Master Thesis:

Integration and development of distributed nonlinear model predictive control for ground based mobile robot swarms on embedded systems

Xx Xx, matriculation number: xxxxxx

The development and usage of single instances of autonomous robot agents for support missions are rapidly increasing. However, to fight the complexity of demanding missions a larger number of cooperative autonomous robot agents is needed to be able to fulfill the task or to do it an appropriate time. Current challenges are the generation of mission plans, the assignment of task to subgroups and agents as well as the entire management of the system as a whole. Thereby either a central instance nor the entire knowledge of the situation is available and communication possibilities are restricted as in real world. Einzelne autonome Robotersysteme werden zunehmend entwickelt und verwendet, um Unterstützungsaufgaben zu erledigen.

A modern, advanced concept for the control of a swarm is distributed nonlinear model predictive control, which uses a decentralized distributed potential field to determine the cost function under consideration of limited communication. Therefore, a highly efficient and parallelized agent simulation has been developed to prove mission and control concepts.

The goal of the thesis validation of the developed concepts in a physical simulator and on real embedded systems, that has been assembled. In addition, a digital twin and a co-simulation to the existing simulator should be achieved. At first an interface between the existing simulator and a robot middle layer is required. As middle layer the robot operating system (ROS) and as physical simulator for single agents Gazebo is recommended. For the evaluation appropriate missions should be tested and can be compared to other approaches. A working cross platform version of the simulator and an assembled robot will be given.

The following procedure is recommended for processing the tasks:

1) Literature research and familiarization with the topic and software environment
2) Development of a bidirectional interface between ROS and the simulator
3) Integration of the nonlinear model predictive controller into the ROS stack
4) Evaluation and validation based on physical simulation for at least one agent
5) Adaption of the developed approach to the embedded system
6) Evaluation and validation based on the real physical system
7) Documentation of the results

Begin: xx.xx.xxxx

End: xx.xx.xxxx

X

Peter Buchholz
Univ.-Prof. Dr. rer. nat.

X

Alexander Puzicha
M. Sc.

Recommended Literature:

1) Puzicha, A.: Modeling and analysis of a distributed non-linear model-predictive control for swarms of autonomous robots with limited communication skills (in German). Master's thesis, Department of Computer Science, TU Dortmund (2019)
2) Reif, J. H. & Wang, H. 1999. Social potential fields: A distributed behavioral control for autonomous robots. Robotics and Autonomous Systems, 27(3): 171-194.
3) Eun, Y. & Bang, H. 2006. Cooperative Control of Multiple Unmanned Aerial Vehicles Using the Potential Field Theory. Journal of Aircraft, 43(6): 1805-1814.
4) J. Amiryan, & M. Jamzad (Eds.) 2015. Adaptive motion planning with artificial potential fields using a prior path. 2015 3rd RSI International Conference on Robotics and Mechatronics (ICROM).
5) https://www.ros.org/
6) Hämäläinen, P., Rajamäki, J. & Liu, C. K. 2015. Online Control of Simulated Humanoids Using Particle Belief Propagation, Proc. SIGGRAPH '15. New York, NY, USA: ACM.