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Bottleneck Detection and Graph Optimization for Improved Multi-Robot Traffic Flow

Company Introduction

openmaind is a deep-tech startup founded by the former incubed IT team, which was acquired by Verizon. The company develops AI-driven fleet orchestration software that enables factories and distribution centers to efficiently coordinate heterogeneous mobile robots. Acting like Uber and Google Maps for mobile robots, openmaind orchestrates robots from different vendors, optimizing their routes in real time to prevent congestion and maximize throughput. By combining graph-based traffic control, generative AI for intuitive interaction, and data-driven optimization, openmaind minimizes operational costs while unlocking significant efficiency gains.

Problem Description

Even in layouts that already use directed graphs with traffic rules, operational inefficiencies often arise. Robots may experience congestion at intersections, narrow corridors, or high-demand stations. These bottlenecks limit throughput and can vary depending on order flow and fleet behavior, making them hard to predict by static analysis.

The objective of this thesis is to develop a systematic approach to detect and mitigate bottlenecks in robot traffic networks. By analyzing interaction patterns and flow dynamics, the method should identify where capacity is restricted and propose layout or routing modifications that improve efficiency. The solution should be robust across different layouts and adaptable to various operational conditions.

How Does Success Look Like?

Success is achieved when the thesis delivers:

- A methodology for analyzing traffic data and robot interactions to detect bottlenecks in directed graphs.
- An algorithmic framework that proposes and evaluates improvements, such as rerouting strategies or structural modifications to the graph.
- Quantitative evidence that applying the improvements leads to measurable performance gains (e.g., higher throughput, reduced waiting times).
- A validation process that demonstrates the effectiveness of the approach across multiple facility layouts.

The thesis will advance the state of the art in graph-based motion planning by introducing a methodology that bridges theoretical models with practical, real-world layouts.

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