DRDO'S UAV-GUIDED UGV NAVIGATION CHALLENGE

TEAM 11

Submission Documentation

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                    Depth Input
                         │
                         ▼
                   Image Gradient
                         │
                         ▼
                   Thresholding
                         │
                         ▼
                    Component
                   Segmentation
                         │
            ┌────────────┴────────────┐
            ▼                         ▼
      Road Detection            Car Detection
            │                         │
            ▼                         ▼
      Target Steer           Car Location &
       Direction            Pose Estimation
            │                         │
            └──────┐          ┌───────┴────┐
                   ▼          ▼            ▼
                UGV Control        UAV Control
                                 (Car Following)
                    │                    │
         To /<UGV TOPIC NAME>   To /setpoint_velocity
                    ◇                    ◇
```
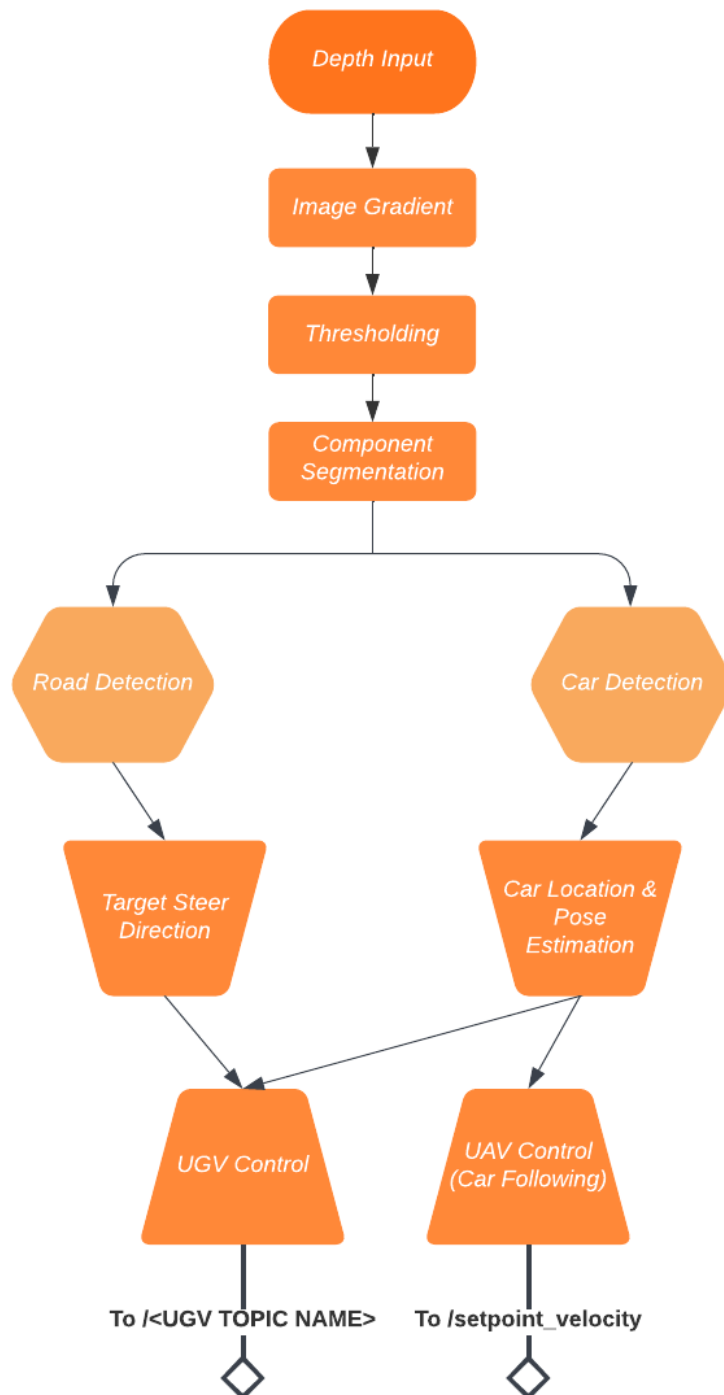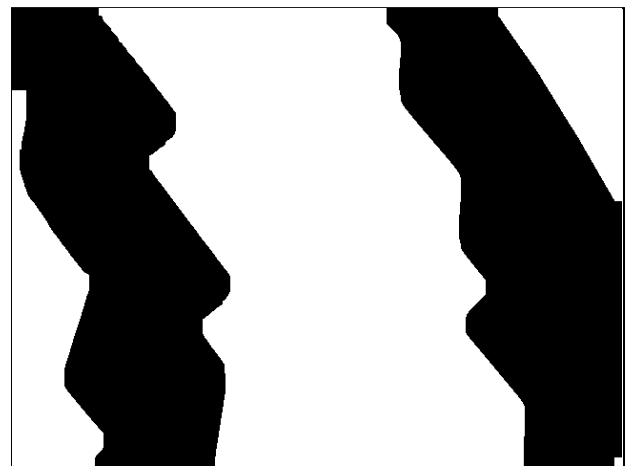
Road Detection

Road detection takes place using depth data from the UAV feed.

First, the X and Y gradients of the depth image are calculated using Sobel filters and then combined to give the absolute gradient at every pixel in the image. This gives a good estimate of the steepness of every feature in the visible terrain.

Next, the gradients are thresholded to differentiate between flat and steep areas of the visible terrain. This gives a mask to identify possible sections of the depth image that correspond to the road.

(Raw Depth Gradient Image)   (Depth Image Gradient)

To extract the component that corresponds to the road itself, the largest connected component is identified and the rest of the components are masked to black. The obtained component is then assumed to be the road.

From the UGV Detection component, the location & orientation are fetched. These are used to estimate the target direction to steer the UGV: A horizontal line at a certain distance above the UGV is scanned and the edges of the road are detected. The midpoint of the detected points is taken to be the target setpoint and passed to the UGV Controller

UGV Detection

After getting the road mask from contours, the car is found by selecting the smallest contour from it. By using the minimum area rectangle function from cv2, we get the bounding box around our car and from this box coordinates we get the center and orientation of car.
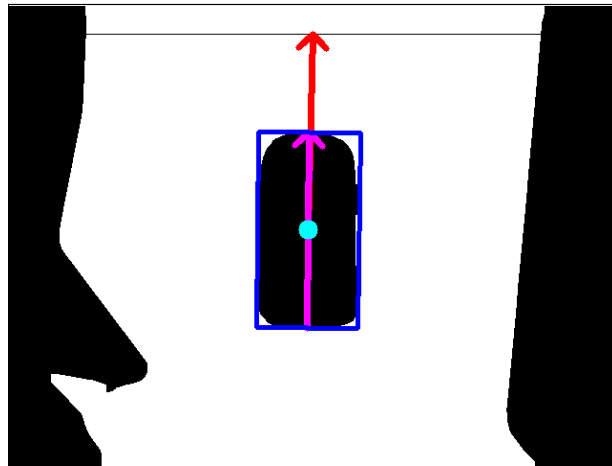
(Car Location & Pose Detection)

UGV-UAV Control

Methodology: UGV leading the path and UAV following the UGV

1. UGV leading the path:
A forward vector is generated by **Road Detection** module which is given to UGV to navigate forward.

2. UAV following the UGV:
UGV center and UGV forward is given by **UGV detection** module, which is passed to the UAV. The UAV first align its orientation towards the UGV forward vector and then navigate forward towards the center to follow the UGV.

In case if anyhow drone deviates from its path and car is not visible to the drone, drone remembers the last known vector and reaches there, meanwhile UGV comes in UAV frame.

ROS Integration:

Depth Image feed from UAV camera

UGV navigating path through UAV Image

UAV following UGV

Navigation command to UGV(Prius model)

ROS Module