DRDO UAV - UGV Challenge

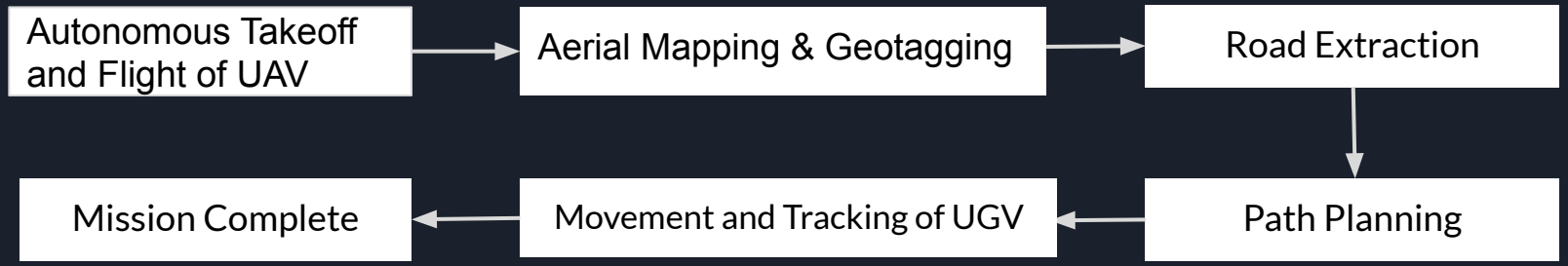
Team number : 17

INTER IIT TECH MEET ’22

Problem

An unmanned aerial vehicle equipped with GPS and RGBD camera is supposed to survey a given terrain and guide an unmanned ground vehicle with no sensors. This requires the team to map the mountain road in the worlds using a UAV and guide a UGV through the area, navigating across various turns, altitudes, and depth of terrain under various constraints

APPROACH



Software Stack Used :

1. ROS Melodic 18.04 LTS and Gazebo
2. Ardupilot Firmware
3. Mavros

UAV Operation & Code

- The UAV is controlled through ardupilot Software In The Loop (SITL) and MAVProxy

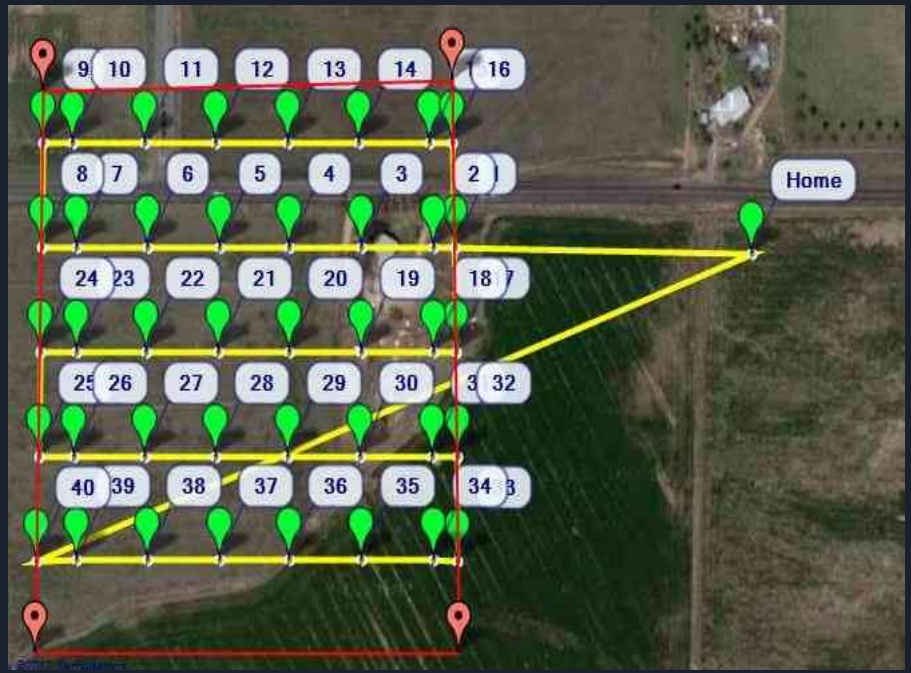
- The commands to the UAV will be given by a python program which makes decision based on the exploration and mapping phase of the UAV.

- UAV is also responsible for determining the position and orientation of the UGV so as to make it move in the planned path.

- UAV will compute the deviation of UGV from the planned path and make the UGV track the path using PID control.

Aerial Surveying

The Mission Planner create a mission by itself, which is useful for function like mapping missions, where the aircraft should just go back and forth in a “lawnmower” pattern over an area to collect photographs.



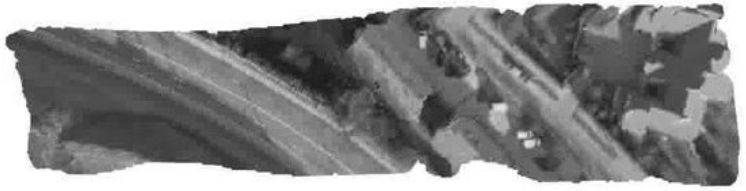
Ardupilot AutoGrid

Image Segmentation for Road Extraction

D-LinkNet: LinkNet With Pretrained Encoder and Dilated Convolution for High Resolution Satellite Imagery Road Extraction Lichen Zhou, Chuang Zhang, Ming Wu; Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, 2018, pp. 182-186

Mapping and Geotagging

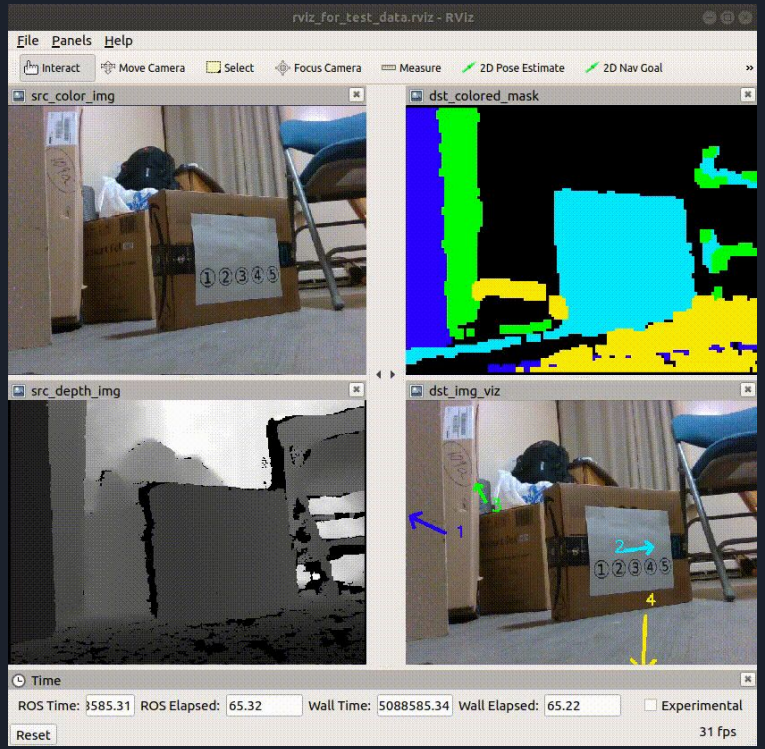
We use Ardupilot Mission Planner and use 2D stitching methods for obtaining the final map . Geotagging is the process of assigning coordinates to photos. In general, these coordinates are in latitude and longitude and in decimal degrees .



T. Hinzmann, J. L. Schönberger, M. Pollefeys, and R. Siegwart
"Mapping on the Fly: Real-time 3D Dense Reconstruction, Digital Surface Map and Incremental Orthomosaic Generation for Unmanned Aerial Vehicles"

https://github.com/ethz-asl/aerial_mapper

Detecting Planes from Depth Images

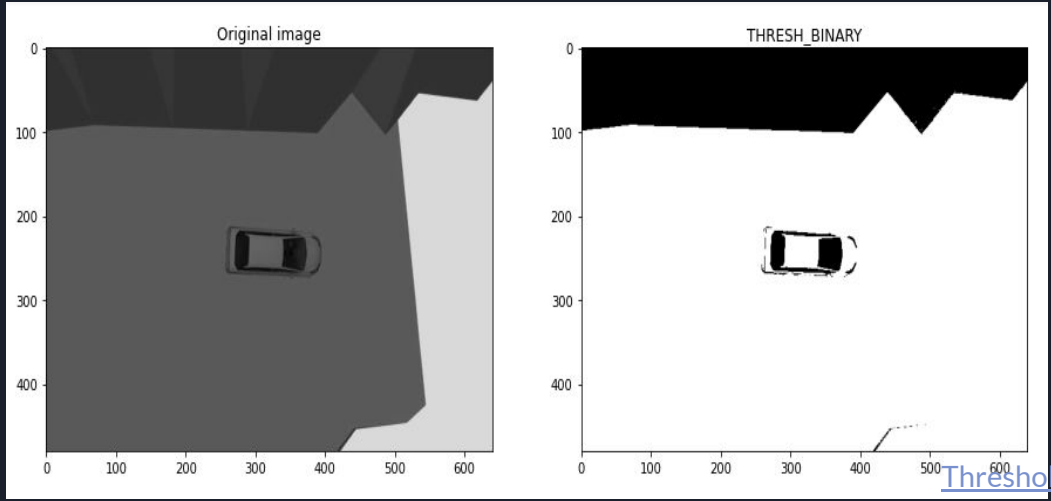


Jin, Z., Tillo, T., Zou, W. *et al.* Depth image-based plane detection. *Big Data Anal* 3, 10 (2018). https://doi.org/10.1186/s41044-018-0035-y

Image thresholding for heading detection

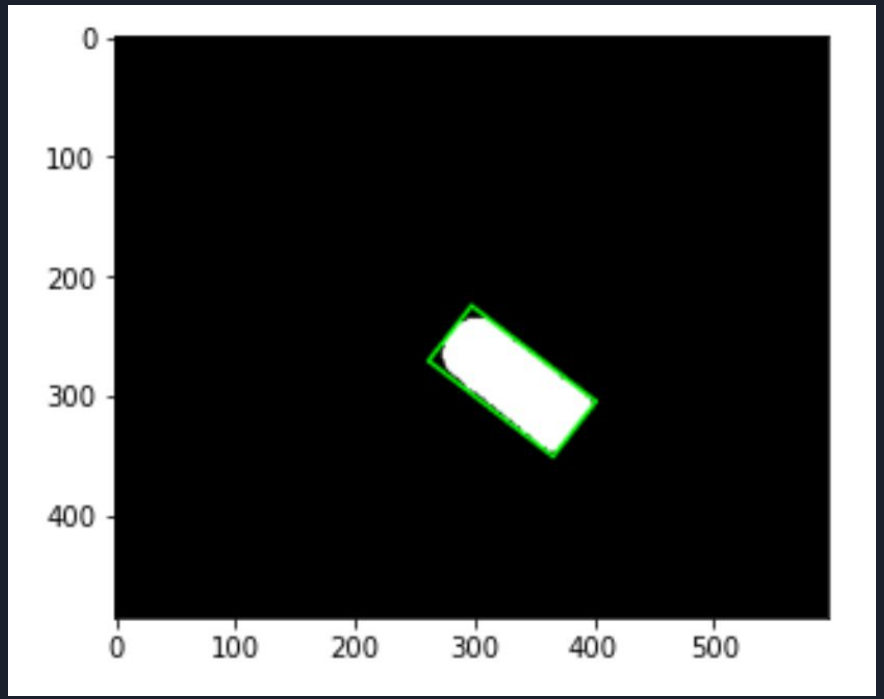
Thresholding is a type of image segmentation, where we change the pixels of an image to make the image easier to analyze. In thresholding, we convert an image from color or grayscale into a binary image, i.e., one that is simply black and white . We are using image thresholding for determining orientation i.e. yaw of the prius or UGV.

We are using PID controller for tracking of the car.



Thresholding_image.ipynb - Colaboratory

Image thresholding for heading detection

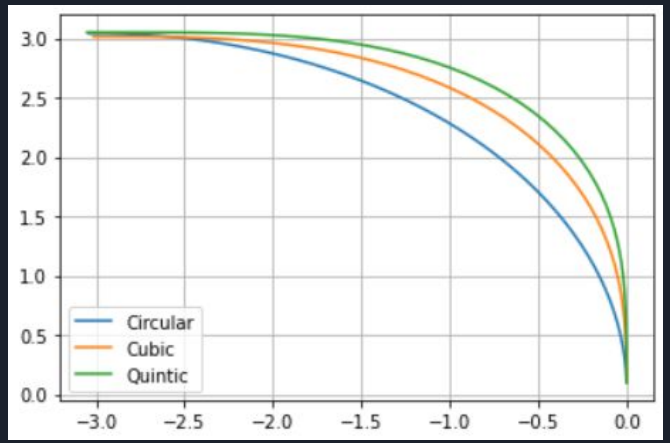


Thresholding_image.ipynb - Colaboratory

Spline Interpolation and Motion Planning

We use A* algorithm for generating array of waypoints that UGV has to transverse to reach target destination.

Spline Interpolation is used to smoothen the sharp turns. We will use cubic spirals to generate smooth local path for the UGV.



Comparison of various ways of smoothening a 90° turn

UGV Movement & ROS Topics

- We created a ROS node string_generator for converting array of waypoints into a string of commands which is then published to prius_teleop node. The cross product of three consecutive waypoints determine the navigation command.

- For 3 consecutive points (x_1, y_1), (x_2, y_2) and (x_3, y_3);

  cross_product = $V_{12} \times V_{13} = (x_1 - x_2)*(y_3 - y_2) - (x_3 - x_2)*(y_2 - y_1)$

  cross_product = 0 —> go straight
  cross_product > 0 —> left turn
  cross_product < 0 —> right turn

- We created a ROS node keyop_prius for utilizing string of commands for generating control msgs for publishing to /prius topic.

- **/prius** - We use this topic for controlling motion of prius car. We publish values of throttle, steer, brake and shift_gears for maneuvering the car

Thank You !