Towards Multi-Layered Dynamic Off-Road Maps

Philip Wickberg

Licentiate Thesis Defence

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Abstract

This thesis is about the requirement elicitation and conceptual modelling of a multi-layered dynamic off-road map with an emphasis on advancing toward real-world validation scenarios. Specifically, it addresses the challenges in fleet management for autonomous haulers moving earth material in open-pit mining applications at construction sites.

The map used to coordinate these autonomous haulers is critical in ensuring productivity and safety, with terrain friction being a key aspect. However, the current state-of-practice relies on static maps that do not support dynamic updating to reflect changes in terrain properties.

To address these limitations, this thesis explores the requirements for a multilayered dynamic map and proposes their integration with the fleet management system using a standardised approach based on a digital twin framework for manufacturing.

Although static maps require validation, maps populated with dynamic components necessitate an even more rigorous validation prior to implementation in real-world applications. Therefore, validation scenarios based on best practices are designed to ensure the map's functionality under various real-world conditions.
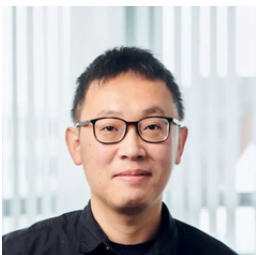
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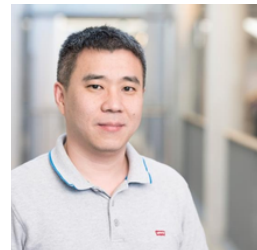Chalmers University of
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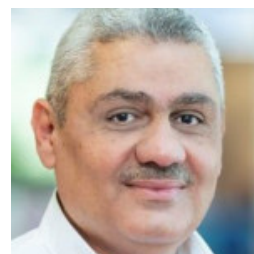*(Reserved Committee member)*

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List of publications in the thesis

Paper A
P. Wickberg, A. Fattouh, S. Afshar, J. Sjöberg and M. Bohlin, "Dynamic Maps Requirements for Autonomous Navigation on Construction Sites," 2022 5th International Conference on Communications, Signal Processing, and their Applications (ICCSPA), Cairo. Egypt, 2022, pp. 1-5, doi: 10.1109/ICCSPA55860.2022.10019082.

Paper B
P. Wickberg, A. Fattouh, S. Afshar and M. Bohlin, "Adopting a Digital Twin Framework for Autonomous Machine Operation at Construction Sites," 2023 7th CAA International Conference on Vehicular Control and Intelligence (CVCI), Changsha, China, 2023, pp. 1-6, doi: 10.1109/CVCI59596.2023.10397254.

Paper C
P. Wickberg, A. Fattouh, S. Afshar and M. Bohlin, "Exploring Dynamic Map Validation at Construction Sites: A Case Study and Feasibility Analysis," (in press) 2024 27th IEEE International Conference on Intelligent Transportation Systems, Edmonton, Canada.

Biography

Philip Wickberg is an Industrial PhD student at Volvo Construction Equipment in cooperation with Mälardalen University. His focus lies within validation of software functionalities enabling autonomy for construction machines. He has worked over 15 years as a test engineer at a complete vehicle level, and previously mainly as an IT consultant.

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