Karlsruher Institut für Technologie

Applied Informatics and Formal Description Methods
Cooperative Autonomous Systems
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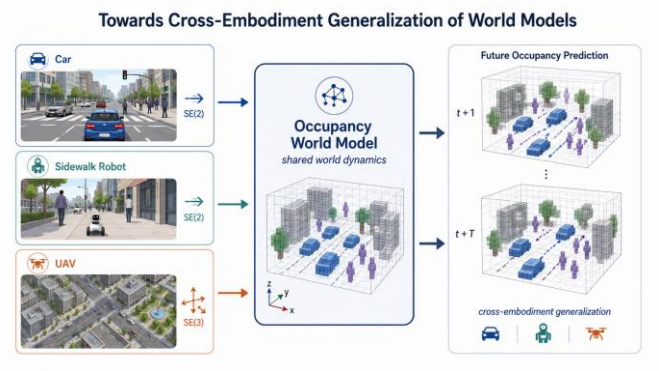
Master Thesis

Towards Cross-Embodiment Generalization of World Models for Urban Navigation

Background:



World models aim to predict how an environment evolves over time conditioned on an agent's observations and motion. While recent occupancy-based world models have shown promising results in autonomous driving, they are typically designed for a single type of embodied agent. It remains unclear whether learned world dynamics can generalize across heterogeneous navigation embodiments operating in the same physical environment. This Master's thesis investigates Cross-Embodiment Occupancy World Models for Urban Navigation, focusing on three representative agents: road vehicles, UAVs, and sidewalk mobile robots. These embodiments operate in shared outdoor urban environments but differ substantially in viewpoint, motion space, speed, and interaction patterns. A simulation pipeline and synthetic dataset covering these three embodiments are already available. Building on this infrastructure, the thesis will focus on developing and evaluating occupancy-based world models that can transfer learned scene dynamics across embodiments. The primary goal is to study cross-embodiment future occupancy prediction, rather than end-to-end navigation or control.

Your Tasks:

- Conduct a literature review on occupancy world models, and cross-embodiment learning.
- Adapt and extend an existing occupancy world model [1] to support Car, UAV, and sidewalk robot data within a unified formulation.
- Evaluate single-embodiment, joint-training, and cross-embodiment generalization across the three agent types, and analyze which scene dynamics transfer across embodiments.
- Write your thesis; publication of outstanding results is highly encouraged.

Your Profile:

- Strong background in computer vision, deep learning, robotics, or related fields.
- Motivation to work on open-ended research problems and conduct independent experiments.
- Solid programming skills in Python and experience with PyTorch.
- Good analytical skills and ability to communicate research ideas clearly in English.

Start date: Immediately **Duration:** As per the applicable examination regulations.

If you are interested or have any questions regarding this thesis position, feel free to contact:

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[1] C. Dang et al., SparseWorld: A Flexible, Adaptive, and Efficient 4D Occupancy World Model Powered by Sparse and Dynamic Queries, AAAI 2026.