Title: Reconfigurable ROS Nodes for Modular Agricultural Robots

Team: ATB: Volker Dworak,
UOS: Mario Porrmann,
HS: Stefan Stiene

Abstract:
Autonomous agricultural robots are a promising approach to reconciling ecological farming methods and economic yields. Modularity and collaboration are key to the success of these systems, keeping flexibility and reusability high and the overall cost low. However, developing such systems is highly challenging since it requires the co-development of mechanics, hardware, and software. This thesis shall focus on the development of new methods for hardware-software integration enabling automatic configuration and resource-efficient control of modular agricultural robots.

The Robot Operating System (ROS) is a robotics middleware, which has become the de-facto standard in the context of mobile robot development in research and industry. The envisioned application scenarios require robust and efficient embedded processing solutions, e.g., for ML-based object detection and classification under hard real-time conditions with a limited energy budget. Therefore, dedicated hardware accelerators need to be integrated into the system. Reconfigurable architectures like FPGAs combine high efficiency and flexibility, making them the ideal candidates for the application domain. While new sensors and actors can be easily integrated into ROS based on the supporting software drivers, integration of hardware accelerators and automatic configuration of the combined system is an open research topic, especially concerning modular, reconfigurable robotic platforms. FPGA-based ROS nodes shall enable optimized processing for varying combinations of sensors and actuators. Additionally, runtime reconfiguration of the FPGAs shall be supported, e.g., to dynamically adapt to changing environmental conditions or to mitigate malfunctioning sensorization.

Desired skills of the applicant:

- Background in ROS
- Experience in embedded systems or FPGAs
- Strong programming skills, e.g., in C/C++, Python
- Experiences in the application field agriculture is also a strong plus

References:

Eisoldt, M.; Flottmann, M.; Gaal, J.; Hinderink, S.; Vana, J.; Tassemeier, M.; Rothmann, M.; Wiemann, T.; Porrmann, M.: *ReconfROS: An Approach for Accelerating ROS Nodes on Reconfigurable SoCs.* In: Microprocessors and Microsystems, Vol. 94, Elsevier, 2022.

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