Motion planning in a crowded environment for mobile robots

MSc. Project at Autonomous Multi-Robots Lab, Cognitive Robotics, TU Delft

Brief Description: This master thesis will focus on motion planning in an crowded and unstructured environment. Imagine if a robot would be able to catch a train during rush hour or pick up groceries in a busy supermarket. If the robot would achieve this task without colliding with other agents, that would be a huge step forwards in autonomous robotics. These environments require the robot to understand the intentions of the other agents and plan a path accordingly. Therefore, I propose two possible research directions for a master thesis: (1) Motion planning for Mobile Manipulators or (2) Intuition for Robotic Systems, of which one is selected. Both research directions will include simulated and real-hardware experiments with mobile robots.

Research direction 1: Motion Planning for Mobile Manipulators
Model Predictive Control (MPC) is a well-known method for local motion planning. Since future predictions about the robot and the environment are included in the optimization algorithm, it is suitable for dynamic environments. However, MPC also comes with its limitations: the computation speed is relatively slow and parameter tuning can be cumbersome for complex systems. Geometric methods, like Optimization Fabrics [2], are fast and easier to tune, but include no prediction horizon. In this master thesis, you will explore the combination of geometric methods and (sampling-based) predictive planning for multi-agent motion planning. This framework will be applied in scenarios with multiple mobile robots, including at least one mobile manipulator.

Research direction 2: Intuition for Robotic Systems
Often, mobile robots assume that other agents move with a constant velocity. This assumption works well in many situations, but in crowded scenarios the robot is unable to find a feasible motion plan, which is called the 'frozen robot problem'. As humans, we reason that others might cooperate and let you pass, while also understanding the risk of a movement if others do not collaborate. The reasoning about others intentions is used to predict future movements of other agents. Therefore the robot should plan a safe motion that is able to reach the goal, while being risk-aware. Interesting approaches lie in the area of Reinforcement Learning, cognitive modelling (for example [4]) or by

using relevant semantic information (for example [3], [1]).

Since the project will start in August/autumn, the exact specifications will be determined later on in consultation with the master student, Saray and professor Javier Alonso-Mora. Therefore the project can be adapted to fit the skills and interests of the master student, and will require an independent mindset.

Desired Qualities:

- Motivated and independent student who is enthusiastic about robotics.
- Good problem-solving skills (especially with the robot)
- Experience with ROS (knowledge of ROS 2 is a plus)
- Experience in Python

Start Date: August to October 2023, earlier is not possible.

For further questions or to apply, please contact Saray Bakker (s.bakker-7@tudelft.nl). When applying, please provide a short motivation, an up-to-date CV, a transcript of your current degree program, and the intended start date.

Group information: www.autonomousrobots.nl

References:

[1] Younes Belkada, Lorenzo Bertoni, Romain Caristan, Taylor Mordan, and Alexandre Alahi. Do pedestrians pay attention? eye contact detection in the wild. *arXiv preprint arXiv:2112.04212*, 2021.

[2] Nathan D Ratliff, Karl Van Wyk, Mandy Xie, Anqi Li, and Muhammad Asif Rana. Optimization fabrics. *arXiv preprint arXiv:2008.02399*, 2020.

[3] Kerstin Ruhland, Christopher E Peters, Sean Andrist, Jeremy B Badler, Norman I Badler, Michael Gleicher, Bilge Mutlu, and Rachel McDonnell. A review of eye gaze in virtual agents, social robotics and hci: Behaviour generation, user interaction and perception. In *Computer graphics forum*, volume 34, pages 299–326. Wiley Online Library, 2015.

[4] Wilko Schwarting, Alyssa Pierson, Javier Alonso-Mora, Sertac Karaman, and Daniela Rus. Social behavior for autonomous vehicles. *Proceedings of the National Academy of Sciences*, 116(50):24972–24978, 2019.