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Praktikum Simulation von autonomen Fahrzeugen

Vorstellung 31.03.21

Gruppe 2

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6. Intersection
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   b. Street Object Detection
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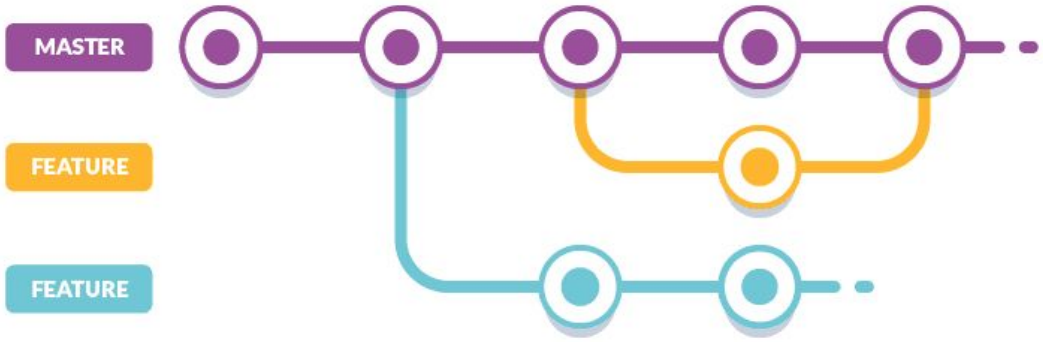
Workflow



- Feature description and assignment with Issues
- Master is protected
- Merging to master is only possible if pull request is approved by at least one
- Pull request should be checked by someone who was not involved at developing the feature

Global Planner

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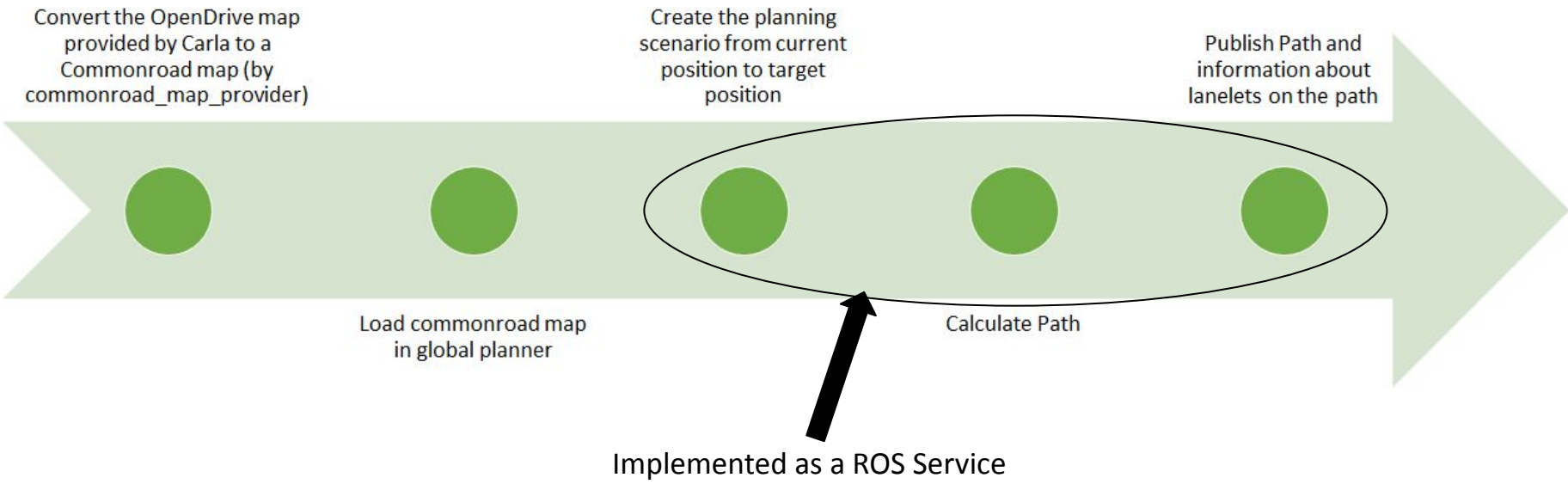

Global Planner

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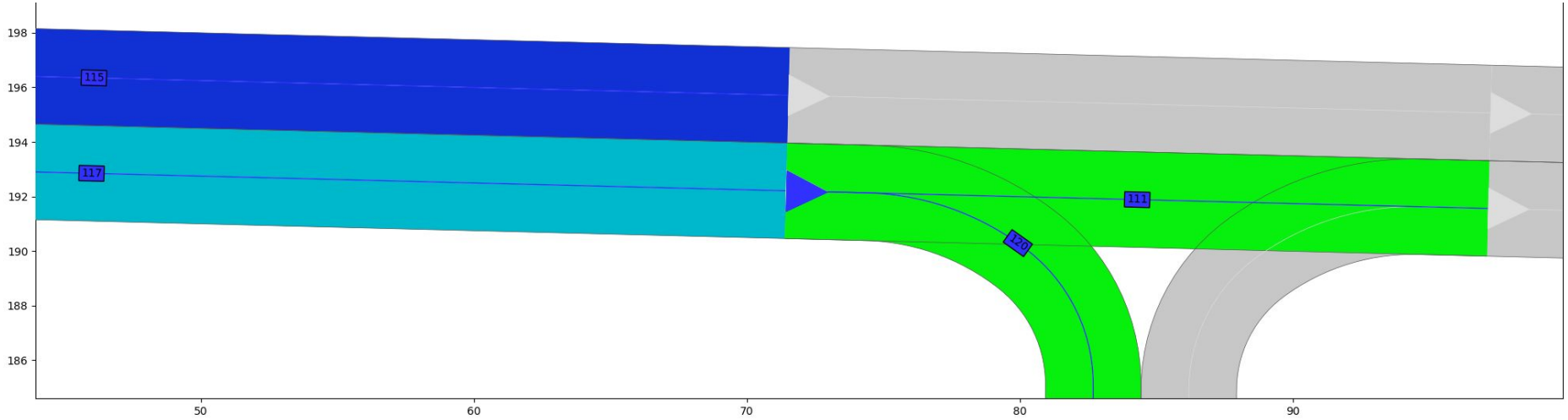
Lanelets



- Cuts road network in separated sections (lanelet).
- Every lanelet owns a left, right and centerline. Those lines are described by polylines.
- Every lanelet can own a left/right adjacent lanelet.
- Every lanelet can own zero to n predecessors/successors.
- Those lanelets form a graph.

Global Planner

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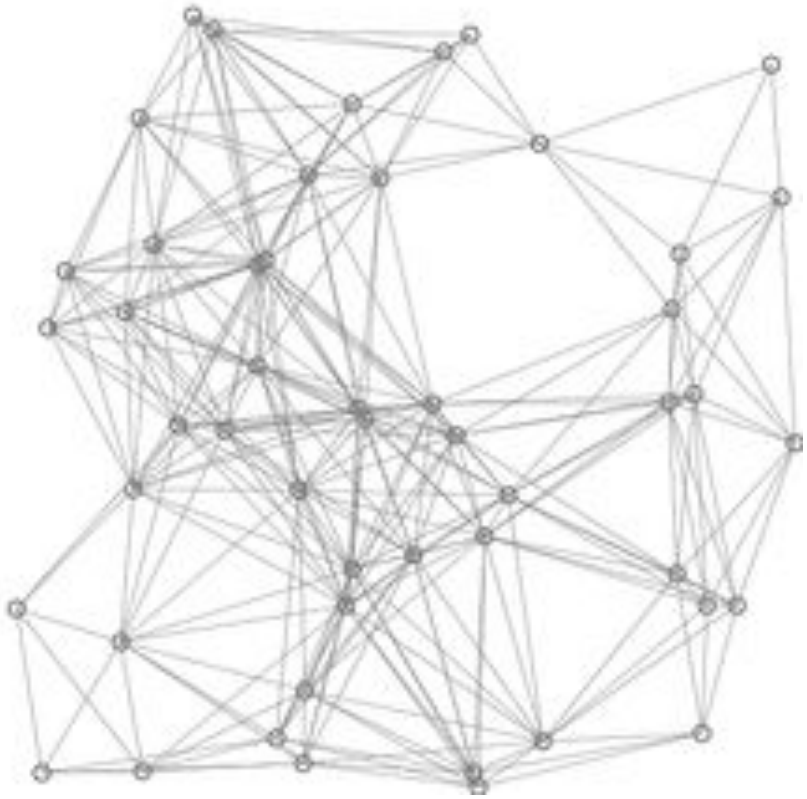
- Planning is done via graph search (Dijkstra) from Commonroad.
- Publish the path as array of points.
- Publish information that is used for the local planner:
  - lanelets on the global path.
  - lanelets that form parallel lanes.
  - lanelets that belong to an intersection.



Core functionalities

If we don’t consider traffic rules or more complex behaviours, the aim is to compute Vehicle Control Commands, so that

- we get from A to B,
- at a controlled speed
- without crashing into anything.

To achieve this, we need

- a path from A to B, that avoids static obstacles,
- a sensor to detect dynamic obstacles on this path,
- a set of controllers that compute steering commands from this information.

Core functionalities as ROS-Nodes

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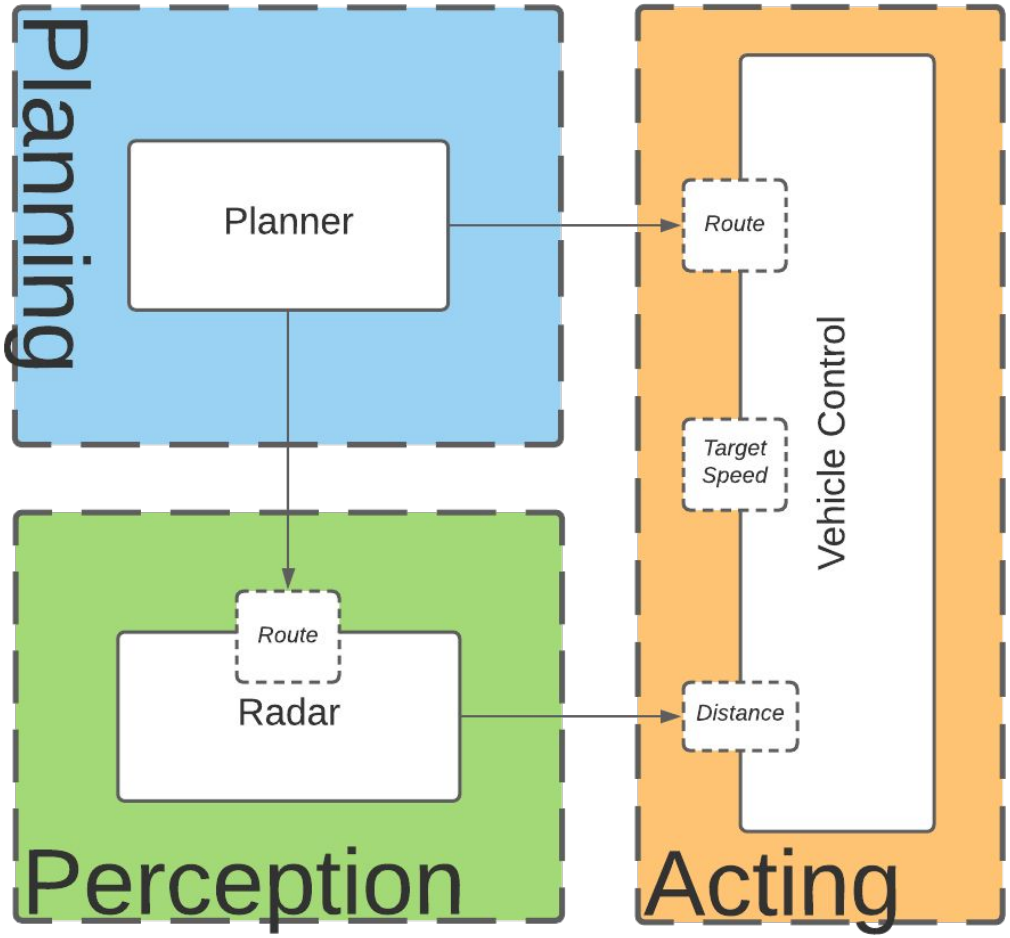
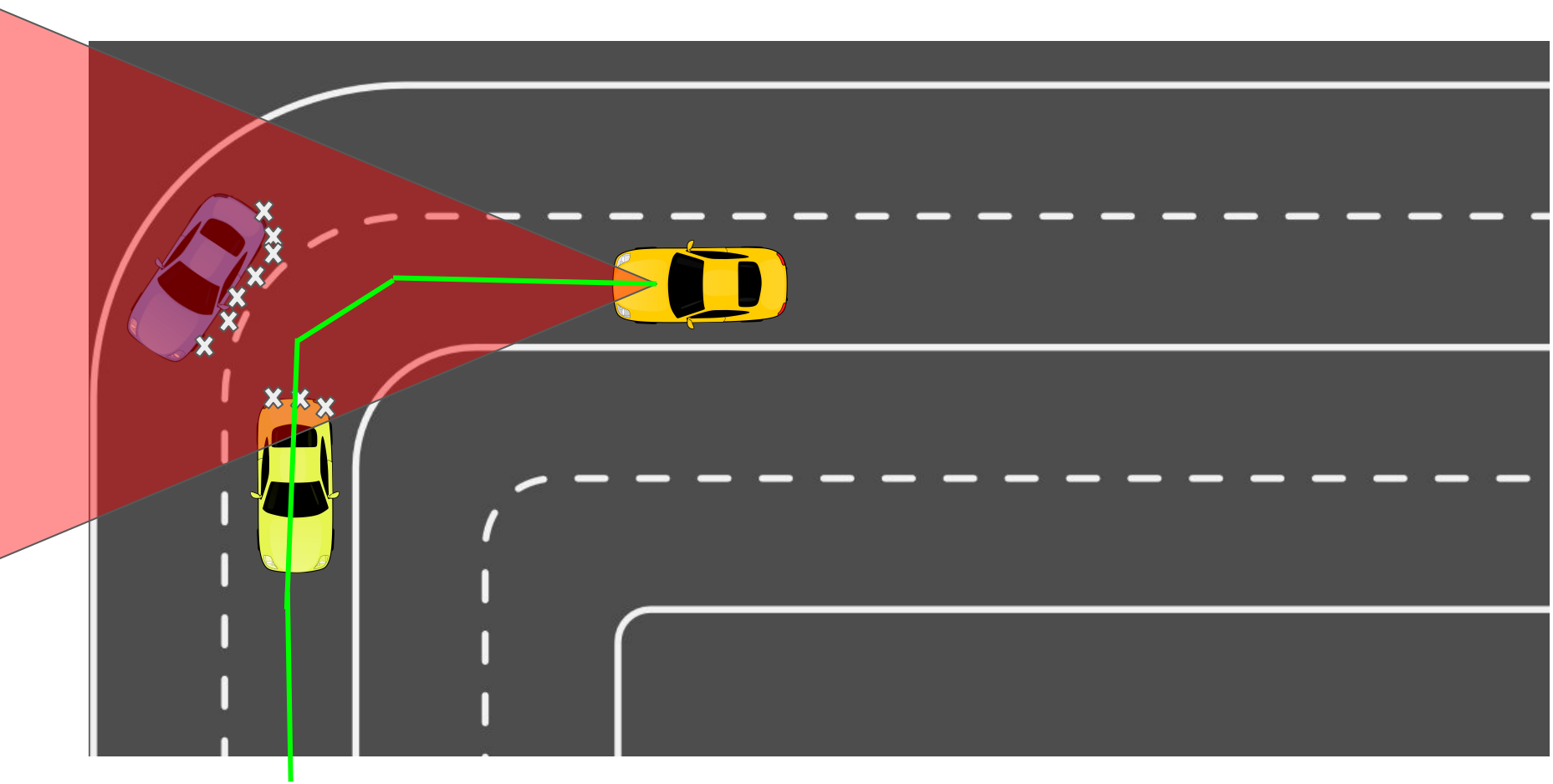


Radar



Vehicle Control - Longitudinal

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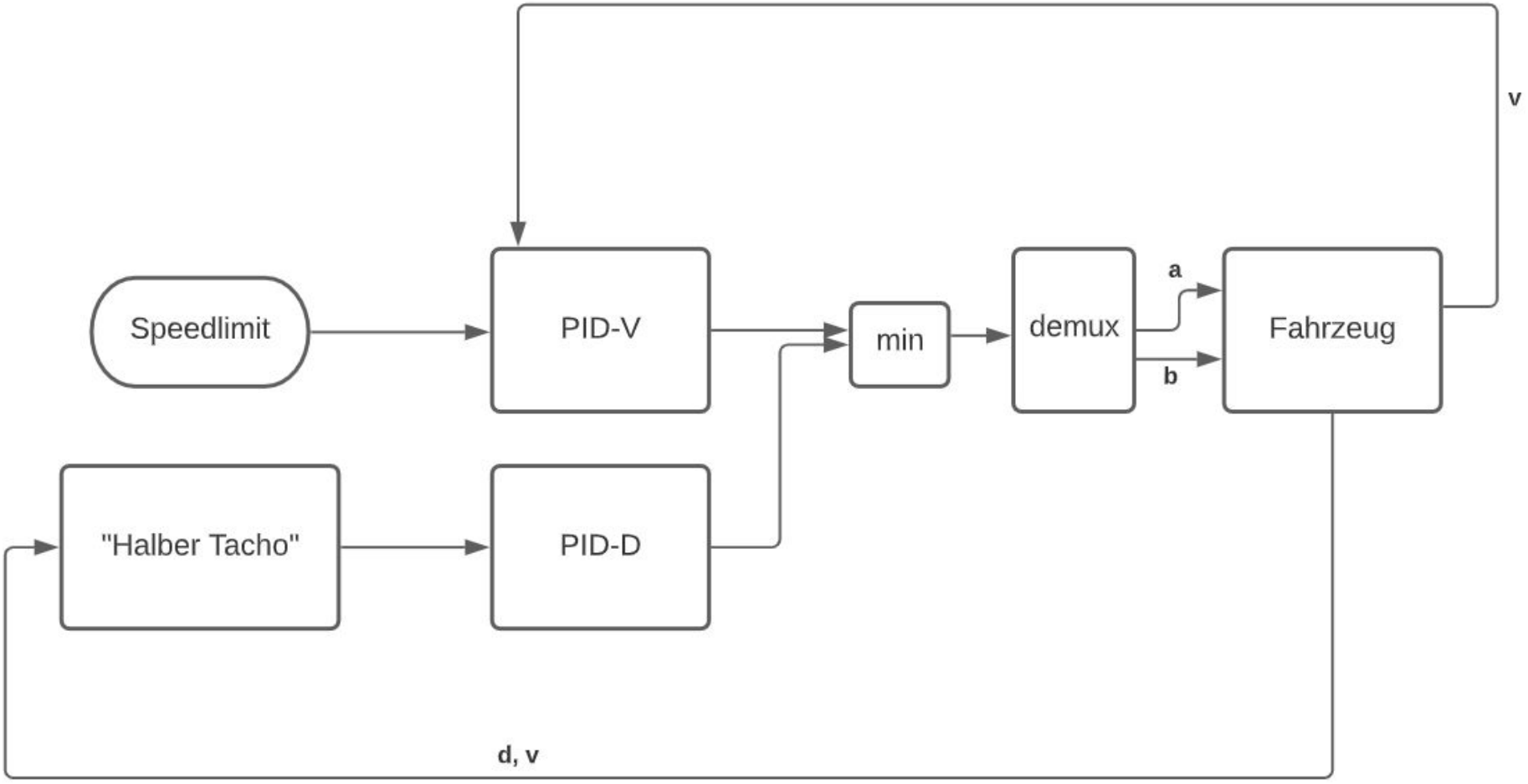

Vehicle Control - Lateral

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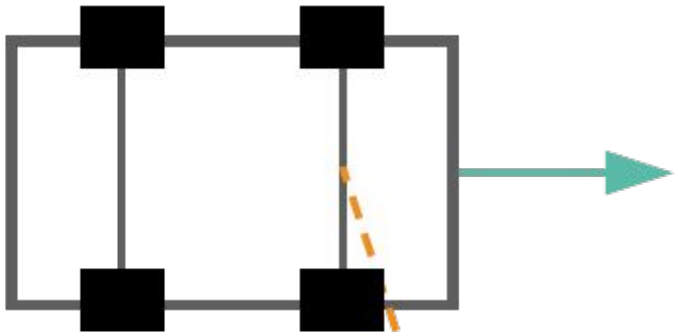
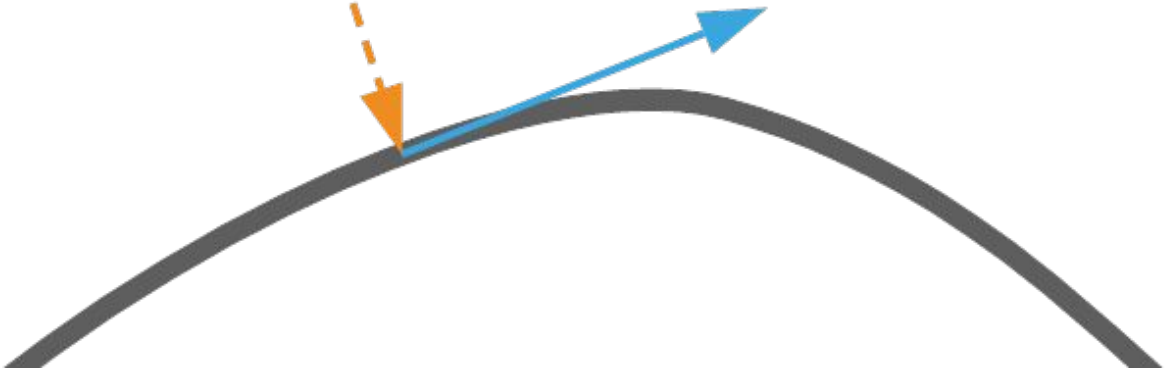
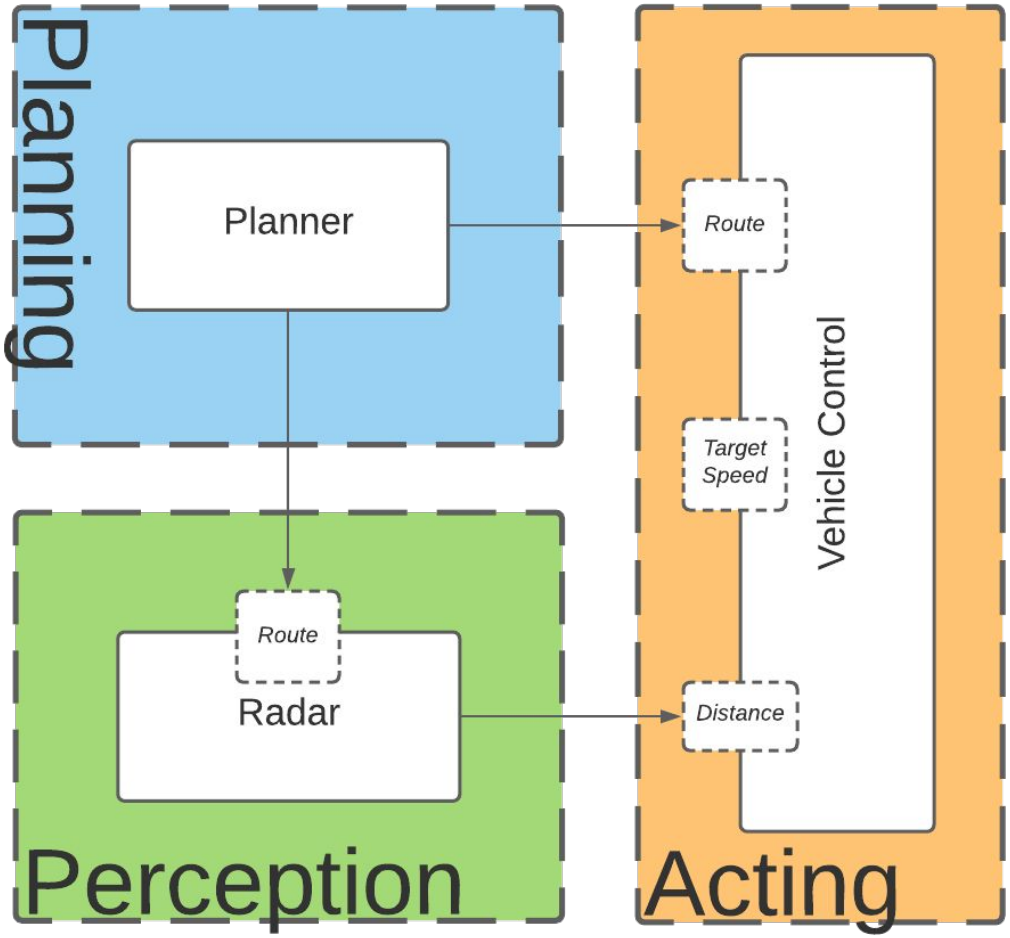


$$s = \theta_e + \theta_d$$



Basic Nodes


Planning
Planner
Route
Target Speed
Distance
Vehicle Control
Route
Radar
Perception
Acting

All Nodes

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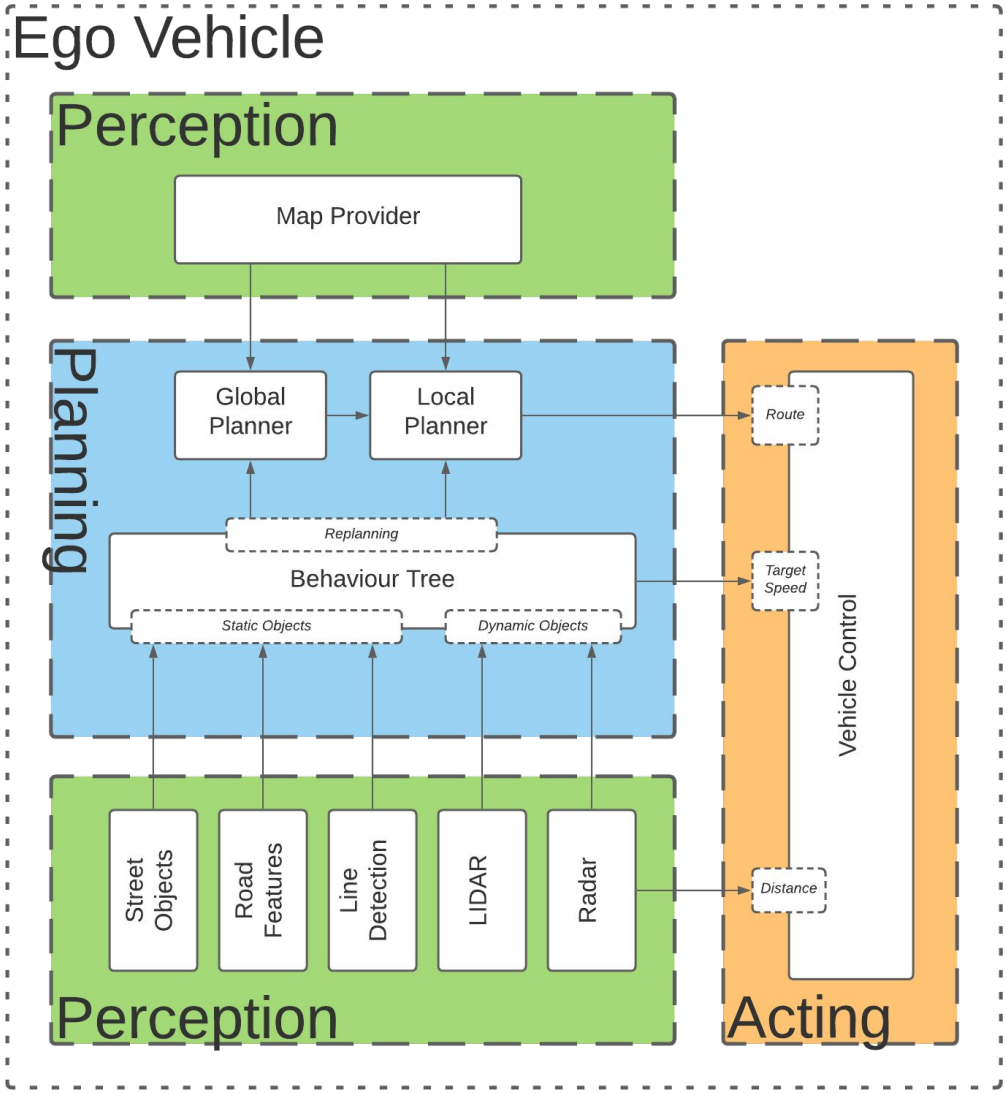

Our Behavior Tree - Overview

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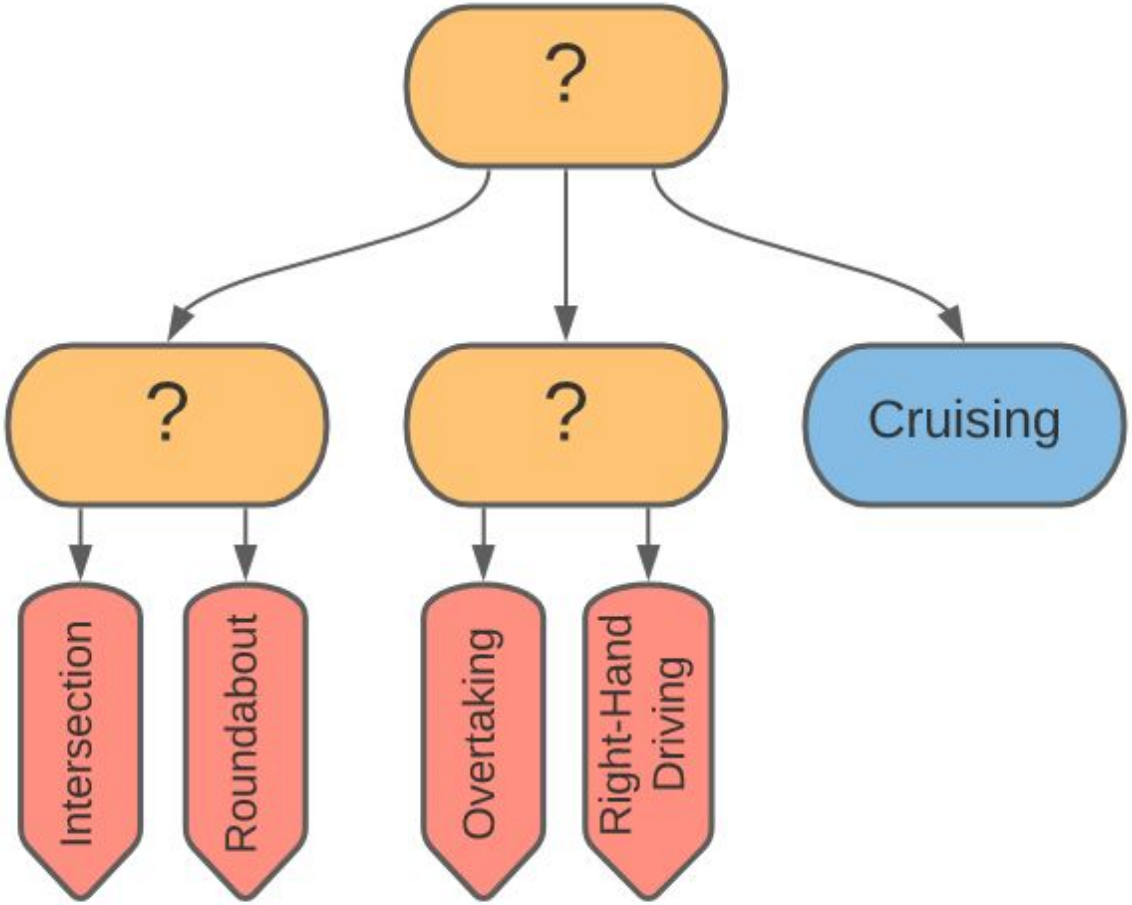

Our Behavior Tree - Intersection Subtree

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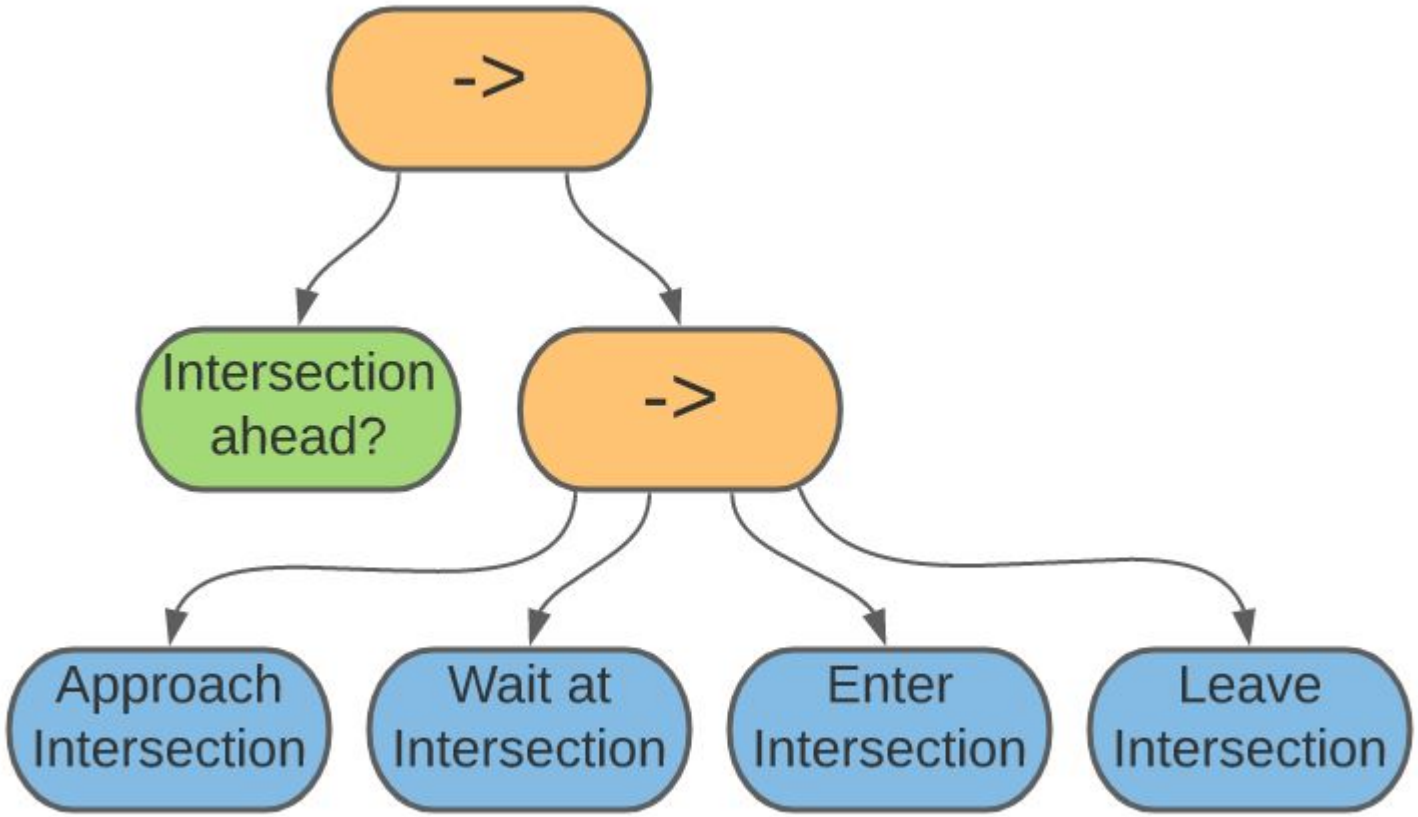

Our Behavior Tree - Overtaking

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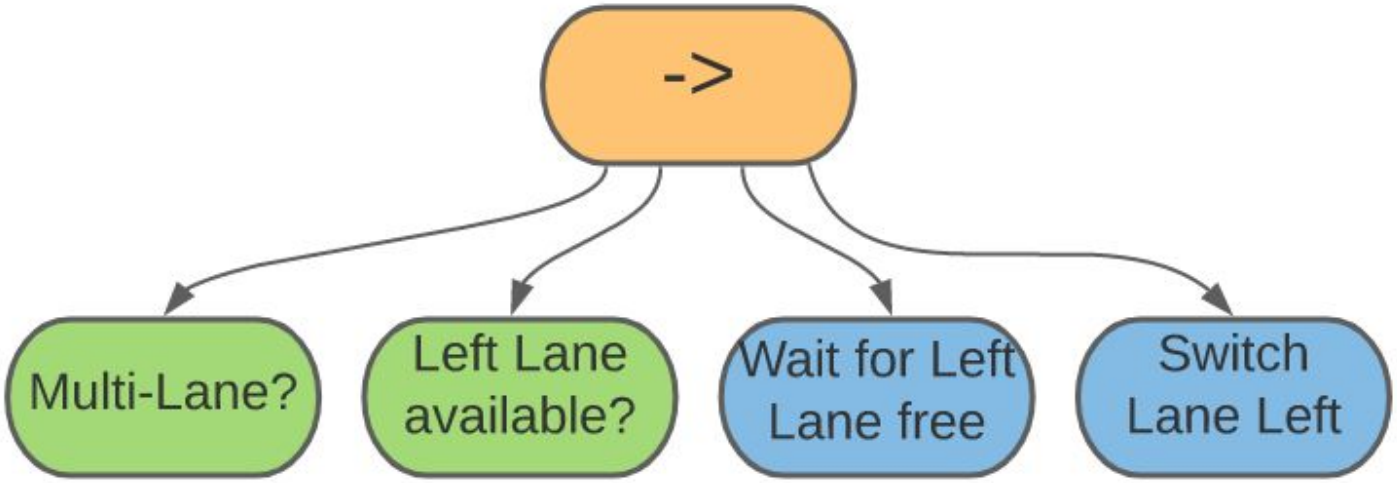

Our Behavior Tree - Right-Hand Driving

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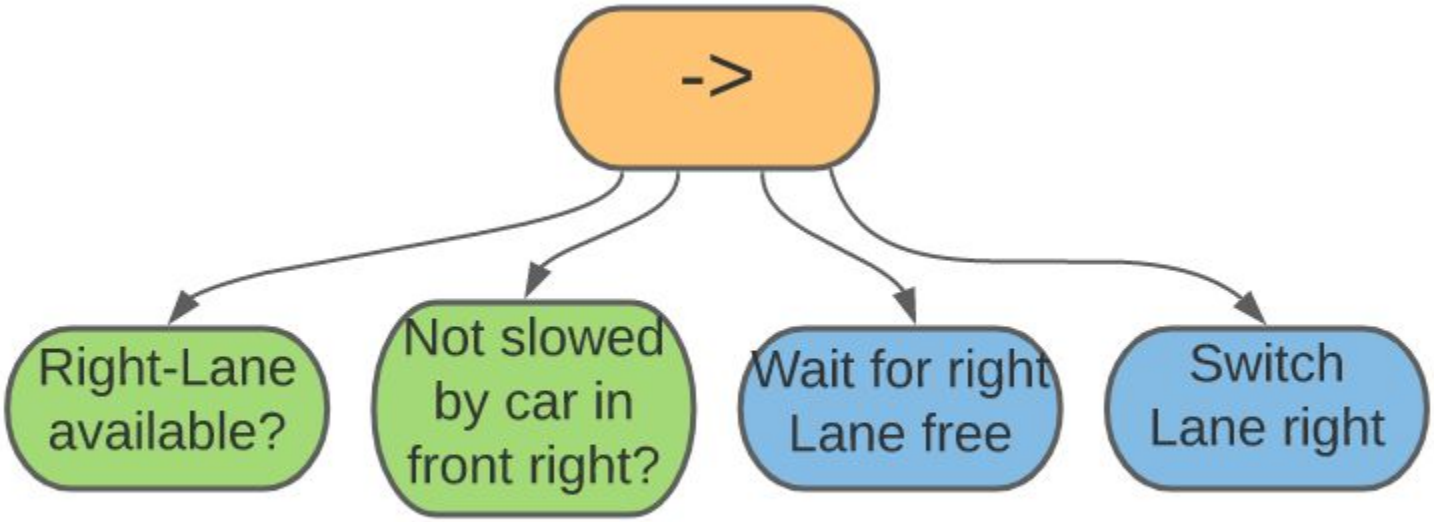

Behavior Tree - Strengths

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- Easy to modify/extend
- Easy to understand/read
- Modularity
- Reactivity
- Can be visualized easily (useful for debugging)
- Whole skeleton can be implemented in advance -> not everyone needs to know how BT works

Overtaking - Lidar

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Main Function:

Overtaking - Lidar

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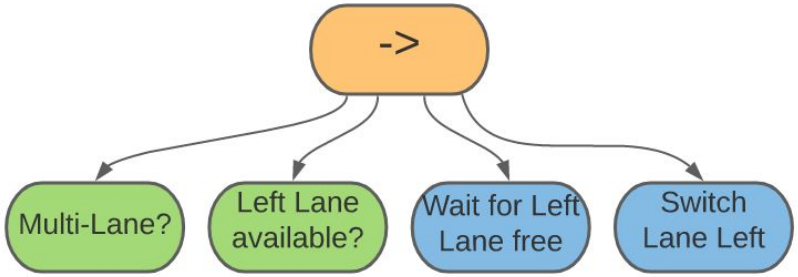
Main Function:



Overtaking - Lidar

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Adjustability:

- **amount of points**
- field of view
- position of sensor
- range

Overtaking - Lidar

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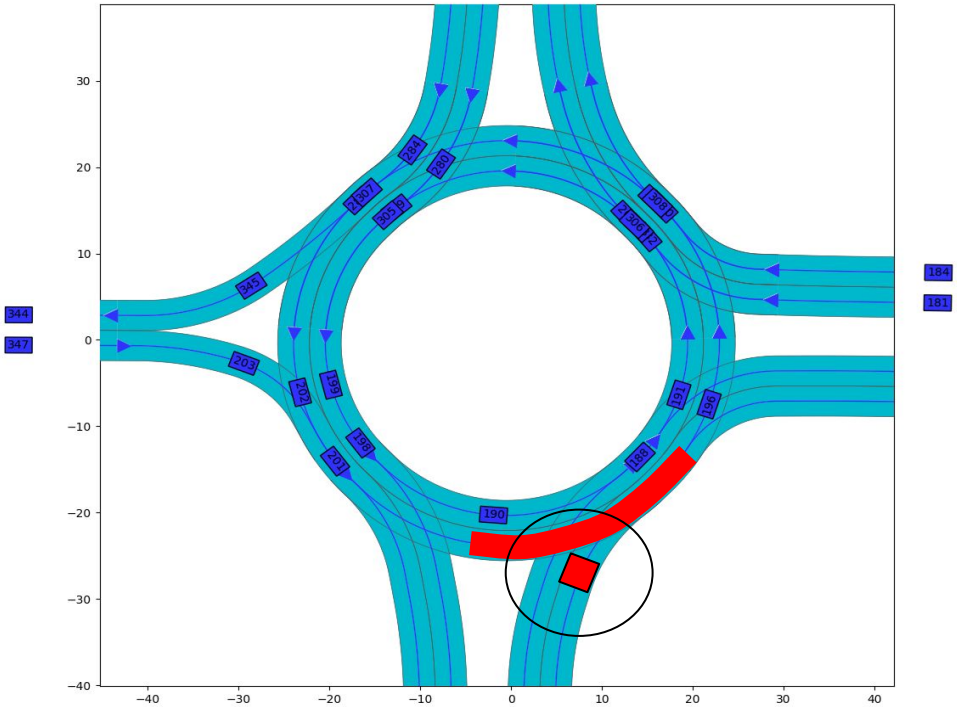
Ros-Service:

- transforms points into map coordinates
- filters the transformed points for points on given lanelet (by id)
- returns true or false, if there is an obstacle or not



Overtaking - Maneuvers

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Switch-Lanes:

- called via Ros-Service “update_local_path”
- includes boolean for change to left and right lane
- next 10 points on current lane, then switch to 30th point on next lane

Intersection - Stop Line Detection

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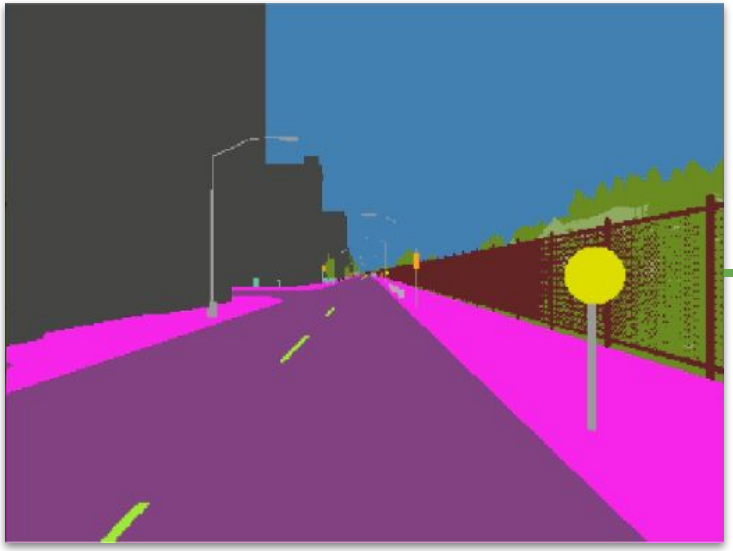

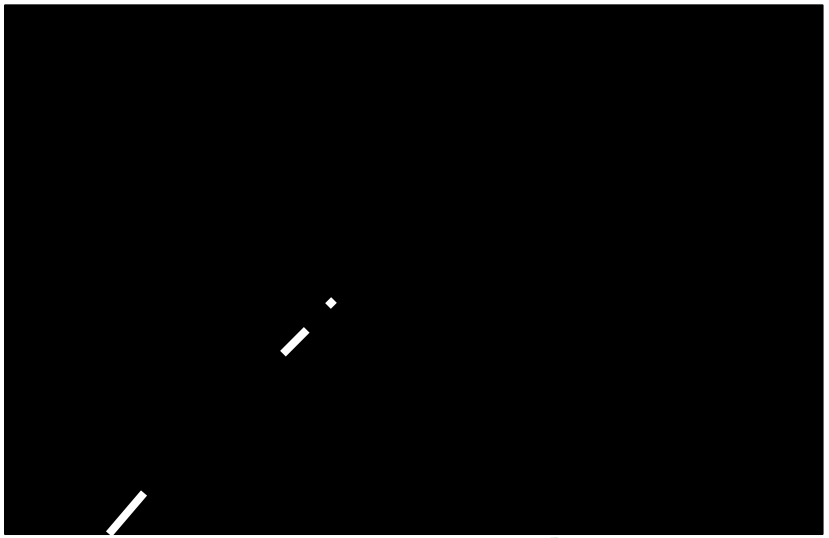

position	angle	length
(3.2,4.8)	1.721	5.3
...	...	...

position	angle	length
(3.2,4.8)	1.721	5.3

distance

Intersection - Street Object Detection

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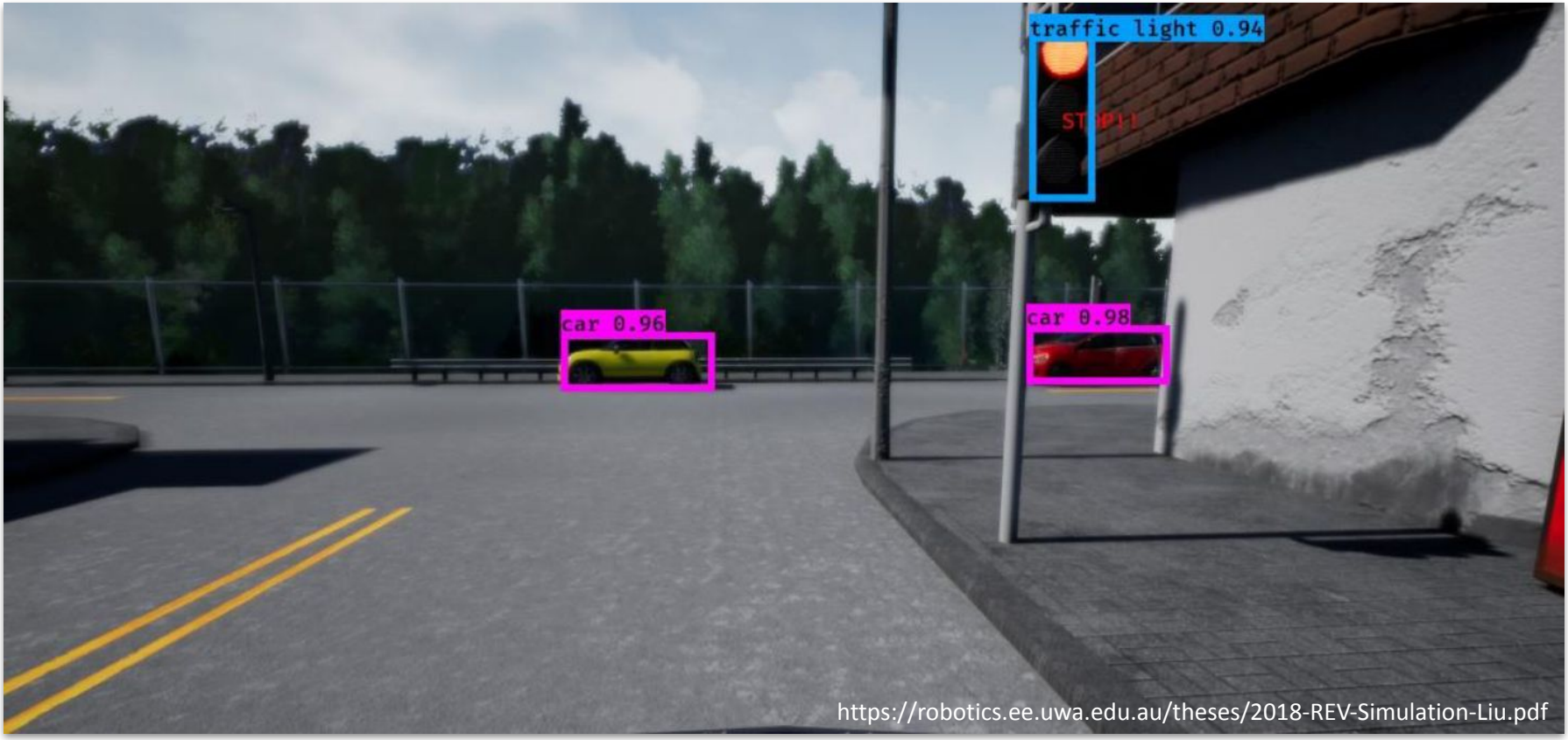
First approach

- YOLO (You Only Look Once) real-time object detection system
- Darknet: neural network framework



Intersection - Street Object Detection

First approach

- YOLO (You Only Look Once) real-time object detection system
- Darknet: neural network framework

Disadvantages

- huge dataset is needed
- needs a lot of performance
- overload for what is really needed

Intersection - Street Object Detection

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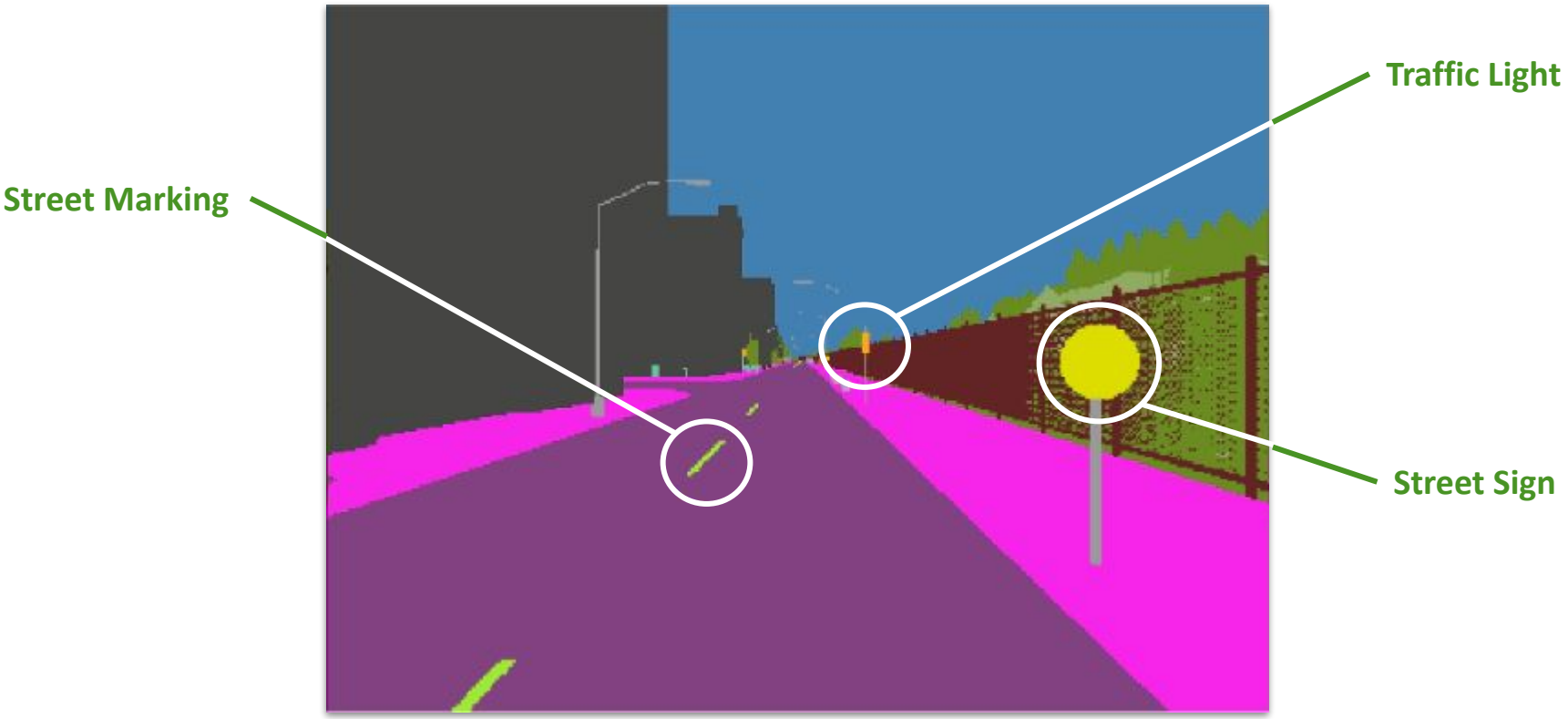
Second approach

- Semantic Segmentation Camera
- Pixel analysis
- OCR (text recognition)



Intersection - Street Object Detection

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First step (street signs)

- Cut relevant objects out of semantic segmentation camera and map them to rgb camera

Semantic Segmentation Camera

RGB Camera

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Second step (street signs)

- Manipulate image for clear edges
- Use text recognition to get the value of speed limits

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First step (traffic lights)

- Cut relevant objects out of semantic segmentation camera and map them to rgb camera

Semantic Segmentation Camera

RGB Camera

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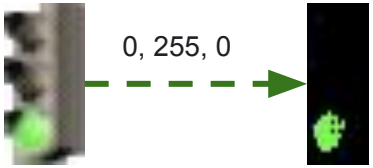
Second step (traffic lights)

Publish in Topic → **“RED”**

Traffic lights are analyzed by the specific dominant color within the extracted image.

Publish → **“YELLOW”**



Publish in Topic → **“GREEN”**

Conclusion

- Core Nodes (Planner, Radar, Vehicle Control) work well together. They are simple and very effective.
- Behaviour-Tree was the right choice for the problem at hand, but it created a lot of research- and implementation overhead. A more traditional solution (statecharts) might have yielded the same results in less time. (mostly because i have more experience designing those)
- Behavior Tree is a good choice as it helps debugging and understanding the system and gives structure
- Optimize global planner to use shortcuts in “no rules” mode
- Line-Detection works okay, but horizontal lines appear very late on the semantic segmentation camera. That makes stopping at a line hard. A HD-Maps-based approach would have been more stable.