Diplomarbeitspräsentation

Meta-Heuristic Local Planning

Masterstudium:
Computational Intelligence

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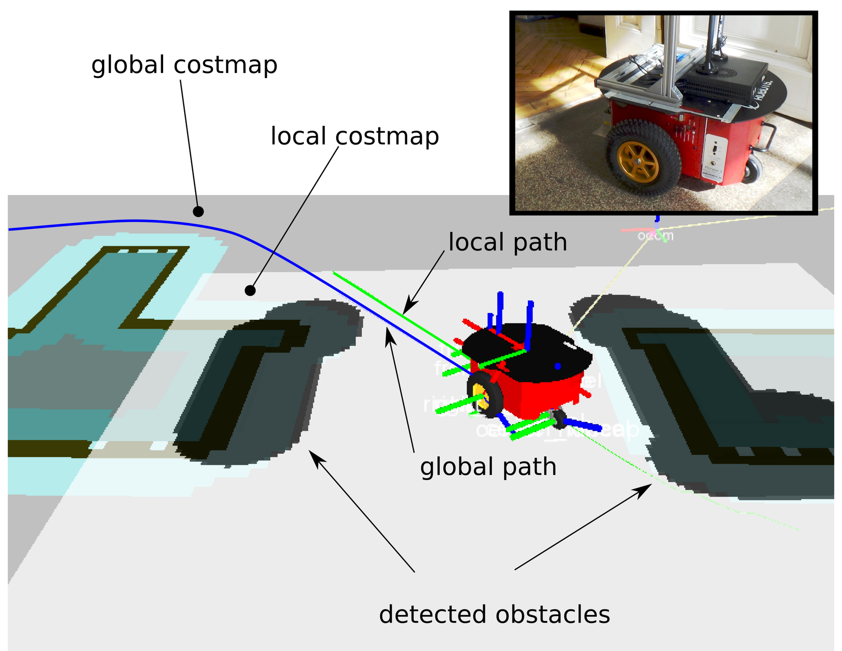
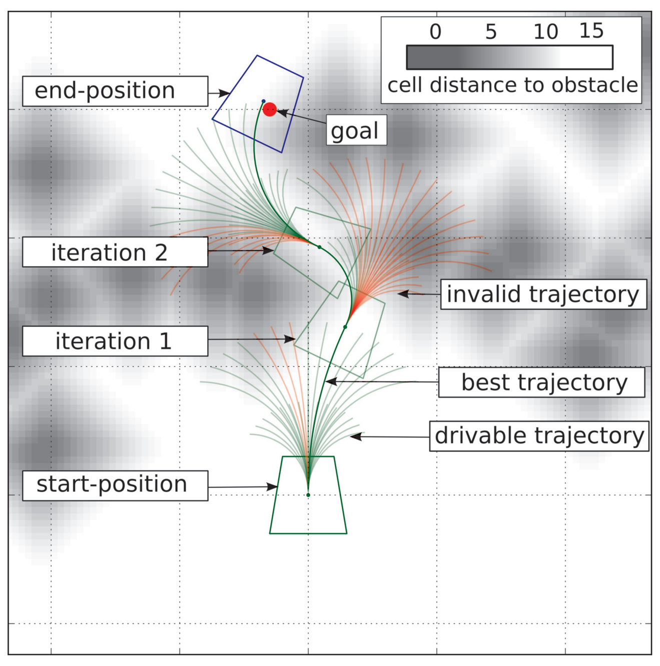
Motivation

Navigation is a vital task for mobile robots driving through dynamic environments. A common approach divides this task into two parts:

- global planning creates a path from start to goal to guide the robot
- local planning uses obstacle avoidance methods to safely follow the guide



Global and local planning



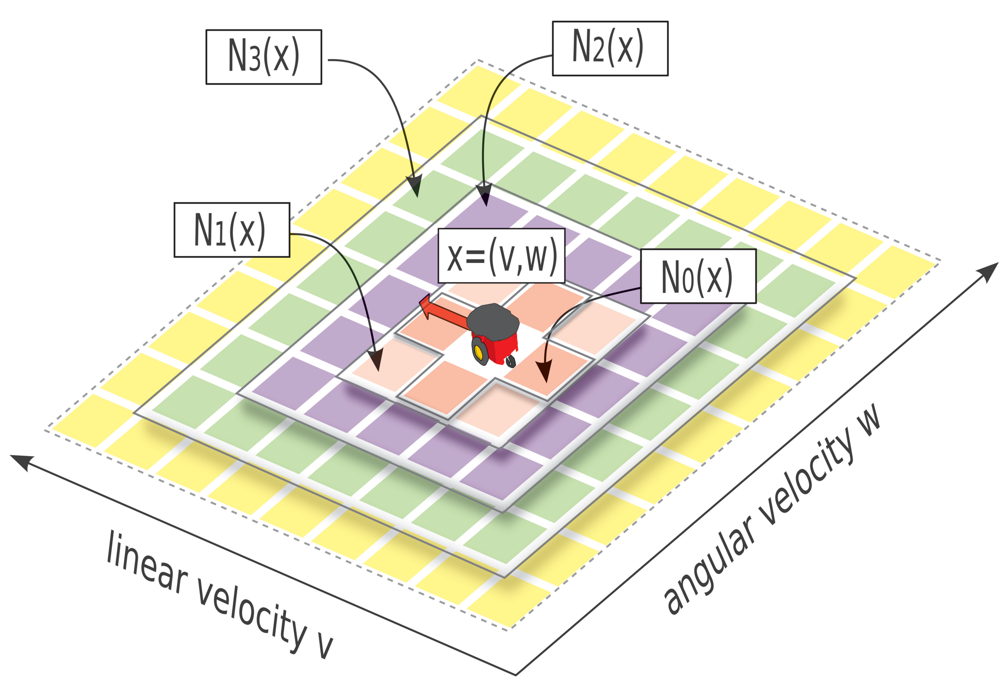
Trajectory selection in local planning

Very effective local planning methods like the Dynamic Window Approach [1] are based on sampling the 2-dim velocity space of the robot vehicle. Possible linear and angular velocities (v, w) are used as control values and their application is simulated for a short period of time.
The resulting trajectories are weighted using a costfunction. The velocity tuple yielding the best trajectory is then propagated to the motor controller of the robot.
The goal of this work is to analyze these local planning approaches and improve the selection process by using meta-heurstics.

Approach

Well known meta-heuristic algorithms are used to speed up the local planning within the trajectory selection step. For this purpose the velocity space is structured according to the following neighborhood definition:

- $N_0(x) =$ 4-connected
- $N_1(x) =$ 8-connected
- $\dots$
- $N_k(x) =$ k-steps reachable neighborhood.

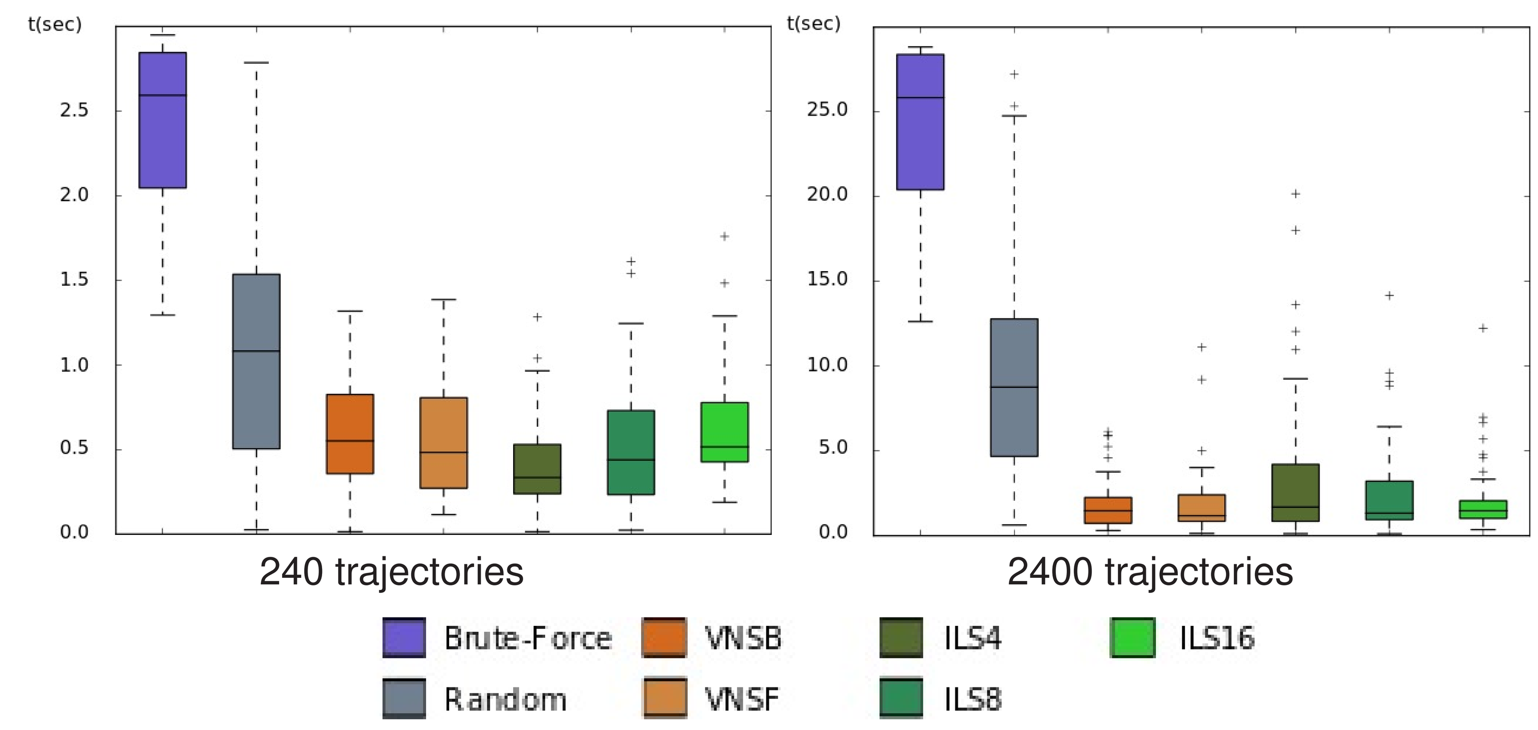


These neighborhoods are used by the following meta-heuristic algorithms:

- Random Search with Tabu List (Random)
- Iterated Local Search with fixed sized neighborhoods (ILS4,ILS8,ILS16)
- Variable Neighborhood Search with Best-, and First-Improvement heuristic (VNSF,VNSB)

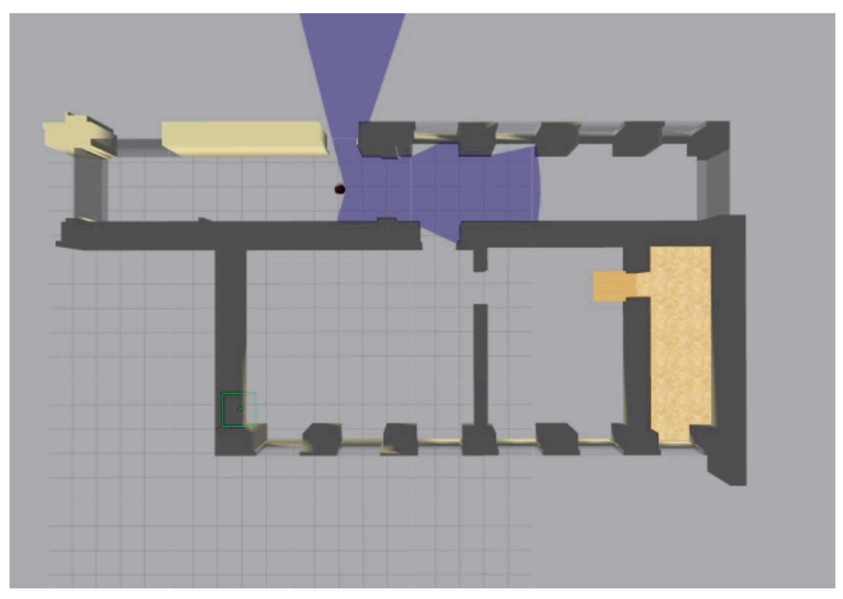
Step 1: Evaluation on static obstacle maps

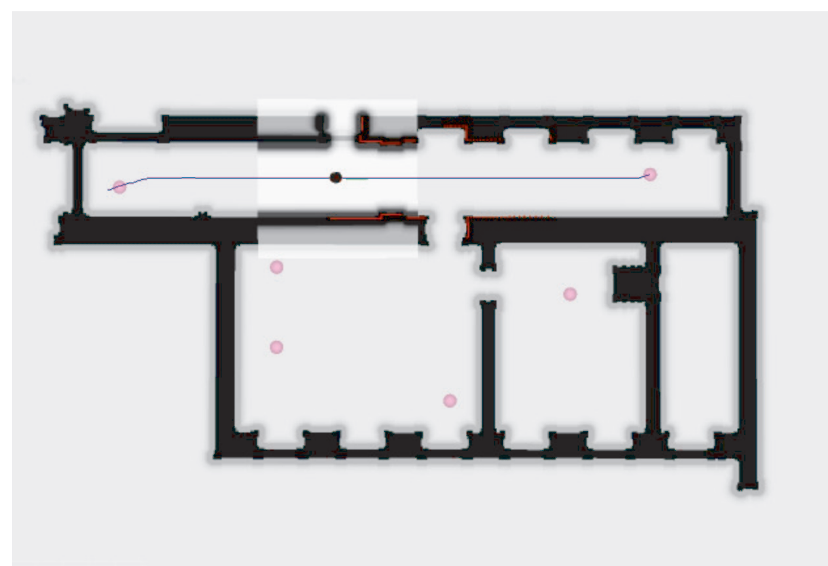
The algorithms were tested on 60 randomly generated static obstacle maps and a simple local planning component. Results are documenting a significant performance increase:



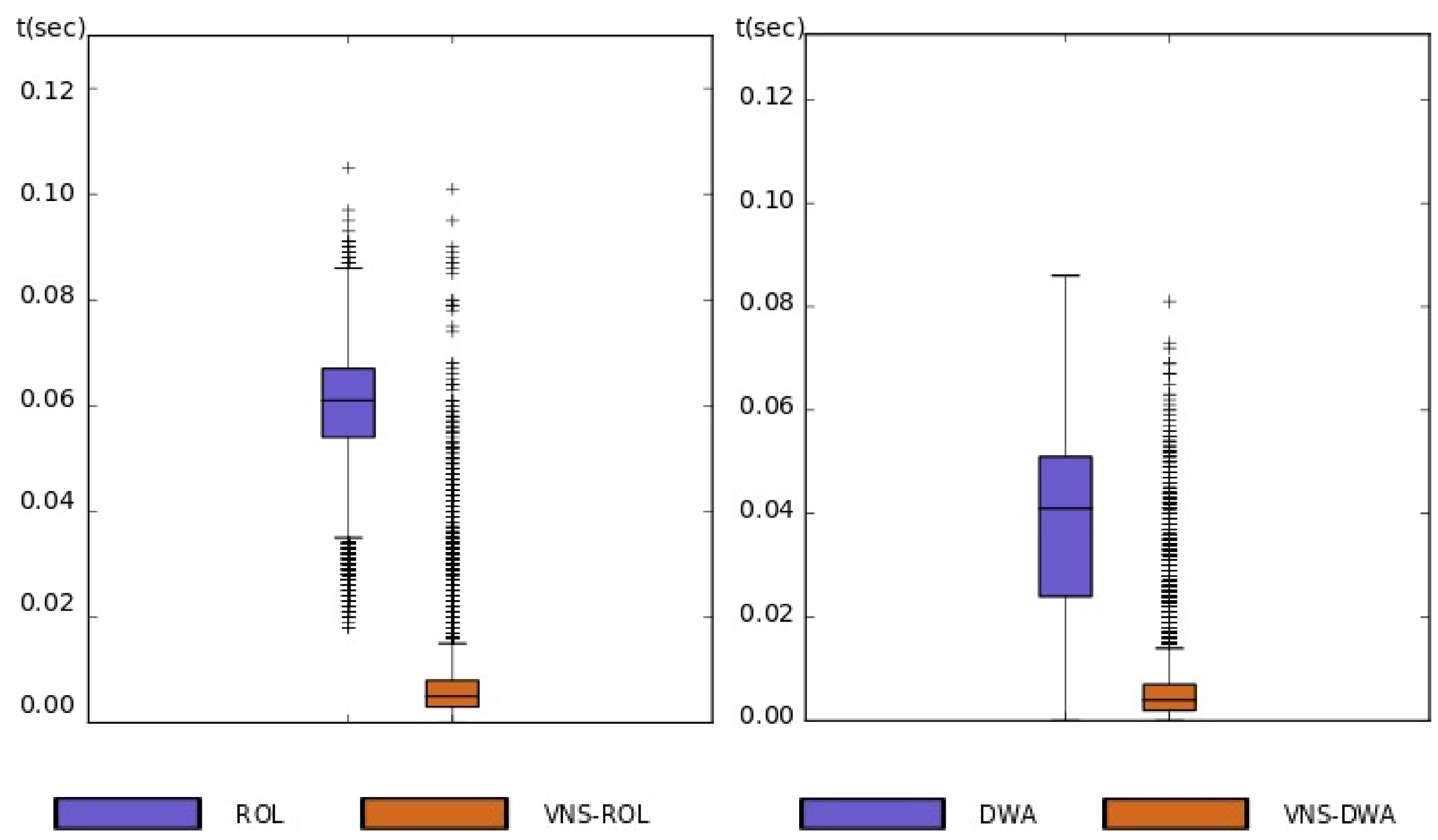
Step 2: Integration into existing planning systems

The VNS approach was selected to be integrated into a state of the art planning system for mobile robots based on Trajectory Rollout (VNS-ROL) and DWA ((VNS-DWA) [2]. The different planners are tested in two virtual environments using a 3D-physics simulation.


3D-Model


View of the robot

The results show, that the VNS approach outperform the brute-force method of the original implementations.



References

[1] D. Fox, W. Burgard, and S. Thrun.
The dynamic window approach to collision avoidance.
Robotics Automation Magazine, IEEE, 4(1):23–33, Mar 1997.

[2] Eitan Marder-Eppstein, Eric Berger, Tully Foote, Brian P. Gerkey, and Kurt Konolige.
The office marathon: Robust navigation in an indoor office environment.
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