Karlsruher Institut für Technologie

Applied Informatics and Formal Description Methods
Cooperative Autonomous Systems
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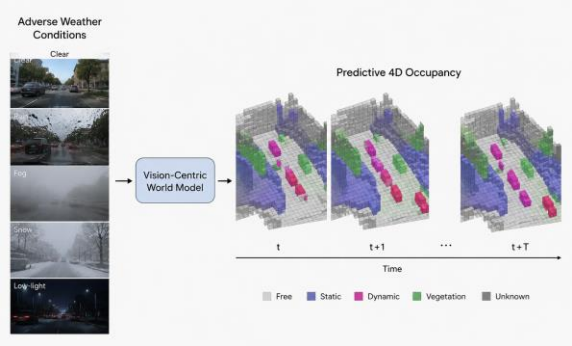
Master Thesis

Robust Vision-Centric 4D Occupancy World Models under Adverse Weather Conditions

Background:

How robust are vision-centric world models when robots operate under challenging weather and visibility conditions? Predictive world models are emerging as a key paradigm in robotics, enabling intelligent systems to understand how their surroundings evolve over time and anticipate future scene geometry, semantics, and dynamics. Semantic 4D occupancy provides a structured representation of this evolving 3D world and is particularly promising for dynamic robotic applications such as autonomous vehicles.



However, most vision-centric 4D occupancy models are developed and evaluated primarily under favorable visual conditions [1]. In real-world robotic environments, rain, fog, snow, low-light conditions, and other visual degradations can significantly affect camera observations and potentially reduce the reliability of future scene predictions. Understanding and improving this robustness is essential for deploying predictive world models in safety-critical robotic systems.

In this Master's thesis, you will investigate the robustness of vision-centric 4D occupancy world models under adverse weather conditions. You will systematically analyze how different environmental conditions affect perception and forecasting performance, identify failure modes, and explore methods to improve the robustness and generalization of predictive occupancy world models.

Your Tasks:

- Investigate the robustness of the model under adverse weather and visibility conditions, such as rain, fog, snow, and low-light scenarios.
- Analyze performance degradation and and explore methods to improve the robustness.
- Benchmark the developed approaches on relevant large-scale datasets
- 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.