HSLU Hochschule Luzern

Technik & Architektur
Mechatronics & Automation

Master's Thesis Mechatronics & Automation

Train Track Detection & Distance Calculation for a Mobile Robot

Fig.1 The Robot in Testing Environment

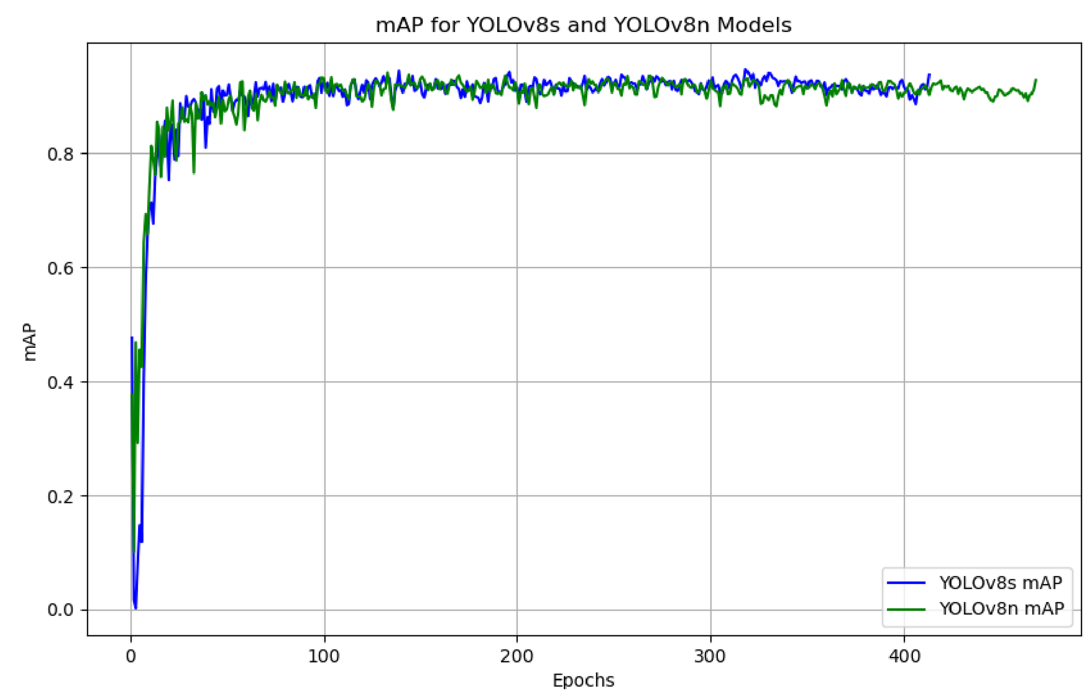

Fig.2: Mean Average Precision of the YOLO Model

Fig.3: Predictions on Validation Batch

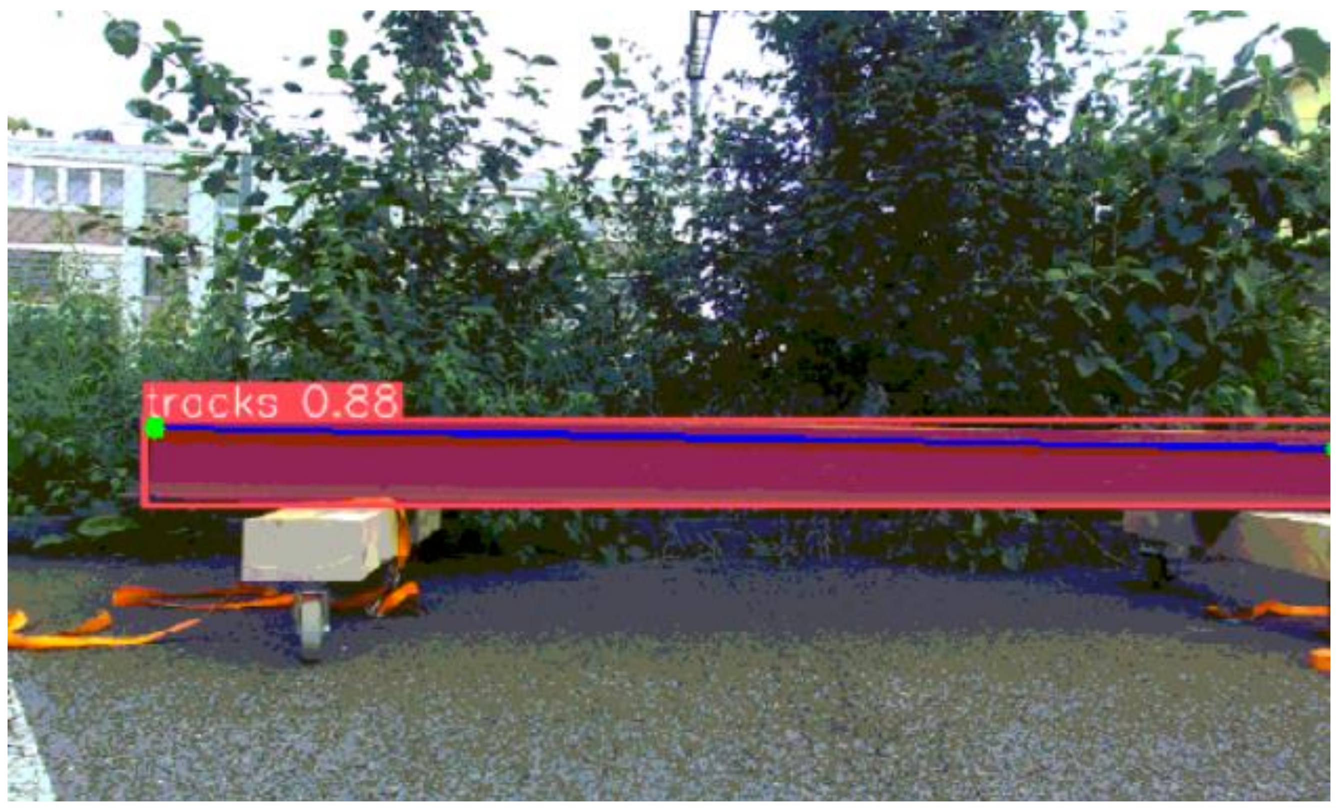

Fig.4 Track Detection and Hough Line Extraction

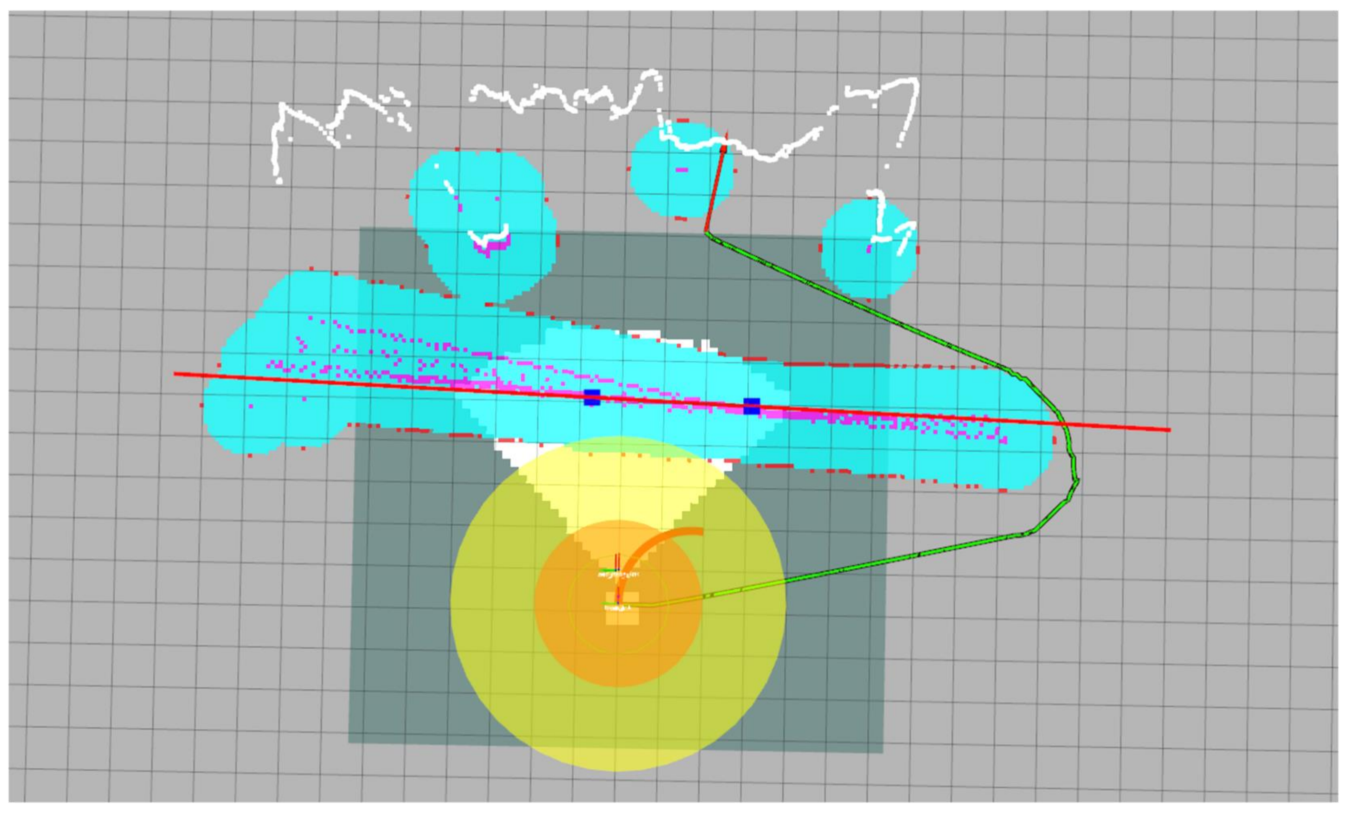

Fig.5 Train Track marked as an Object on the Costmap

Problemstatement

Autonomous robots operate in dynamic and unpredictable environments where safety and robustness are essential. Developing such systems requires the integration of redundant safety measurements to compensate for potential sensor errors or failures. This project focuses on enhancing an autonomous robot with a train track detection system, enabling it to calculate the distance between itself and nearby tracks accurately. Thanks to Machine Learning, the tracks should be detected. With this capability, the robot is designed to navigate autonomously along railway tracks, carefully adjusting its path to avoid them at all costs (Fig.1). The proposed functionalities are integrated into an existing software and hardware framework, ensuring that the robot can safely perform its tasks even in complex operational scenarios.

Method

This thesis enhances the autonomous capabilities of a robot operating near railway tracks through several strategic measures:

Model optimization: Parameters of the existing navigation model are fine-tuned to enable more dynamic and responsive movements.

Track detection: Advanced image processing and machine learning techniques are employed to detect railway tracks accurately.

Dataset preparation: A comprehensive dataset of high-quality images is compiled to train, test, and validate the machine learning models, ensuring robust system performance.

Integration and testing: The developed algorithms are integrated into the robot's software framework, with extensive testing conducted in controlled environments to assess and optimize system functionality

Results

The image processing techniques implemented were effective in detecting railway tracks with high accuracy, thereby ensuring reliable navigation for the autonomous robot (Fig.2 & Fig.3).

Independent safety measures were integrated to respond to operational anomalies, thereby increasing the robustness of the system. Two safety features were successfully implemented, a speed adjustment system that dynamically alters the robot's speed based on proximity to detected objects, and an object avoidance system that passively influences the robot to prevent collisions (Fig.4 & Fig.5). All software-related time constraints were met, optimizing the robot's operating speed and responsiveness. This project not only achieved its immediate goals but also established a strong foundation for future advances in autonomous robotic systems near railway tracks.

Heuberger Mattia

Advisor:
Dr. Christoph Eck

Experte:
Dr. Peter Kolb

Projektpartner:
Institut IME, CC Mechatronische Systeme