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Formal-methods based motion-planning for mobility-on-demand and its application on fleets of autonomous vehicles – an ES4CPS problem

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1 The ES4CPS problem

My research is focused mainly on the development of efficient (i.e compositional and/or decentralized) planning, scheduling and control techniques for fleets of autonomous vehicles with the use of formal methods. Recent developments in the area involve bottom-up decentralized control for robotic teams from possibly dependent local linear temporal logic formulas as well as decomposition of global specifications into individual, independent formulas for individual agents. My work puts emphasis on state-space and knowledge representation, reasoning, and high-level decision making aspects. Specifically, logical reasoning about the other agents' states, knowledge and plans. The general goal is to develop a framework enabling efficient use of rich, yet user friendly, temporal logic as a specification means for complex goals in collaborative or competitive multi-vehicle environments. Some of my recent work includes extensions of temporal logic towards handling explicit time and probabilistic bounds via investigating timed and probabilistic versions of temporal logics and hybrid and Markovian models of the system components. Targeted application areas involve routing, scheduling and control of autonomous vehicles for mobility on demand. We focus on sampling-based approaches of motion planning for these applications. The ES4CPS problem that has been my main interest as of late is that of human-robot interaction for use in autonomous vehicle scenarios and how to model human behaviour so as to provide provable guarantees on safety and performance of the underlying CPS.

2 My Expertise

My main expertise lies in motion planning for autonomous robots (specifically autonomous vehicles) with temporal logic specifications and quantitative guarantees. As stated in

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previous section, the focus of my work has been to develop a framework for specifying complex spatial-temporal goals using temporal logic, with the main application being mobility-on-demand for autonomous vehicles.

I have studied both the high-level routing problem as well as the motion-planning problem for autonomous vehicles. Recent publications as a result of my work is to ECC [KT18] as well as ICRA [Ka18]. Recent efforts have been focused mainly on extending our work into handling probabilistic and stochastic behaviour in complex (dynamic) environments.The first step of doing this is formalizing an intention-aware motion planner. I believe that Intention prediction is an extremely important piece in motion planning for fleets of autonomous vehicles acting in complex and dynamic environments.

3 External Expertise

Given that my recent focus has shifted into probabilistic and stochastic knowledge representation as well as intention-aware motion-planning in environments with autonomous vehicles and pedestrians, an important piece that is missing is the human-robot interaction. For instance, modelling humans, in order to predict behaviour, is a very complex problem that has little concrete published work in the literature. External expertise that I would benefit greatly from is therefore anyone who is currently, or has in the past, worked with modelling human behaviour or any form of human-robot interaction. I am also interested in the combination of formal methods and reinforcement learning in order to provide quantitative guarantees on the resulting policy.

4 Summary

Since my main research interest lies in motion planning for autonomous robots with temporal logic specifications, using Formal-methods based approaches. This is the expertise that I can contribute with during the course of the seminar. As current research into the probabilistic versions of the same problem, as well as the human-robot interaction that is needed for these approaches, I am very interested in exchanging ideas regarding human-robot interaction and reinforcement learning combined with formal methods.

References

[Ka18] Karlsson, Jesper; Vasile, Cristian-Ioan; Tumova, Jana; Karaman, Sertac; Rus, Daniela: Multi-vehicle motion planning for social optimal mobility-on-demand. In: 2018 IEEE International Conference on Robotics and Automation (ICRA). IEEE, pp. 7298–7305, 2018.

[KT18] Karlsson, Jesper; Tumova, Jana: Decentralized Dynamic Multi-Vehicle Routing via Fast Marching Method. In: 2018 European Control Conference (ECC). IEEE, pp. 739–745, 2018.