Autonomous ROS Drone

Localisation, Planning, Navigation and Object detection

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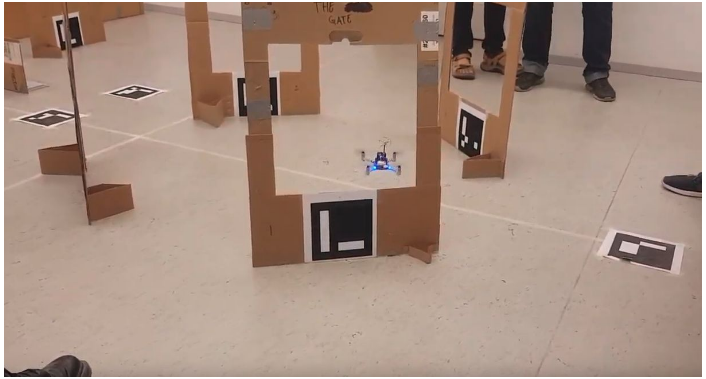
Introduction

- Aim is to program the CrazyFlie drone to enable it to autonomously navigate through a known map and complete a given mission.
- The mission is to pass through certain checkpoints in sequence and locate some objects(Swedish road signs) in map.
- The drone should be able to localise itself using an on-board camera.
- **Keywords**: IMU, Kalman Filter, Python, ROS, RRT, A*, SVM, Machine learning, OpenCV, SciPy, Aruco, HOG features, Gazebo, Rviz.

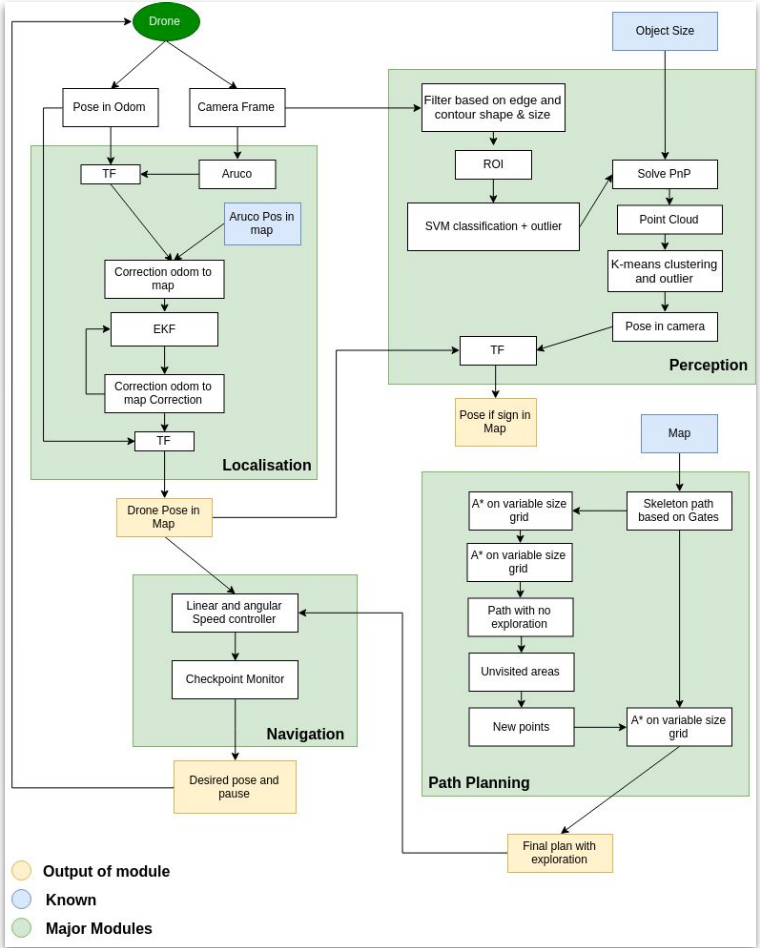


Actual world map with Aruco markers

System Architecture and workflow

- All computing takes place in an of-board computer using ROS.
- Drone and camera is connected via radiowaves.
- Figure below outlines different modules and their cross talks.

Complete System Design



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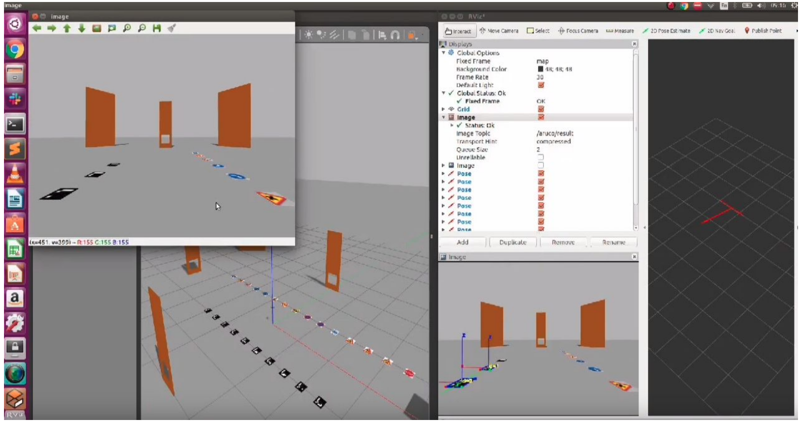
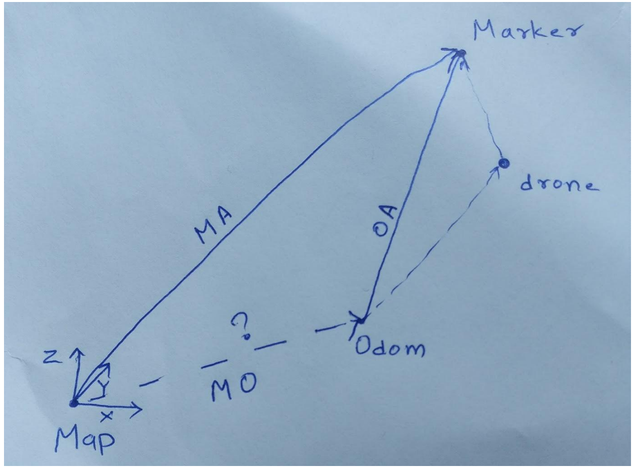
- We developed base algorithm in Gazebo simulation and then implement it on actual drone.
- Rviz and rqt graphs were used for visualization and debugging.
- OpenCV and machine learning used for object detection



Gazebo and Rviz visualisation

Localisation

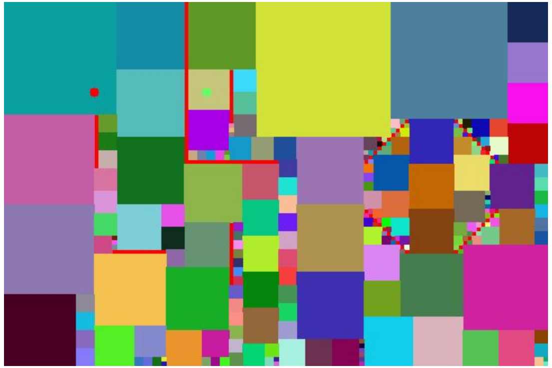
- Aruco packages gives location of marker in odometry frame.
- Known marker location is used to adjust the vector between map to odom center to localise the drone in map frame.
- Kalman filter is used. (Also tried complementary filter)
- Measurement model and prediction step are very simple for our case.



Vector relation between odometry and map frames

Navigation and Path planning

- World is divided into grid and then clustered based on free space.



Clustering of free spaces. Red lines are wall

- A* is used to plan the path on modified grid in map frame, which is then augmented by exploration algorithm.

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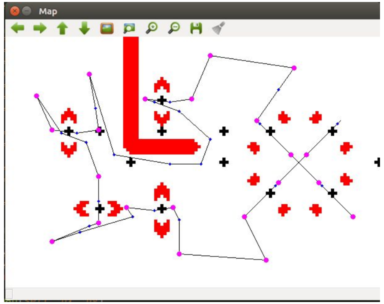
- All boundary points are possible nodes for A* since all boundary points in modified grids are reachable.



Path planning and exploration.

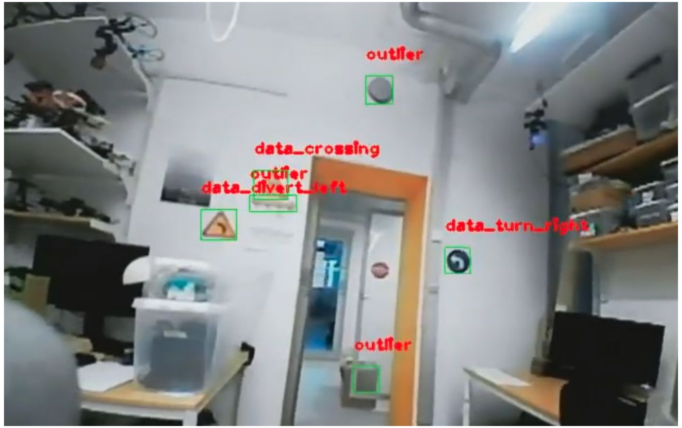
- Each node serves as goal point for drone, which is transformed into odometry frame before sending commands to drone. Localisation is very crucial for correct transformation.

Object Detection

- Images is preprocessed and possible ROI are segmented based on gradients. Which are then fed into SVM for classification and rejection.
- Camera geometry is used to transform position object from image frame to camera frame.
- SVM is trained in HOG(histogram of gradient) feature of signs.

Training set of different sizes. Last image in each row is negative sample

Detection demo



Results

Localisation: https://www.youtube.com/watch?v=JBJQxv_AkvA&feature=youtu.be

Object Detection: https://www.youtube.com/watch?v=FSvuRROtO4k

Thank You!