Karlsruhe Institute of Technology

Autonome Lernende Roboter (ALR)
Prof. Gerhard Neumann

Project Type

- [x] Master Thesis
- [ ] Bachelor Thesis
- [ ] Praktikum
- [ ] Seminar

Supervisors

Vaisakh Shaj
v.shaj@kit.edu

Difficulty

Algorithmic

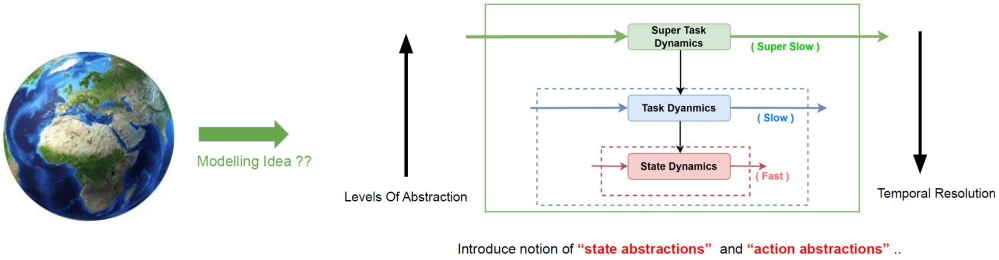
Math

Application

Role of Hierarchy in World Models for Long-Term Prediction

Description

The ability to predict and simulate complex systems over extended time horizons is crucial in various fields, from climate science to economics to autonomous systems. World models [1, 3, 5] attempt to learn a compact and expressive representation of the environment dynamics from observed data. These models can predict possible future world states as a function of imagined action sequences and are a key ingredient of model-predictive control and model-based reinforcement learning. We will investigate a recent hierarchical architecture (under review) developed by our research group that models the world at multiple hierarchies*[4, 2]. The thesis will answer the question of how many hierarchies are needed to achieve accurate and efficient long-term predictions for sequences of different lengths (up to several 1000 timesteps).



Tasks

The primary objectives of this research are as follows:

- Extend the current model: Extend the current model with 2 hierarchies to handle an arbitrary number of hierarchies.
- Evaluate the Impact of Hierarchy: Assess the significance of hierarchy in world models for long-term prediction tasks, focusing on prediction accuracy, computational efficiency, and generalization capabilities.
- Determine Optimal Hierarchy Levels: Investigate the optimal number of hierarchy levels required to balance prediction accuracy and computational efficiency in different domains and scenarios.
- Applications in Real-World Problems: Apply hierarchical world models to real-world long-term prediction problems, such as climate modelling, time-series forecasting and robotic datasets, to assess their practical utility.
- Interpretable Hierarchies: Develop methods to interpret and visualize the latent variables within world models, providing insights into their decision-making processes.

References

[1] David Ha and Jürgen Schmidhuber. World models. *arXiv preprint arXiv:1803.10122*, 2018.

[2] Danijar Hafner, Kuang-Huei Lee, Ian Fischer, and Pieter Abbeel. Deep hierarchical planning from pixels. *Advances in Neural Information Processing Systems*, 35:26091–26104, 2022.

[3] Danijar Hafner, Timothy Lillicrap, Jimmy Ba, and Mohammad Norouzi. Dream to control: Learning behaviors by latent imagination. *arXiv preprint arXiv:1912.01603*, 2019.

[4] Yann LeCun. A path towards autonomous machine intelligence version 0.9. 2, 2022-06-27. *Open Review*, 62, 2022.

[5] Vaisakh Shaj, Philipp Becker, Dieter Büchler, Harit Pandya, Niels van Duijkeren, C James Taylor, Marc Hanheide, and Gerhard Neumann. Action-conditional recurrent kalman networks for forward and inverse dynamics learning. In *Conference on Robot Learning*, pages 765–781. PMLR, 2021.