlier. Diagonally similar rotating motors are placed, such that the sum of the reaction torques is zero during hovering. The RPM is controlled by the electronic speed controller each of 30amps

We currently tested this model and it had successful results. Structure-wise, comparing the model with the prototype yielded optimistic outcomes. We have tested the fan's thrust and estimated the results for the ultimate prototype.

Software system overview

We develop the software structure of UAV in Ubuntu 14.04, and the system frame is based on Robot Operation System (ROS). Briefly, the software structure of the UAV system could be divided into different functional parts namely localization, tracking, detection, navigation and obstacle avoidance.

Gesture control

Quadcopters are one of the most famous drones which have engulfed the global market. The applications of such drones are enormous; be it in rescue missions, spying, delivering, or studying unreachable landscapes. We must also notice that while some people use autonomous technologies for navigation, these are also expensive.

We want to make quadcopter handling much easier and intuitive so that it can be learnt by anybody and also fun to control!

We also want an efficient navigation technique in closed spaces specifically in the context of rescue missions during natural disasters.

Use of OpenCV and Python to capture frames using a webcam: Extract the ROI(region of interest) i.e. background subtraction in each frame -- Converting image to grayscale and blurring it using Gaussian blur for smoothening and reducing the noise in the image. Next use thresholding for image segmentation. We will use Otsu’s binarization method which calculates threshold value so as to minimize the interclass variance of foreground and background.using image histograms. Finally, we would get a binary image with our ROI in white and background in black

Draw contours for the ROI. Next, we would find the convex points which are generally the tip of fingers and some other convexity defects like the point connecting between the fingers and thus we would get the number of fingers in each frame. For velocity of a particular point across frames and directions we will use optical flow generated trajectories

Human tracking

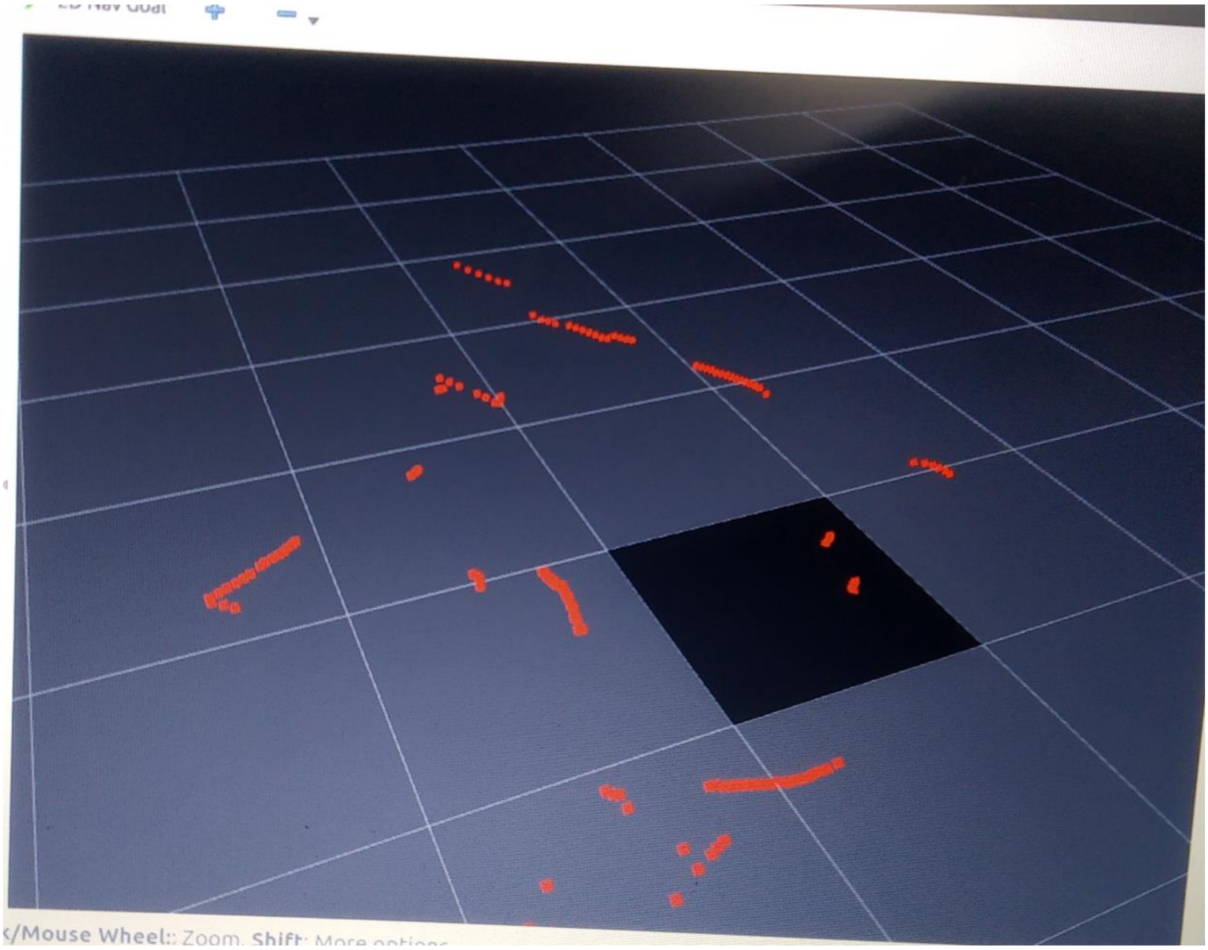
TensorFlow is a powerful open-source software framework used to power AI projects. TensorFlow is used for machine learning and the creation of neural networks. Our On-board computers perform complex tasks, image processing, detection, and tracking and collision avoidance.

Image recognition is an important segment of our on-board task. We tried these software frameworks with Raspberry Pi.

OpenCV is a powerful computer vision framework, containing a huge number of algorithms for processing and analysing images. A sample of our testing is shown in the following figure.

Human detection

Obstacle avoidance:



The full autonomy gets completed when we are able to prove that our system is capable of demonstrating collision avoidance. We have included Lidar (Light detection and ranging sensor) as a part of collision avoidance. The 360 degree scanning Lidar provides reliable scanned data about the surrounding. The scanned data is used and integrated with our algorithm for demonstrating obstacle avoidance. A sample test image of scanned data is shown in the above figure.

TESTING

Prior to testing, we have done simulations in software and we carry out the flight tests in an arena much like the actual one. The test arena is built based on the suggestions provided on the website in our flight tests we were much focusing on obstacle avoidance and target detection. We are still working on with the interaction of man to machine and swarming.

Conclusion

As the modern era is looking to establish its dominance over all regions, providing peace and harmony has become a difficult task and many difficult tasks can’t be done with the help of humans. So, Artificial Intelligence integrated into unmanned vehicles is the future and we hope that our system can be a good contender for this mission 8.