Motion Planning

Sameep Pote

Trailer Location Estimator

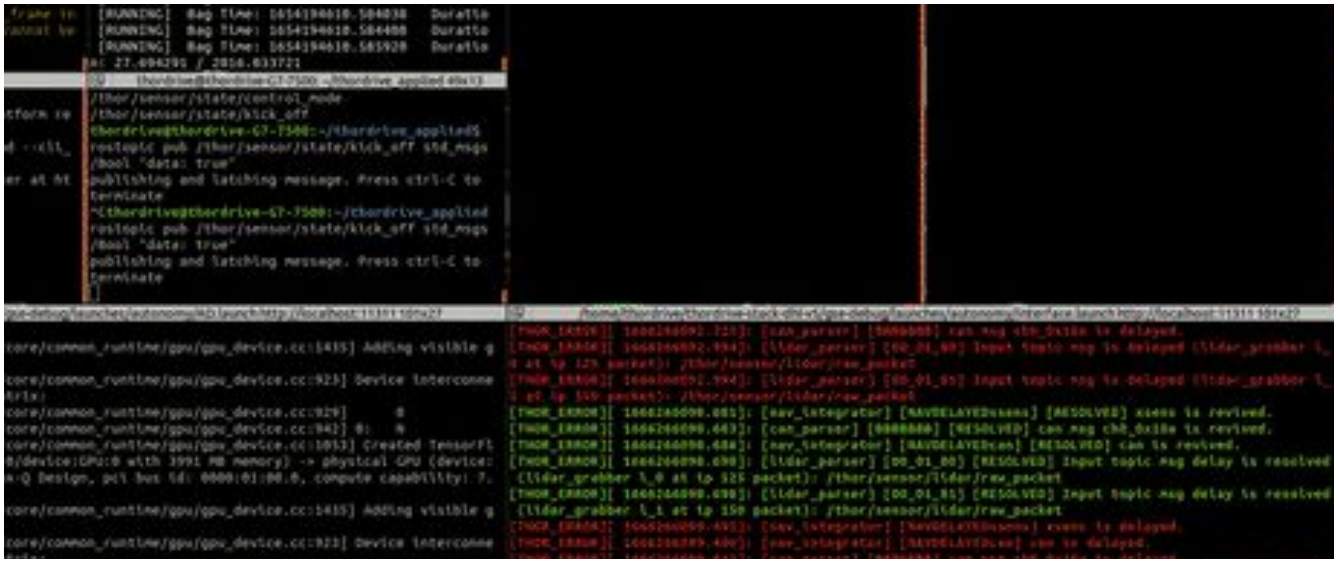
- The dollies behind us do not follow the same path which is followed by the ego vehicle.
- During Turns this might lead to collision and hence taking dollies into consideration is must.
- To predict the future path knowing the current location of dollies is must.
- Using kinematics of car pulling trailer and the data obtained from Localization the position of dollies with respect to the ego vehicle was predicted and visualised of Rviz

$$
\begin{aligned}
\dot{x} &= s\cos\theta_0 \\
\dot{y} &= s\sin\theta_0 \\
\dot{\theta}_0 &= \frac{s}{L}\tan\phi \\
\dot{\theta}_1 &= \frac{s}{d_1}\sin(\theta_0-\theta_1) \\
&\vdots \\
\dot{\theta}_i &= \frac{s}{d_i}\left(\prod_{j=1}^{i-1}\cos(\theta_{j-1}-\theta_j)\right)\sin(\theta_{i-1}-\theta_i) \\
&\vdots \\
\dot{\theta}_k &= \frac{s}{d_k}\left(\prod_{j=1}^{k-1}\cos(\theta_{j-1}-\theta_j)\right)\sin(\theta_{k-1}-\theta_k).
\end{aligned}
$$

THORDRIVE 2

Trailer Future Path Prediction

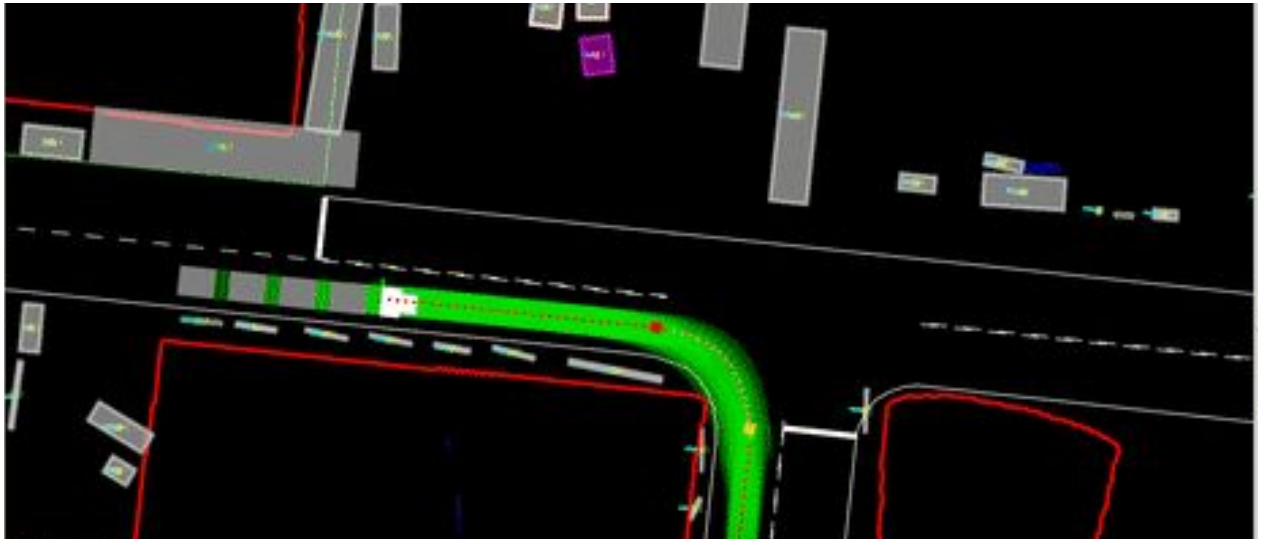
- Once we get the current location we used path provided by reference planner and path planner to predict future path taken by the dollies.
- Depending whether there is collision on with dollies on reference path or path plan decision to overtake the obstacle or stop is made



THORDRIVE 3

Collision Detection

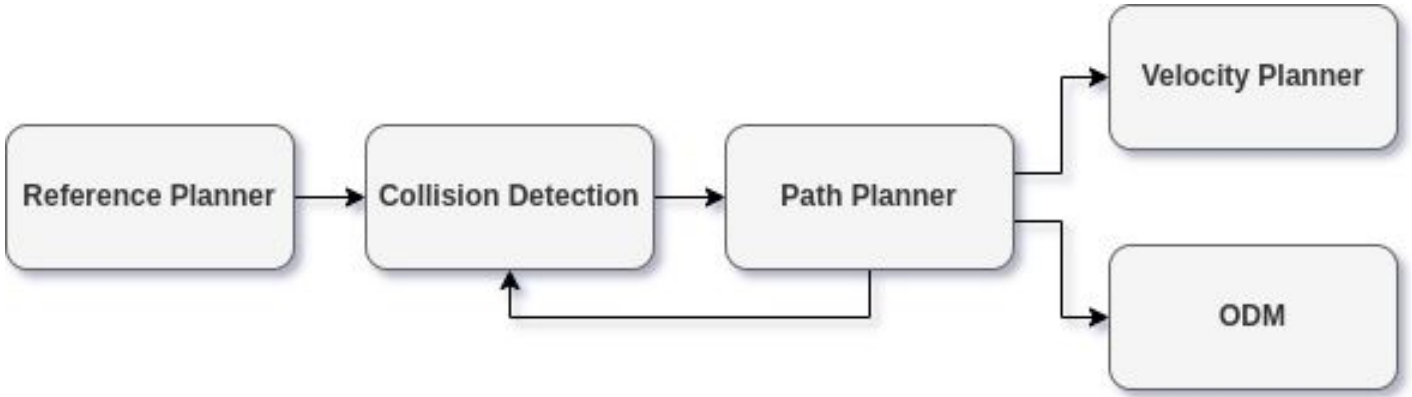
- Once we get the futur path we iterate through the this future path and with the help of risk map check for different types of possible collision on the path



Collision Detection

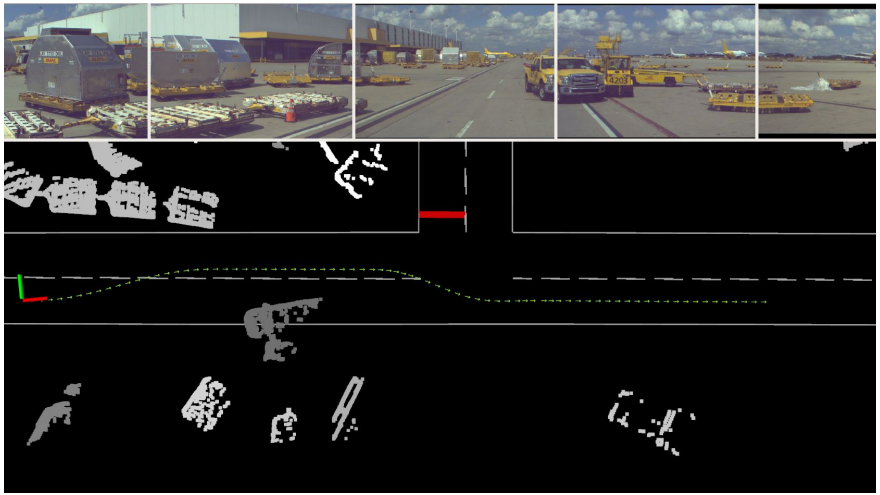
To accurately estimate the current position and predict the future position of the trailers, ego-vehicle carries.

Integration with Stack:

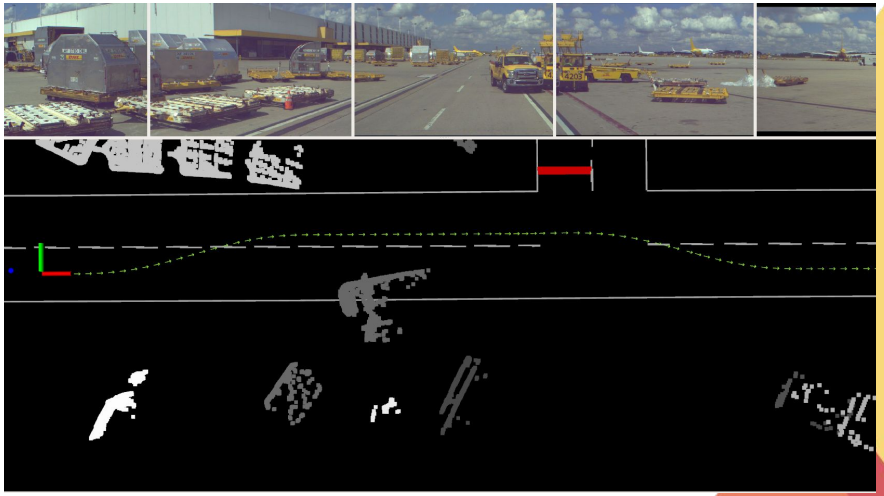


Dolly CTR integration with ODM

1. Making the start point for overtaking more adaptive. Takes into consideration:
   a. Lateral shift
   b. Distance to object on path
   c. Current velocity
   d. Cart Kinematics
2. Adding new costs and improving the cost function
3. Creating more number of potentially feasible paths and finding the lowest cost path among them

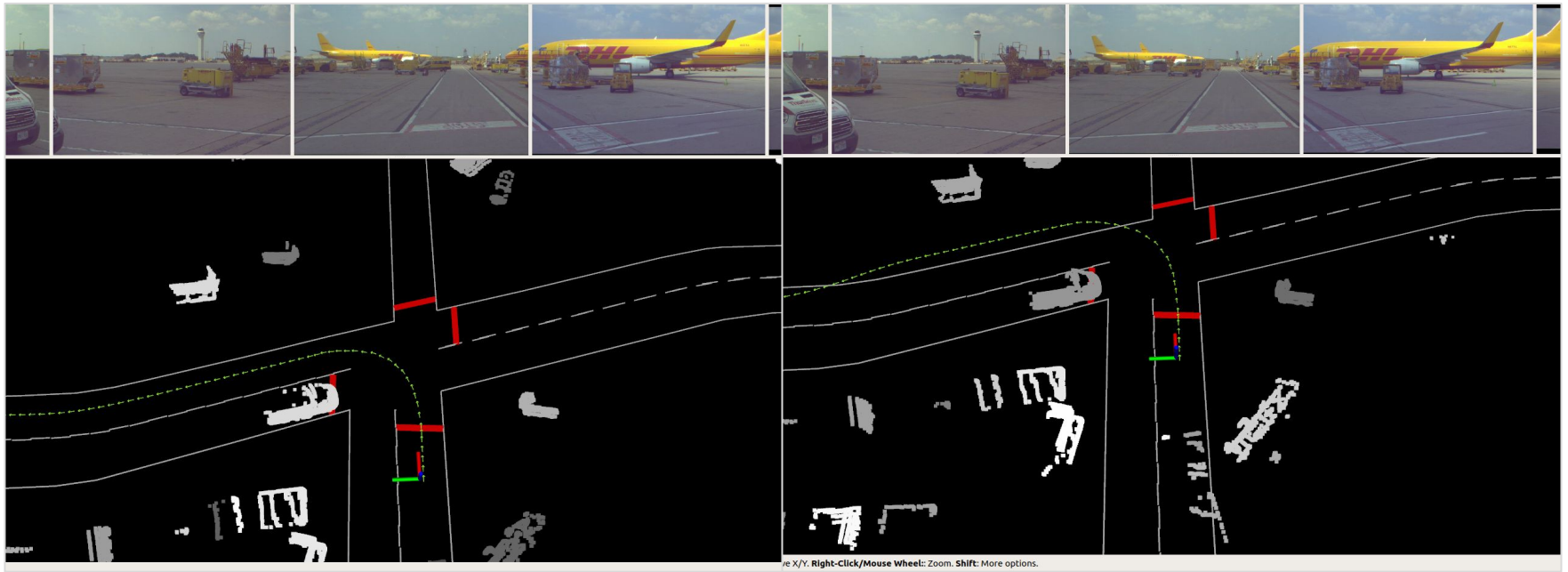


Old Stack



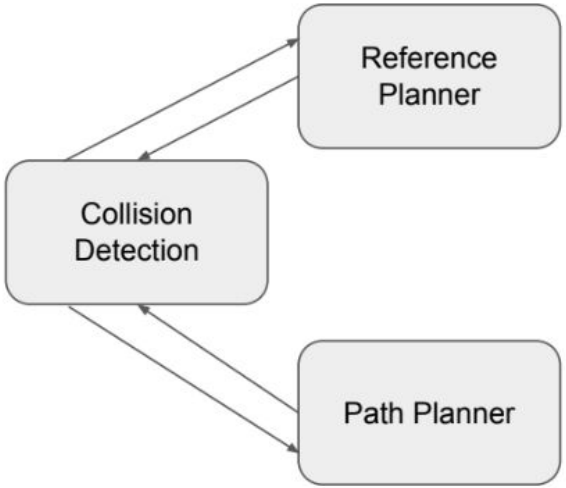
After New Changes

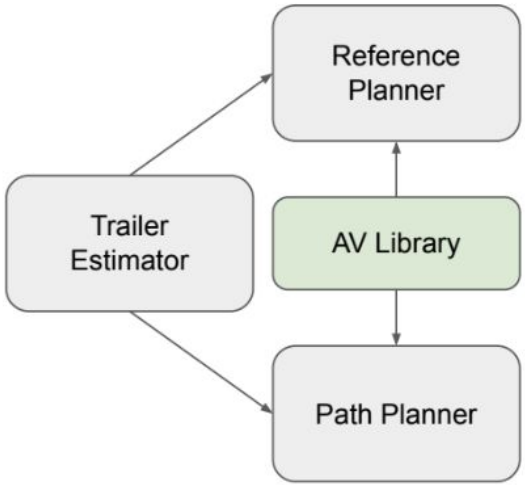
Dolly CTR integration with ODM



Collision Detection AV Library

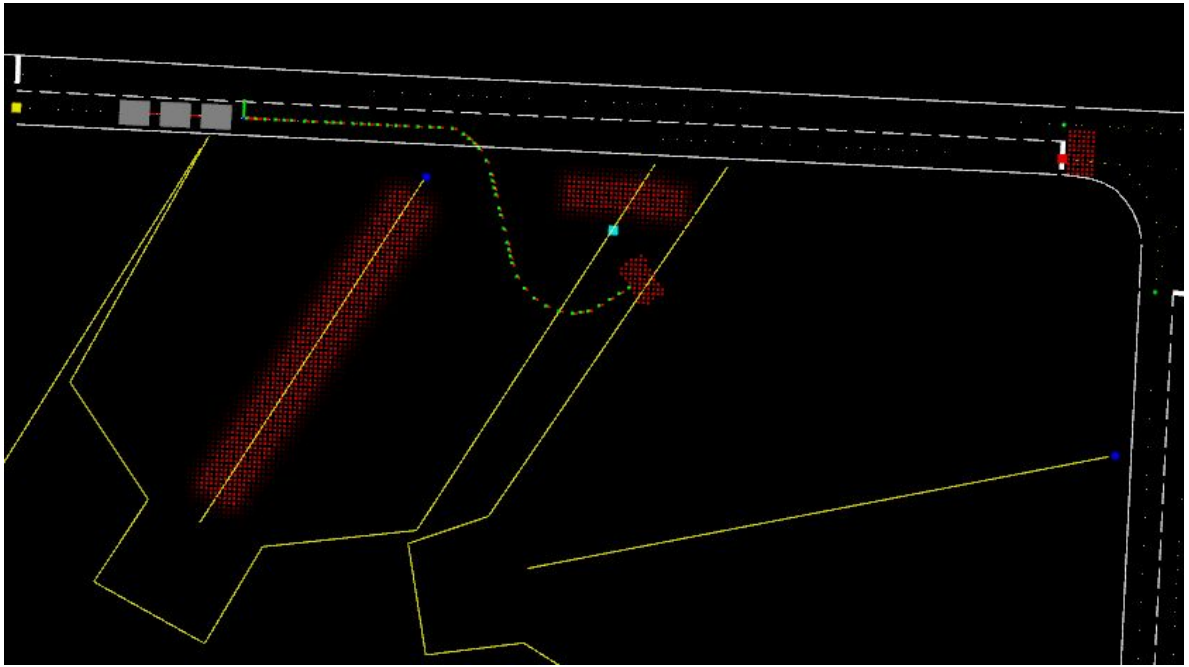
- Requirement of Collision detection in multiple packages
- Transfering ROS messages back and forth to various nodes
- Elimination of the latency caused while transferring this data





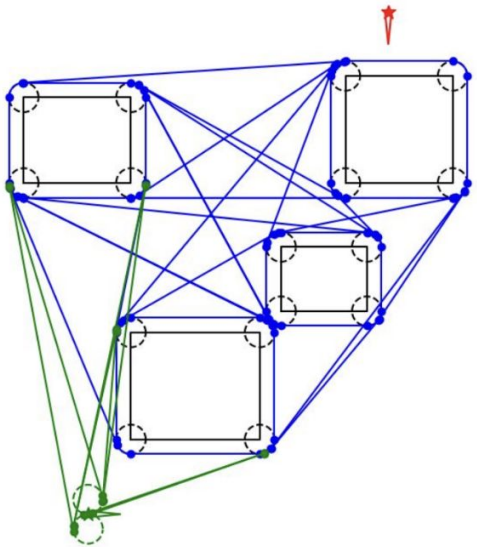
Adaptive Destination

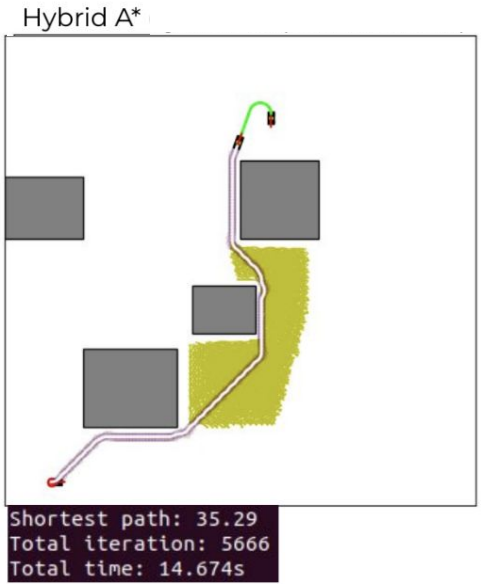
- Getting a new feasible destination using Dijkstra when original destination is no more feasible

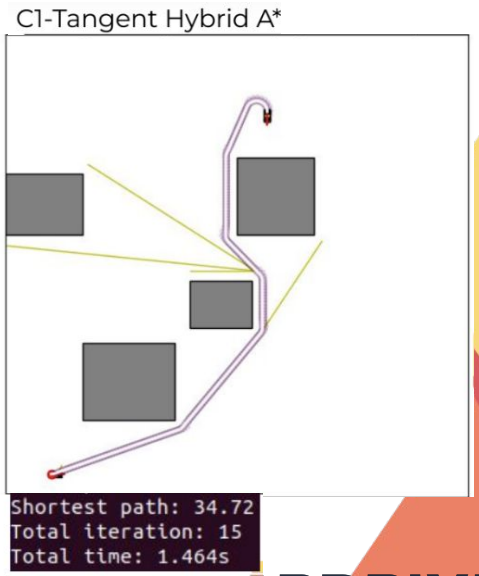


Adaptive Destination Boundary Tangent Method

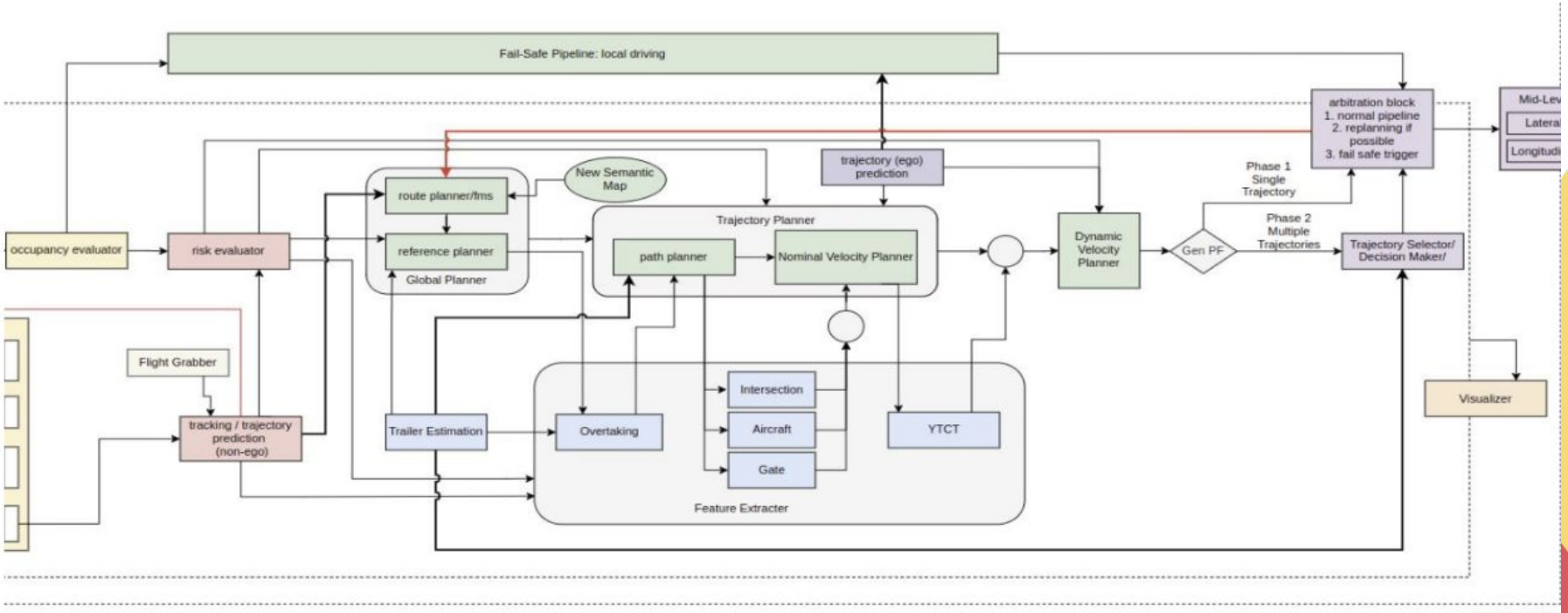
- Create Dubins curve boundary for each obstacle and find common tangents to these boundaries
- Using Hybrid A* Expand only to the neighbour tangent points on these boundaries
- Reduced Number of node expansion hence reduced computational time
- Always yields kinematically feasible and collision free shortest path.







Planning Gen 1 Architecture

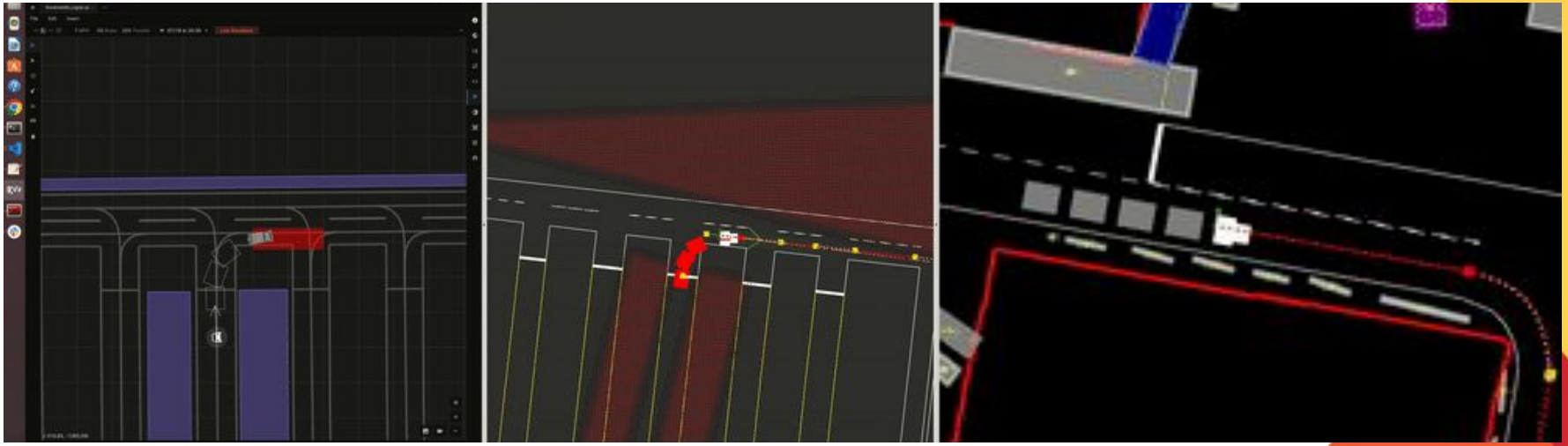


Simulation

Sameep Pote

Features Developed - Trailer Location Estimation Simulator

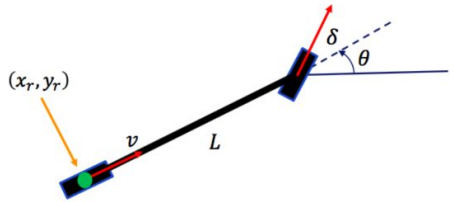
- The dollies behind us do not follow the same path which is followed by the ego vehicle.
- During Turns this might lead to collision and hence taking dollies into consideration is must.
- We simulate the same in Simian to find collisions in the simulation world.



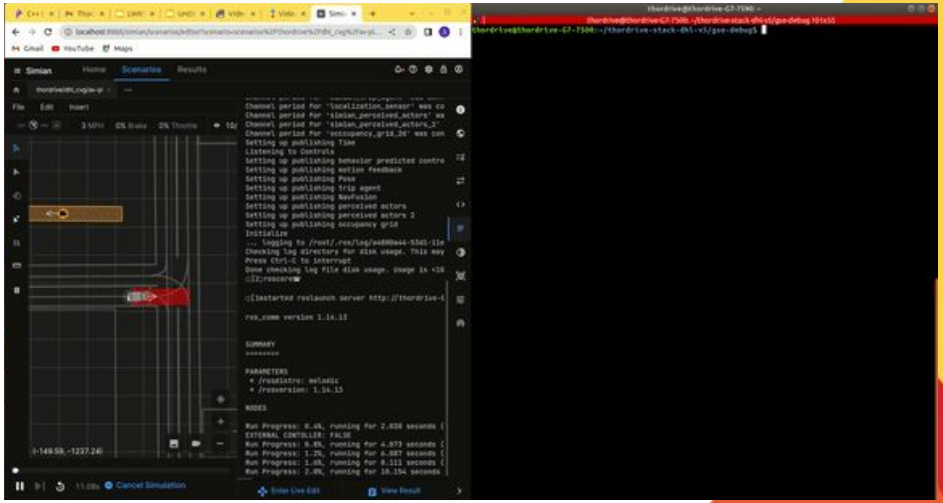
THORDRIVE

External Controller mode

- Using the external controller (EC) an operator can give ‘manual’ commands to the vehicle
- Instead of generating just a straight line in the direction requested through the controller, we predict the trajectory of the ego vehicle with inputs from wheel angle and velocity to understand its current state
- Adding same functionality to Simulator world
- This helps us to debug docking while in simulation mode.



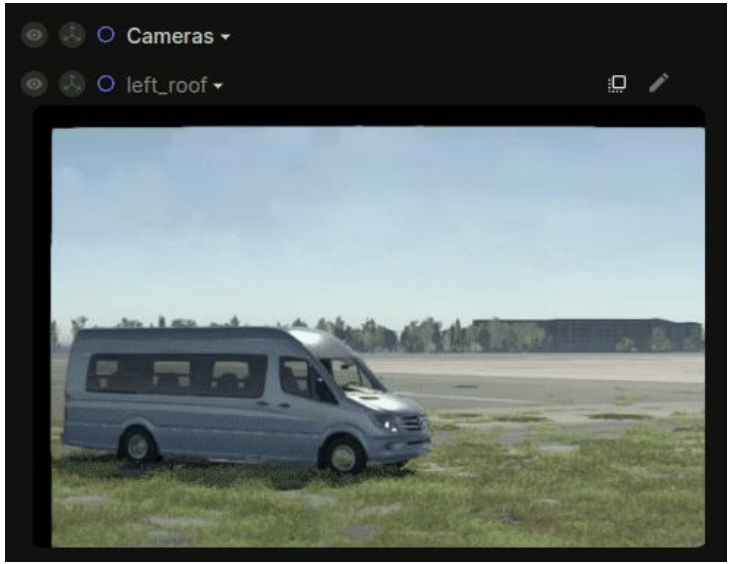
Kinematic bicycle model



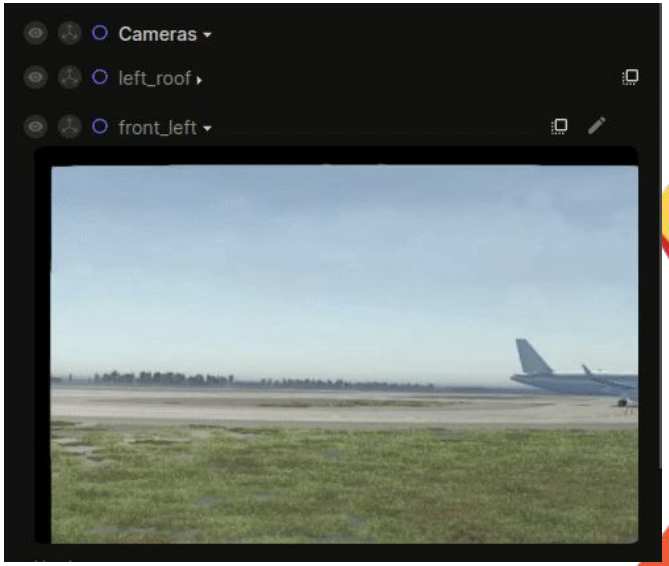
THORDRIVE

Sensor Vibrations

- In real world it was observed that there is fluctuation in risk because of vibration when the TUG is moving.
- The same behaviour was bought to simulation world which would now help perception team to tackle this problem.
- Currently we are collecting more vibration data from field to make this feature as realistic as possible.



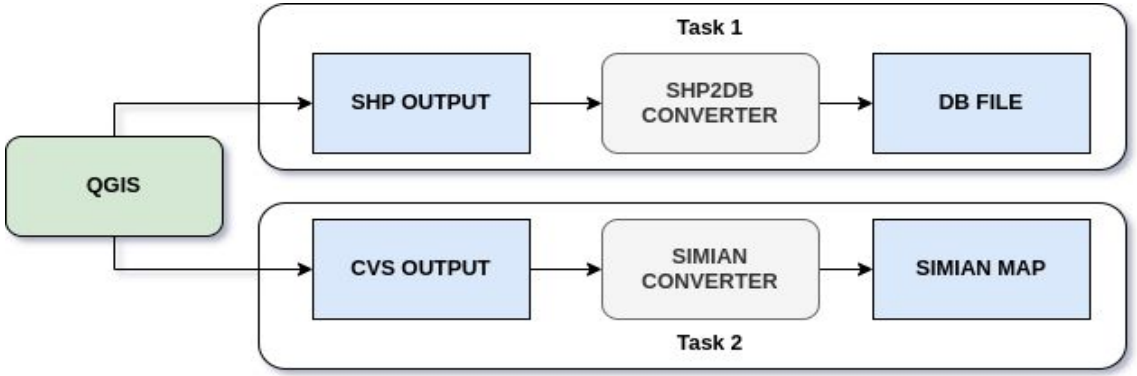
Simulation Without Vibration



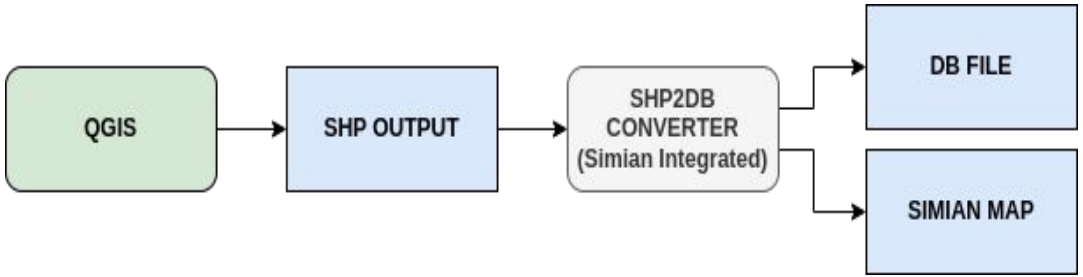
Simulation With Vibration

THORDRIVE

Map Converter Update



Old map converter



New map converter

THORDRIVE

Visualization

Sameep Pote

Visualiser

- One package to take necessary data from all planning packages and visualize data on RViz.
- Add informative visualizations for e.g. Different colours of stop sign for different types of stops.
- Add graphical data representation for an overview of vehicles kinematic performance.
- Converting the whole visualization to 3D with proper object meshes