Comparison of advanced control methods for autonomous navigation of a mobile platform in a human populated environment

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Research team

ACENTAURI is a robotic team located in Sophia Antipolis that studies and develop intelligent, autonomous and mobile robots that collaborate between them to achieve challenging tasks in dynamic environments. The team tackle perception, decision and control problems for multi-robot collaboration by proposing an original hybrid model-driven/data driven approach to artificial intelligence and by studying efficient optimisation algorithms. The team focus on robotic applications like environment monitoring and transportation of people and goods. In these applications, several robots will share multi-sensor information eventually coming from infrastructure. The effectiveness of the proposed approaches are demonstrated on real robotic systems like cars AGVs and UAVs together with industrial partners.

LARSEN is a robotic team located in Nancy that studies how to bring robots outside of the research labs and manufacturing industries. To reach this goal, the team is developing methods to endow robots with long-term autonomy and interaction skills, taking into account the embedded and/or external sensors in the environment. These skills are grounded on physical and social interaction, machine learning, and planning under uncertainty. Experiments, especially in service and assistive robotics, are at the core of our methodology. The proposed techniques will potentially impact all the robotics fields and catalyze the ongoing efforts to transfer robots into our society.

Motivations and general objectives

This subject is proposed in the context of a collaboration between the ACENTAURI and the LARSEN teams in the European project Eurobin. The student will spend most of the time in the ACENTAURI team in Sophia Antiplois and will perform the final demonstration with the platform of the LARSEN team in Nancy.

Autonomous navigation in human populated environment is difficult as it is facing the freezing robot problem [1] where generally reactive techniques fail. With a certain level of density, there is no solution if we don't take into account the future evolution of the environment over a time horizon. There are different aspects to consider in this global problem. Human behaviors require to be observed or learnt in order to predict their evolution. An accurate and realistic model of such agent is necessary. In that area, recent advances have been done in [2] by enhancing the classical Social Force Model. The second aspect concerns the observation as human represents an Hidden dimension [3] and the question is what is necessary and can be observed [4] ? The third aspect deals with the control in order to monitor the action of the robot. The question is: what is the best action to do taking into account the knowledge we have and the observation we do in order to join a particular place in the human populated environment ?

The main purpose of the Master thesis is to work on this problem and focus on the control aspect. MPC (Model Predictive Control) technique is well known for taking into account physical characteristics of the systems (communication delays, low level actuators delays, curvature of the path to follow, ...). In previous work we evaluated this technique obtaining promising results [11]. However, the nature of our problem push us to consider more advanced techniques to take into account the uncertainty of observation and modelling. In this aim, the master will investigate the novel technique called MPPI (Model Predictive Path Integral) which has been introduced in 2016 [7-8] and extended to dynamic environment in [9-10]. MPPI is a Sample Based technique a bit different from Sam-ple Based MPC [5-6]. The master will setup a framework under ROS and PEDSIM, representing an open and shared area with humans. Comparison of different techniques will be done first in simulation, then in real with the ACENTAURI mobile platform and finally implemented on the LARSEN platform.

Work-plan

The work will be decomposed with incremental steps as follows:

1. Bibliography on MPPI, sample based MPC, stochastic MPC,
2. Mathematical background in MPC, SBMPC, SMPC, NLMPC, MPPI
3. Develop a first implementation using Sample based MPC
4. Develop a second implementation using MPPI environment
5. Provide comparison between MPC, Sample based MPC and MPPI
6. Develop real experimentation with our fully equipped mobile platform.
7. Develop real experimentation with our fully equipped mobile platform.
8. Writing master Thesis and potential papers

Skills

The candidate is expected to prepare a Master in Robotics, as well as solid skills in software development (MATLAB/Simulink, LINUX, Git, C/C ++, ROS, Python, OpenCV). A good level of written/spoken English is also important.

How to apply

Interested candidates must send a detailed CV, motivation letter and at least one recommendation letter to ezio.malis@inria.fr

Financial support

Financial support offered to the student: around 570 € per month during 6 months

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