Decision-Making and Risk-Aware Navigation in Mobile Robotics: From Path Planning to Emergency Response

In modern robotic navigation, efficiency is no longer defined solely by the optimality of the path, but by the robot's ability to make context-based decisions. This dissertation investigates the trade-offs between avoiding obstacles and tolerating controlled risk to improve operational performance in autonomous mobile robots. Although conventional systems treat all obstacles as hazards to be avoided, this work introduces a learning-based framework that enables robots to estimate potential collision damage and determine whether avoidance is truly necessary.

The methodology integrates supervised learning models trained on simulated collision data and couples them with classical path planning algorithms. The result is a system capable of adapting navigation behavior based on obstacle type, potential risk, and mission context. This hybrid approach not only minimizes unnecessary detours, but also conserves energy and time, resources that are critical in complex environments.

A key contribution of this thesis is the explicit integration of damage-aware learning into navigation, filling a gap in the literature where obstacle handling was traditionally risk-blind. Furthermore, the thesis proposes a flexible emergency planning framework designed to be adapted across various robotic domains. The framework emphasizes preparedness and operational continuity in unpredictable situations. Experimental validation, including multiple scenario simulations and statistical analysis, confirms the effectiveness of the proposed methods in improving both safety and efficiency.

This study enhances robotic autonomy in unpredictable and changing conditions by integrating conventional algorithms with data-centric risk assessments, providing effective tools for practical applications in fields like industrial logistics, agriculture, and disaster response.