Master’s thesis proposal, Spring semester 2023

The railway AI digitization testbed

Background

An increased ratio of the transport of goods and people by railway is favourable from a sustainability perspective. However, a consequence of increased utilization of the railway systems is increased wear and increased risk of damage to the railway infrastructure. This will lead to increased need for maintenance and repair of the railway infrastructure, which in turn will counteract the increased demand of railway transportation of goods and people.

Digitization, AI, and robotics have been identified as potential solutions. A novel contribution to more efficient railway maintenance and repair is digital twins. These intelligent simulations can then be used to more precisely predict when a preventive maintenance measure should be carried out. Thus, the risk of sudden, unexpected breakdowns, which can be very costly and dangerous, is reduced. Traffic disruptions due to maintenance activities can also be minimized. However, they need to be continuously updated with fresh data.

Together with the Swedish Transport Administration (Trafikverket) the Applied AI research group at Chalmers-M2 is developing an autonomous railway robot demonstrator for data collection and inspection of railways. The robot was successfully tested on real railway tracks for the very first time in June 2022[1].

Several Master’s thesis projects will be offered in this area during the spring of 2023, with start in January, as described below. In general, experience and good knowledge in

software development is required, especially in C++ and Python. The software framework is based on the Robot operating system, ROS. Therefore, experience with ROS and Gazebo, and robotics is desirable, and genuine interest and previous education and experience in AI, robotics or autonomous vehicles is expected.

**Visual perception module** The robot needs to perceive the environment through a visual flow in order for it to be able to perform its tasks. This can be, for example, discovering people in the work area, discovering and recognizing certain types of objects or traffic signs, for localization and positioning, and safety and collision avoidance. A preliminary, general purpose robot vision node has already been developed, using the OpenCV library and a YOLO neural network. However, it needs to be taken from a proof-of-concept level to a fully functional vision system, in order to be employed on the autonomous robot and integrated with the software framework. It is crucial to improve both its performance and robustness. The previously developed module can be used as starting point.

**A ROS-Gazebo simulation set-up** In order to develop the autonomous railway robot a physical simulation is needed. The Gazebo simulator is tightly integrated with ROS, which therefore is the preferred choice. This project should focus on developing a simulation of the autonomous railway robot on tracks. It should include a detailed specification and simulation model of the actual, physical railway vehicle, a user/command interface, and basic set of sensor (camera, lidar, odometry, gps) and a rudimentary decisionmaking system. The simulation should allow for a complete run of a mission (use case), on tracks, from start to completion.

**Graphical command and control interface** The native interface to the robot consists of a Linux shell against ROS, i.e. a command line based interface. A more user-friendly graphical user interface needs to be developed for the robot, with developers and end users in focus. It shall include (1) a monitoring section including the vehicle basic state information, job plan read and list, environment monitoring and operator manually intervention, (2) the autonomous navigation-related information will be presented e.g. geo-location, environment video from camera, vehicle motion control and status, collision alert, and (3) information and command related to inspection and repair.

**Multi vehicle on-track coordination** Through the automation of freight yards, considerable gains in efficiency and safety can be expected. Freight wagons seen as self-propelled units, can then e.g. be shunted into complete train sets without shunting locomotives and direct human intervention. Creation and virtual demonstration of methods for coordinating groups of autonomous self-driving wagons, as well as a possible demonstrator in a model railway are expected outcomes.

**Supervisor and examiner:**
Krister Wolff, associate professor, Department of Mechanics and maritime sciences.
Contact for further information and application: krister.wolff@chalmers.se

[https://www.ros.org/](https://www.ros.org/)