Rakshak UAV

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INTER IIT TECH MEET 2021

Objectives & UAV Design

The project Rakshak aims at developing UAVs to provide **relief measures in disaster-stricken areas** and can be used for **surveys & mapping of cities** and **conservation of wildlife** with slight modifications. Our design efficiently tackles the above problems cost-effectively without compromising on human safety.

Autonomous Flight- Stable flight controller, long range communication

Obstacle Avoidance- Feasible path generation, mission trajectory update

Object Detection and Classification- Highly stable imaging system, shape and letter detection and classification

Air Delivery- Accurate dropping mechanism accommodating shift in CG position

Takeoff weight	4.816 kg
Cruise speed	18 m/s
Stall speed	10 m/s
min turn radius	15 m
endurance	60 min
wingspan	2 m
chord length	33 cm

Fig. UAV Design Specifications

Controls & Communication

The path planning algorithm represents all **obstacles as circles** by adding a grace radius around it for safety purposes. The algorithm works by trying to find a straight-line path between two waypoints. If obstacles are present in the path, the algorithm generates waypoints such that the UAV will **trace the boundary** of the obstacle.

- Offline path generation pre-mission
- Guaranteed to give solution
- Defined running time, won't enter an infinite loop

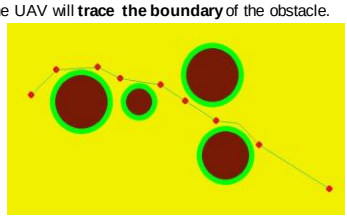


Fig. Path Planning Algorithm

Rakshak UAV uses the flight controller **Pixhawk,** along with its ground control station software **QGroundControl.** The autopilot receives the refined mission waypoints from ground station and performs autonomous navigation using internal sensors- accelerometer, gyroscope, magnetometer. Pixhawk flightstack uses **MAVLink** protocol for communication which facilitates the use of **MAVROS** (ROS package).

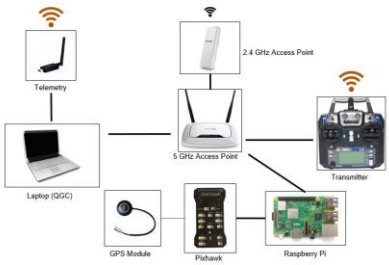
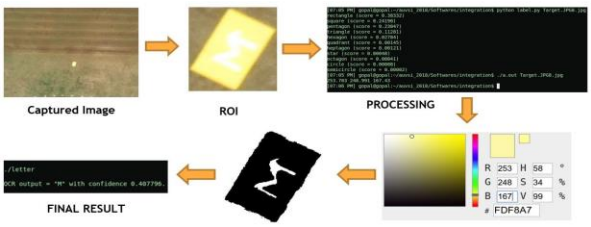


Fig. Communication System

Interoperability: The obstacle locations and desired flight waypoints are obtained from a server. The process is automated with the help of **python scripts** for login, collection of data and transfer of mission imagery in **JSON** format.

Computer Vision

Model Pipeline :



The significant tasks involved making the UAV capable of detecting and classifying the objects present on the ground.

Object detection :

The objects include alphanumeric characters and humans engaged in various activities. A YOLO-v5 model pre-trained on the COCO dataset was taken and then fine-tuned on our dataset. The dataset prepared for this task initially had 177 images captured by our drone in the gymkhana grounds of IIT Bombay. Data pre-processing and augmentation were performed to improve the model results which are as follows :

- mAP@.5 - 0.837, mAP@.5:.95 - 0.413
- Precision - 0.844, Recall - 0.807

Object Recognition :

If the object is detected as a letter, the task is to recognise the alphabet in the cropped image. The major problem with the dataset was that it had a lot of background noise. The images were converted into LAB colour space and thresholding was applied to reduce noise. The test accuracy was around 62%.

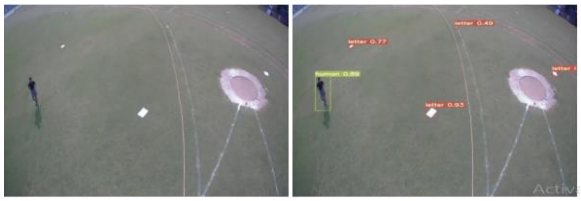
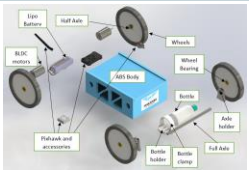


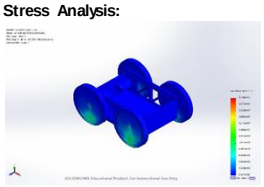
Fig. Object detection results

UGV-aided Delivery

- **4 wheel, Pixhawk Controlled Forward Drive** UGV model
- Enclosing dimensions of the UGV are **275 mm x 200 mm x 103 mm** – space to carry items (like the bottle shown in the fig.)

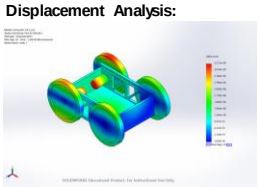


Stress Analysis:



Impact initially taken by the wheels and then passed to the wheel axle. Maximum Stress reached in the axle is 291.9 MPa, within limits.

Displacement Analysis:



Maximum displacement achieved is 3.27 mm at the top portion of the front wheels. Wheel tire is expected to take the impact, acting as a natural suspension.

Miscellaneous

Path Planning Demonstration:
Offline path planning, Online path planning
Flight Demonstration: Rakshak
Manufacturing:

Fig. Wing loading test

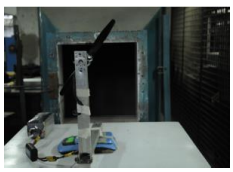


Fig. Motor test

Fig. Wing structure

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