Motion Primitive Tree Planner MPTree

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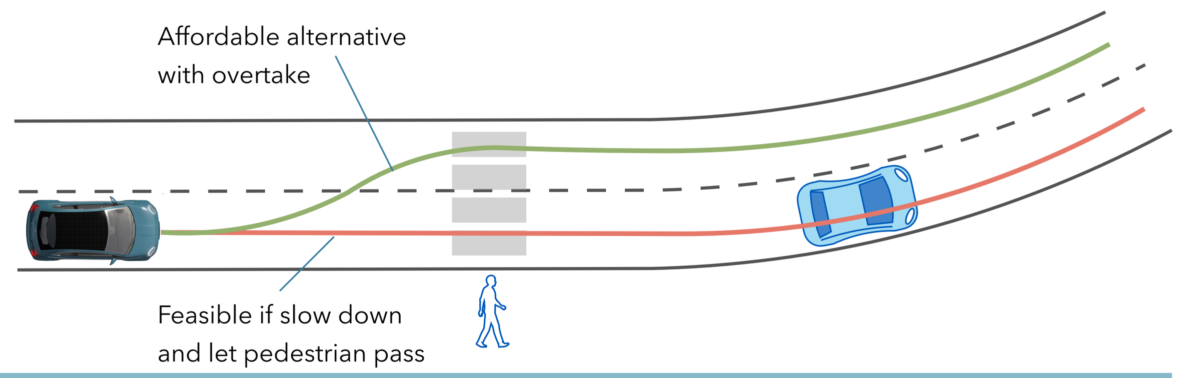
MOTIVATION

Trajectory planning for **autonomous vehicles** with dynamic obstacle avoidance

Model Predictive Control (**MPC**) have a high computational time and find sub-optimal solutions

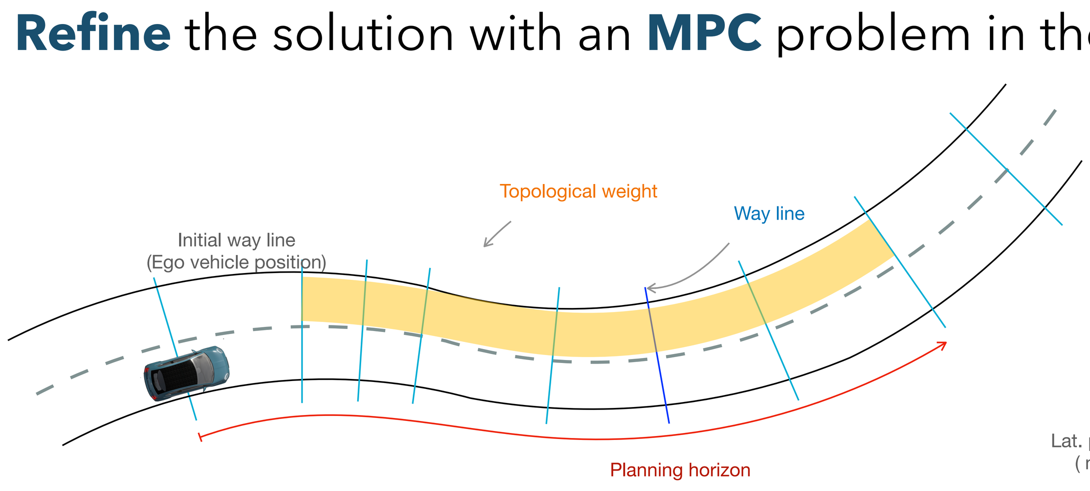
Sampling-based exploration methods (**RRT***) generally not suitable for real time

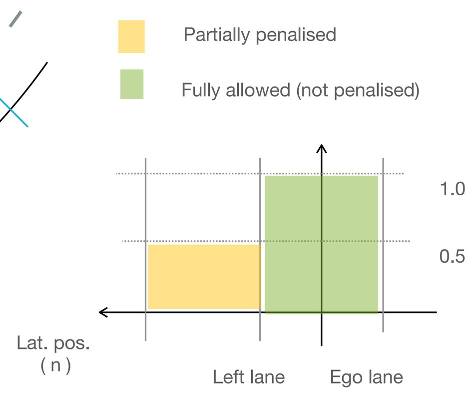


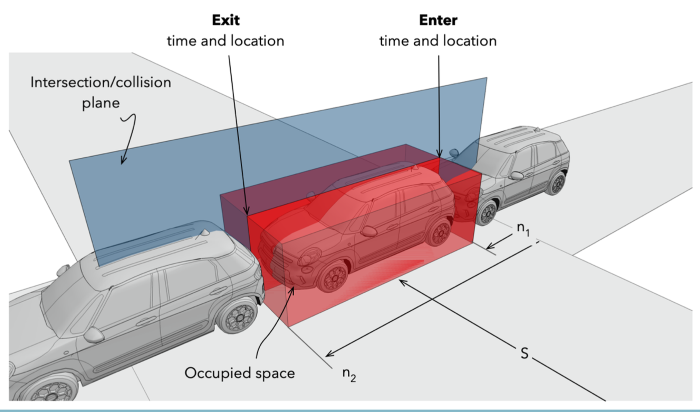
PLANNING FRAMEWORK

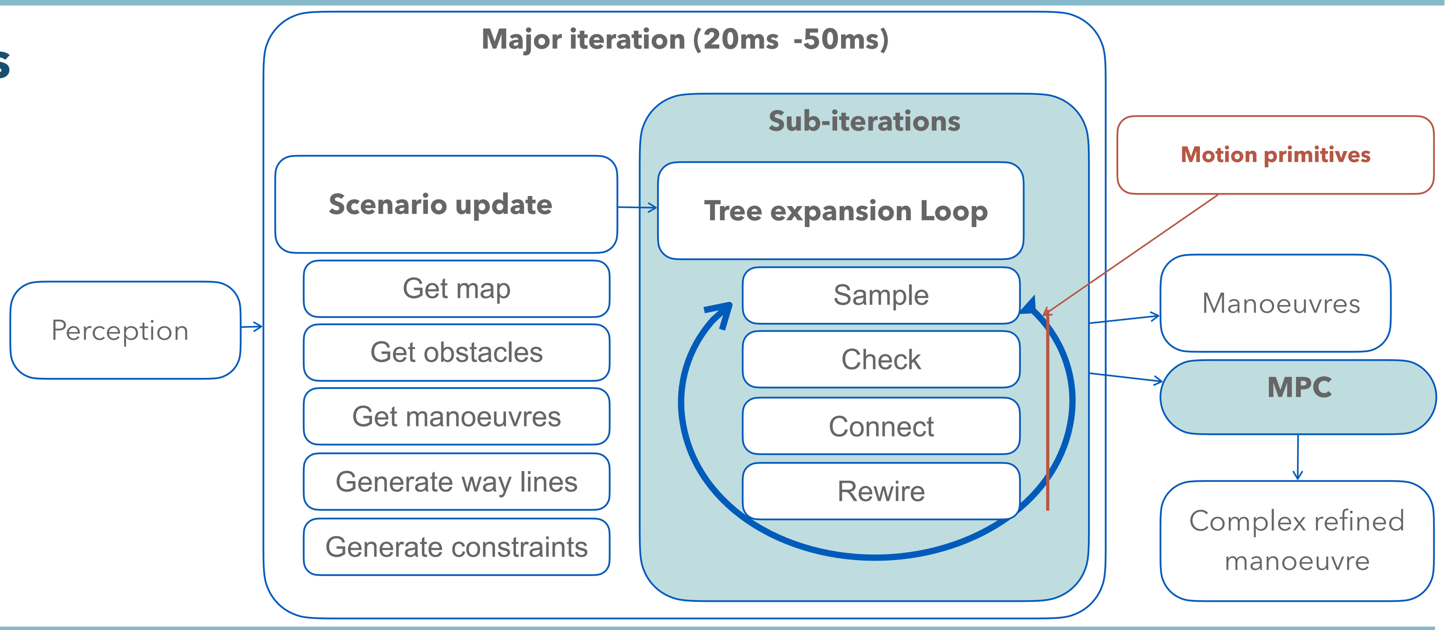
Sampling-based exploration in a **structured** grid to expand a tree of optimal **motion primitives**

Refine the solution with an **MPC** problem in the computed **collision-free corridor**









METHOD

URBAN

- Trajectory planning with dynamic **pedestrians** and moving **vehicles**
- **Cooperative** maneuvre exchange
- Combining multiple planning **goals**: minimum jerk, minimum time, reference speed error
- Motion primitives to connect pairs of waypoints:
  1. **Path**: G2 clothoids (curvature continuity ensured)
  2. **Velocity** primitive: semi-analytical optimal control problem

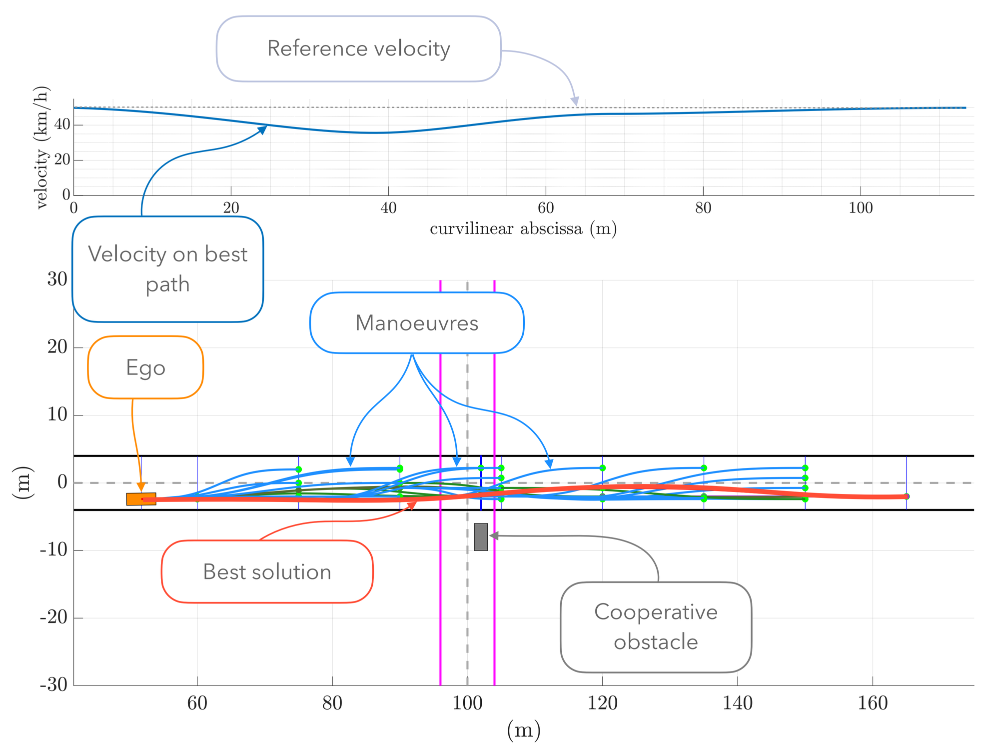
RACING

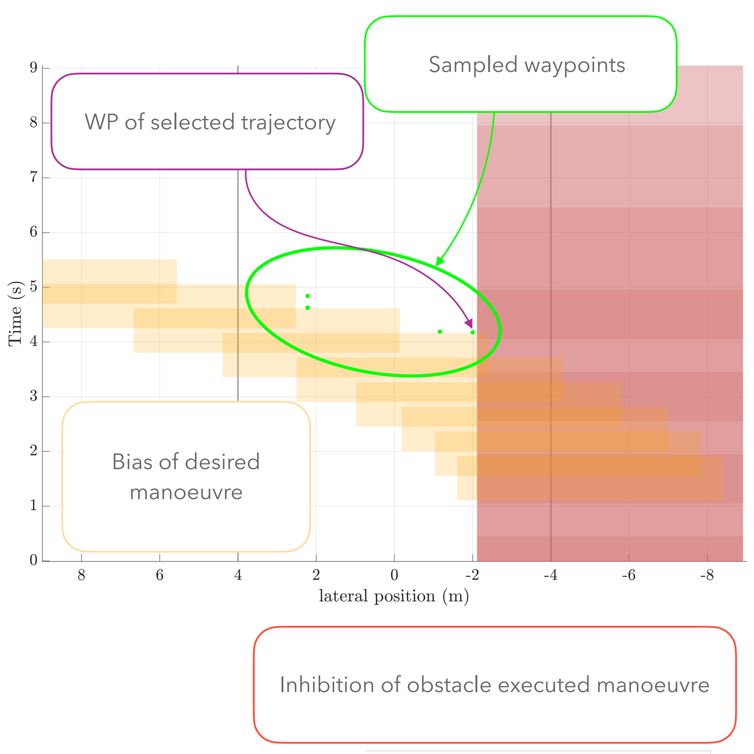
- **Minimum-time on-line** motion planning with **dynamic** opponents
- Explore a **structured grid** of waylines and waypoints
- **Space-temporal** prediction of the obstacle motion
- Motion primitives to connect pairs of waypoints:
  1. **Path**: Polynomial Neural Network (**NN-Poly**), approximating the minimum-time nonlinear MPC solutions
  2. **Velocity** trajectory: semi-analytical min-time optimal control problem with acceleration constraints

RESULTS

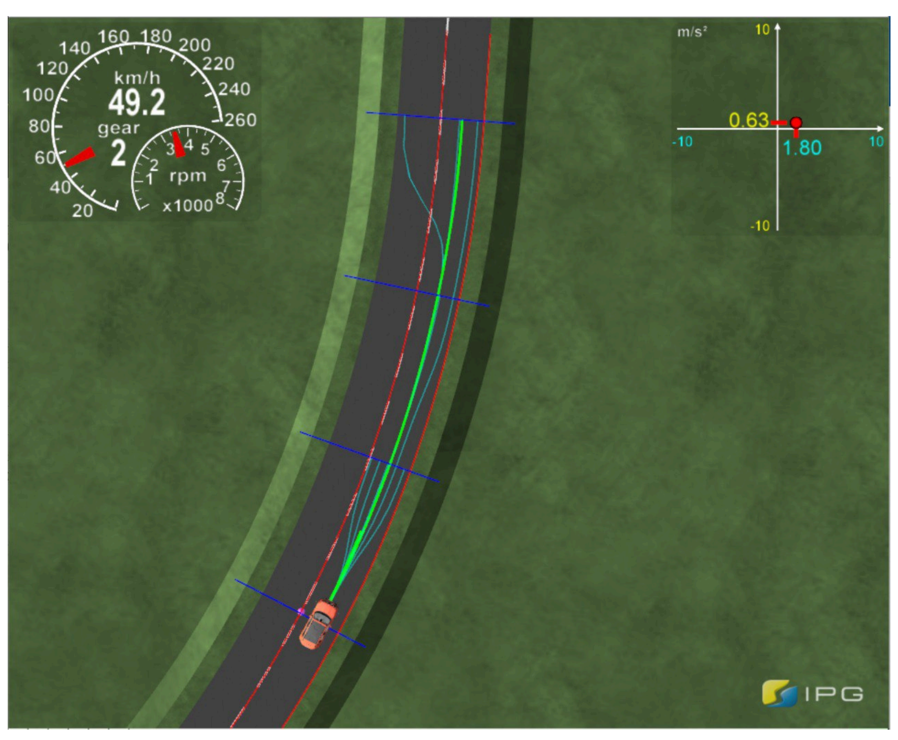
URBAN

Road intersection with manoeuvres exchange (cooperative) [**MATLAB prototype**]



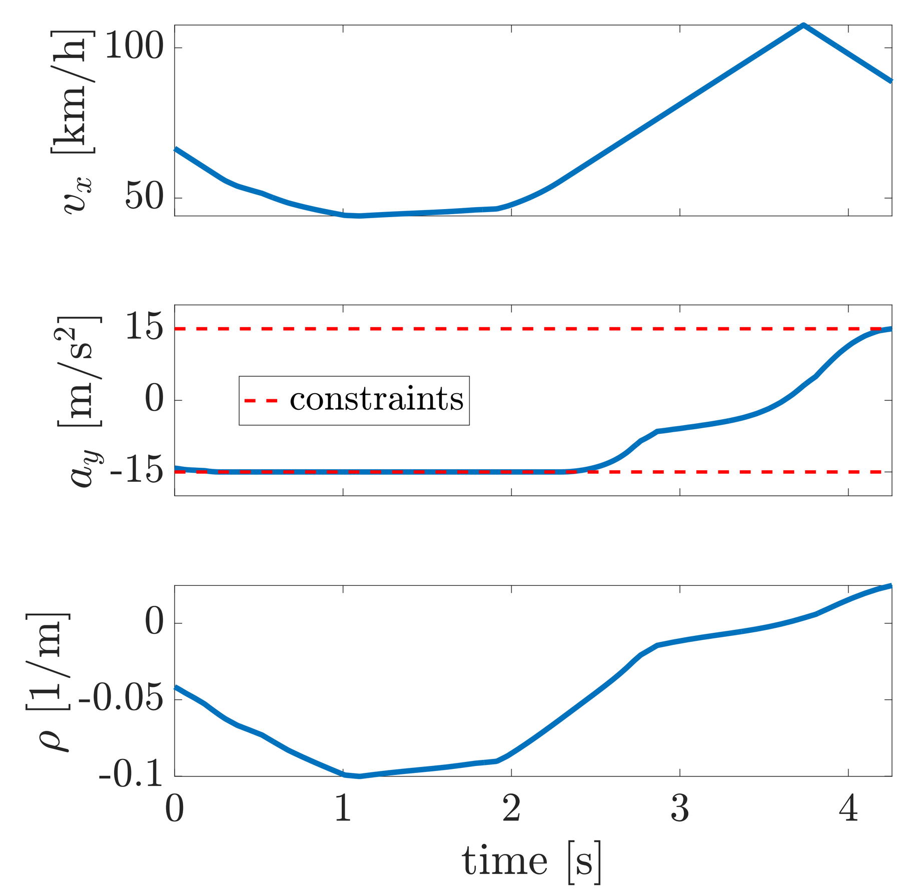


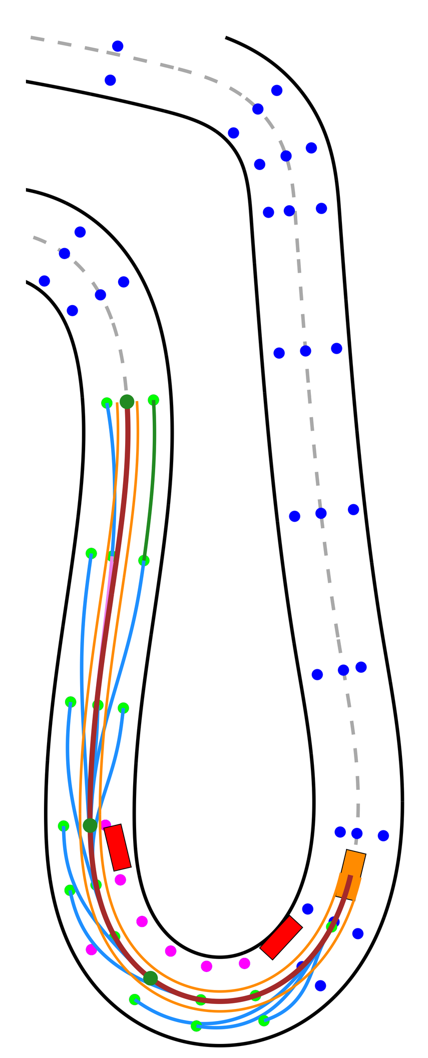
IPG CarMaker integration with **C++** interface



RACING

- **Real-time** motion planning, horizon length approx. 100 m
- MPTree outperforms a benchmark obstacle avoidance MPC
- NN-Poly outperforms a benchmark generic NN, and it guarantees the path curvature continuity





	Mean cpu time
MPTree	33 ms
Benchmark MPC	> 200 ms

	NN accuracy (test set)
NN-Poly	0.0059 m
Benchmark NN	0.0506 m

FUTURE DEVELOPMENTS

- Vehicle In the Loop testing in collaboration with automotive partner
- Explore by **informed sampling** around previous best solution
- Train a **NN** or **RL** to sample node not randomly
- Compare **MPTree** with **Codriver** (bio inspired planners)
- Use **MPTree** in cascade with **ARD** framework

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