講演番号	254

文献番号	20225254

Monte Carlo Tree Search and Knowledge Graphs for Decision Making in Autonomous Vehicles

Irene Cara [1] **Mauro Comi** [1] **Batrice Masini** [1] **Beatrice Masini** [1] **Ihsan Yalcinkaya** [1] **Rutger Beekelaar** [1]

1) Integrated Vehicle Safety TNO Helmond, The Netherlands

KEY WORDS:electronics and control, autonomous driving system, intelligent,Decision making, Monte Carlo Tree Search [E1]

To achieve full automation, the vehicle is expected to drive in any condition and scenario, implying that more decisions are to be taken by the vehicle and not anymore by the human. These decisions are needed to be able to interact in a highly dynamic and uncertain environment, while guaranteeing a safe behaviour and the comfort of the passengers. In complex scenarios in which there is a lot of interaction with other road users, tactical decision making is essential to enable high level of automation. A general and scalable approach for this problem could be to use AI techniques, such as Monte Carlo Tree Search (MCTS), and to model decision making as a finite Markov Decision Process (MDP). Domain knowledge and contextual information can be used to increase the explainability and trustworthiness of the Decision Making framework. This domain knowledge and contextual information can be well represented by ontology-based Knowledge graphs and combined with AI techniques into a Hybrid system.. The goal of our work is to investigate a novel method in the context of AI-based tactical decision making that combines MCTS and an ontology-based Knowledge graph database called TypeDB. The Knowledge Graph database embeds domain knowledge into the data-driven process and supports the decision making process via first-order logic inference rules, increasing the controllability of the system. Besides increasing trustworthiness and controllability, our approach ensures scalability to a vast set of different scenarios. When the current scenario was not seen in the collected data, a Rule-based Decision maker is used. This is based on the information contained in the Knowledge Graph and expert domain knowledge.

In order to test the performance of our framework, we have decided to use Carla simulator to reproduce two Highway use cases and one Urban use case. For each use case the speed of EGO, target vehicles and the bicycle have been variated. The extracted states have then been given as input to the Decision Making framework. The highway use cases consist of EGO and a slower Target vehicle in front, where EGO is expected to change lane to the left, see Fig. 1. As it can be seen in Fig. 2, MCTS suggests to change lane to the left or to decrease the speed to avoid collision with the slower target vehicle in front. Changing lane is safe because no other vehicles are present on the left lane. In the urban use case 2, EGO handles the interaction with a bicycle approaching the crossing from the right. In this case, EGO is expected to brake when the distance to the bicycle is short, as the bicycle has right of way. The tests on urban use case 2 show that when EGO is far from the bicycles, with distances higher than 20m, the suggested action is keep speed by both MCTS and the rule-based DM. When approaching the bicycle a soft or hard braking action is suggested.

The framework can operate in different classes of scenarios and was proven to work in two highway scenarios and an urban scenario reproduced in Carla simulator. The rule-based DM and TypeDB support MCTS when the state action pair is not present in the collected data. More sophisticated rules can be combined with MCTS and/or Reinforcement Learning based decision makers for increasing the reliability of the system. More data is needed to improve the performance of MCTS, especially when only one action is available in the state action transition function. Future work will include online MCTS and TypeDB and closed loop simulations to test the long term effects of the actions selected.

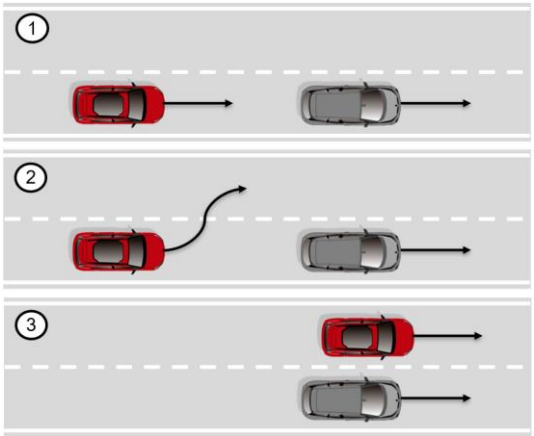

Fig. 1 Use case 1.1: EGO has a slower vehicle in front and performes a lane change in order to overtake the other vehicle.

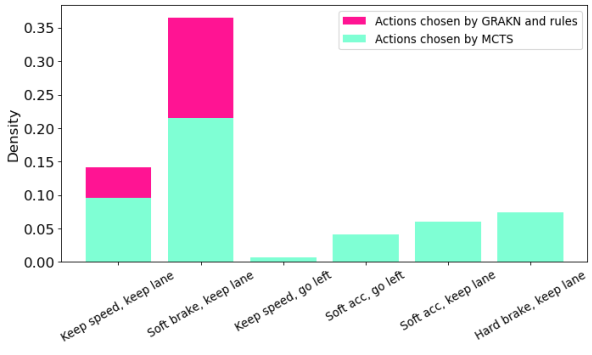

Fig. 2 Histogram of actions chosen by the decision-making in highway scenario 1.1: pink bins refer to the actions chosen by the rule based DM and TypeDB, green bins refer to actions chosen by MCTS based on the knowledge of collected data.