Computationally Efficient Graph Search Algorithms for Experiments of Distributed Trajectory Planning

(Master Thesis)

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Motivation

This thesis takes place within the scope of the "Graphenbasierte, Optimale und Kooperative Trajektorienplanung für Interagierende Automobile" (GROKO-Plan) project. GROKO-Plan allows distributed trajectory planning for networked vehicles by means of a priority-based and graph-based approach. The GROKO-Plan algorithms can be evaluated on model-scale vehicles in the CPM Lab of i11. Planning algorithms for such experiments need to finish the computations in a suitable time step duration. For this reason, it must be possible to limit the computation time per vehicle. GROKO-Plan uses a receding horizon control in form of a graph search with an accordingly limited search depth equal to the prediction horizon. The search-graph is constructed from the Motion Primitive Automaton (MPA), which describes the possible states and maneuvers for vehicles. The current implementation uses an A* graph search algorithm without any option to limit the computation time.

State of the Art

There exist anytime capable algorithms like Anytime A*, Anytime Repairing A* or Rapidly-exploring random tree. Such anytime algorithms can be used to quickly get a preliminary and non-optimal solution that will be further improved over time. By this, the computation time for the graph search can be limited. Furthermore, the state of the art provides incremental graph search algorithms such as LPA* or Adaptive A*, which reuse information from previous time steps and thus increase graph search efficiency.

Goal

The goal is to be able to run experiments in the CPM Lab in a distributed manner, where each vehicle computes its plan on its own PC. To this, the algorithm needs to be anytime capable. In order to achieve still good quality trajectories in limited time, the efficiency of the graph search algorithm has to be improved. This can be achieved by the implementation of an incremental graph search as well as by analyzation and reduction of additional computational bottlenecks. Furthermore, the MPA should be more fine-grained to allow potentially higher quality trajectories.

Planned Approach

Initially, the research on graph search algorithms will be completed, such that it is clear, which anytime or incremental algorithms can be applied on this project and whether or how they can be combined. In addition, the software architecture will be designed considering that the trajectory planning will take place distributedly, meaning each vehicle will plan on its own PC. During the implementation of the solution, unit tests and continuous integration will be introduced to GROKO-Plan to test and ensure functionality. Finally, the new algorithm will be deployed distributedly and evaluated in CPM Lab.