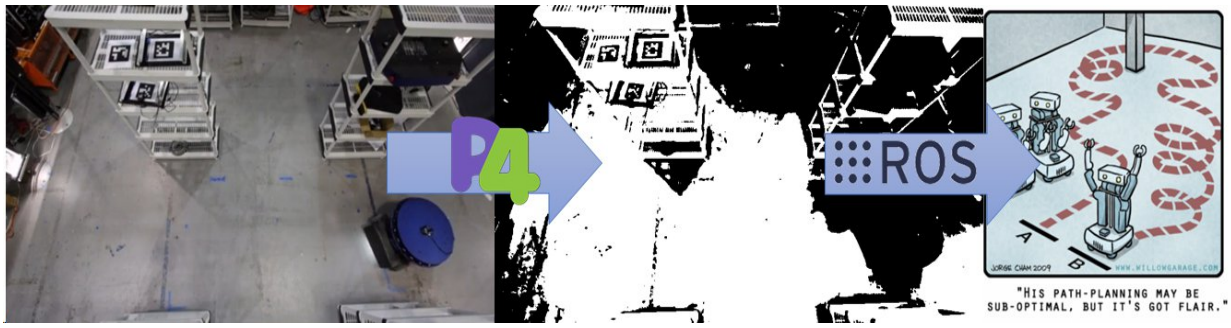
(Team) Project / Bachelor/Master Thesis | Computer Science & Mechanical Engineering

In-Network Computing meets Low-Latency Robot Control



Modern industrial cyber-physical systems require profound knowledge in both computer science and mechanical engineering to make full use of the abundance of possibilities in both domains. Within the Cluster of Excellence "Internet of Production", the *Institute of Mechanism Theory, Machine Dynamics and Robotics (IGMR)* and the *Chair of Communication and Distributed Systems (COMSYS)* offer you the chance to gain first-hand experience of when these fields meet.

Together, we aim to build demonstrators combining cutting-edge research revolving around *in-network computing* in computer science with *low latency control models* and *complex robot coordination* from mechanical engineering. In this project, the goal is to support a robot's path planning algorithm using live video camera feeds pre-processed on programmable network hardware.

Structure:

Ideally, you work on this interdisciplinary research project in a team of two, featuring one computer scientist and one mechanical engineer. Individual as well as team applications are possible (see below). For the computer scientist, the module counts for the **applied course mechanical engineering** (2 x 3 CP) while for the mechanical engineer it counts as a **research project**. Depending on your expertise, restructuring this project as a **thesis** in either field might also be possible. Starting dates can be freely arranged between March and May 2021.

Computer Science:

In-Network Computing (INC) describes the idea of deploying well-chosen computation tasks onto networking hardware, such as switches. This, e.g., enables meaningful latency reductions, but program complexity on switches is limited and implementing functionality thus challenging. In this project, we plan to leverage INC for simple image analysis to speed up and improve decision making for remote robot control. Your task will be two-fold: First, you transfer INC-based image analysis solutions (written in the INC-specific P4 programming language and C) to the concrete problems of our robotic scenario. As a second step, you then integrate your solutions into a surrounding control framework based on the robot operation system (ROS) by letting your INP program communicate the analysis results to the controlling mechanisms of the robot. You may even generate simple control commands for the robots from within the network if time permits.

Mechanical Engineering:

Collision-free motion planning for mobile robots in time-varying environments requires fast control systems and reliable low-latency sensor data. One of the possibilities to tackle this problem is search-based motion planning. In this case, a graph of the environment shall be provided with the current position (initial state) and the goal position (goal state). The obstacles are to be introduced as occupied vertices of the graph. To enable such a control system, we would like to use depth information of RGBD cameras to build the dynamically varying graph. Here the output of the INC may be used to ensure low latency data streaming. Implementation of the search-based motion planning in ROS concludes the task.

Your profile:

- You are comfortable with working in a team. Although you can work on your tasks mostly independently, you will eventually have to cooperate with your fellow student to define e.g., communication protocols / interfaces and the like. We will also conduct regular meetings with all students and teaching assistants to discuss progress and next steps.

Computer Science

- Ideally, you have some familiarity with the P4 language and/or C, as well as with ROS. However, such knowledge is not required, and you should, above all, be motivated to learn and feel comfortable writing and debugging (!) C-like code.
- Knowledge of computer vision methods is a plus, but also not a requirement; the algorithms possible on networking hardware are rather straightforward.

Mechanical Engineering

- Interest in robotics.
- Fun with programming (ROS is written in C++ and Python).

Corona note:

All tasks can be completed remotely. However, if the Corona situation permits, we will offer you the possibility to test your work using real robots and cameras at the IGMR lab.

Further information:

Internet of Production / Robot Path Planning

- https://www.igmr.rwth-aachen.de/index.php/de/rob/rob-iop

P4 language

- https://www.youtube.com/watch?v=UEMAvXXNWsY (quick intro; first 13 minutes)
- https://p4.org/

Robot Operating System (ROS)

- https://www.ros.org/

Interested? Questions? Contact Us!

Computer Science

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