Hybrid Data-driven/Model-based Methods for Mobile Robot Control

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Romea team, INRAE in Clermont-Ferrand

Research team

The ROMEA (RObotique et Mobilité pour l'Environnement et l'Agriculture) team conducts research in robotics for the development of autonomous machines in natural environments. ROMEA is developing perception and control approaches allowing robots to adapt to their environment in a safe manner. The work carried out within ROMEA covers various aspects, from the development of new sensors to the development of intelligent algorithms for reconfiguring robotic behaviour. ROMEA is a INRAE team located in Clermont-Ferrand. INRAE is the French National Research Institute for Agriculture, Food and Environment. Because of its size and research outcome, INRAE is ranked number one in the world for research on agriculture, food, and the environment. Clermont-Ferrand is a middle-size city in the center of France. Living in Clermont-Ferrand enjoys a high quality of life and a low cost of rent.

Objective

Mobile robot control can be achieved by either model-based [1] or data-driven methods [2]. Model-based methods have stability guarantee, but they need analytical models with a higher accuracy. It is usually difficult to obtain an accurate model for high-speed and off-road mobile robots because of the presence of sliding [3]. Data-driven methods need a huge amount of data instead of an accurate model, but they lack of stability guarantee. It is natural to combine both methods for control design in order to get the advantages of each method. Existing hybrid methods [4] assume that the data is enough to predict the model, which is usually not guaranteed in real application. Therefore, the main objective of this master project is to investigate a methodology to combine data-driven model(Bayesian neural network) with model-based control(model predictive control) to achieve stable path following tasks, even if the amount of data is not enough to recover the robot model. Results aims at adapting an off-road mobile robot behaviour to the diversity of encountered situations in an agricultural context. The proposed trainee will take part of experiments conducted on different robot available at INRAE.

Main activities

The main tasks of this research work are to:
1. Understand mobile robot modeling, Bayesian neural network (BNN) architectures[5] and Model Predictive Control (MPC)[6].

2. Explore possible way to merge BNN and MPC for mobile robot control.

3. Data gathering and the implementation of the proposed hybrid method in simulation.

4. Validation using real experimental setup.

Qualification and skills

Technical Skills: machine learning, control theory, robotics

Software: Python, C++, Pytorch, ROS

Language: English

Financial support

Around 550 € per month during 6 months.

How to apply

Interested candidates should send a detailed CV, a statement of interests in the position, bachelor and Master's results, and one or more letters of recommendation to zhongkai.zhang@inrae.fr

References

1. S. Tzafestas, Mobile Robot Control and Navigation: A Global Overview, 2018.
2. X. Xiao, et al, Motion Control for Mobile Robot Navigation Using Machine Learning: a Survey, 2020.
3. R. Lenain, et al, High accuracy path tracking for vehicles in presence of sliding: Application to farm vehicle automatic guidance for agricultural tasks, 2006.
4. F. Cursi, et al, Bayesian Neural Network Modeling and Hierarchical MPC for a Tendon-Driven Surgical Robot With Uncertainty Minimization,2021.
5. L.V. Jospin, et al, Hands-on Bayesian Neural Networks – a Tutorial for Deep Learning Users, 2020.
6. R. Gonzalez, et al, Robust tube-based predictive control for mobile robots in off-road conditions, 2011.