Karlsruhe Institute of Technology

Autonome Lernende Roboter (ALR)

Prof. Gerhard Neumann

Project Type

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

Supervisors

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Difficulty

Algorithmic

Math

Application

Variational Learning Of Multi Time Scale World Models

Description

Intelligent agents use internal world models to reason and make predictions about different courses of their actions at many scales. For efficient long-horizon prediction, reasoning and planning, the world model needs to predict at multiple levels of temporal abstractions [4, 2].

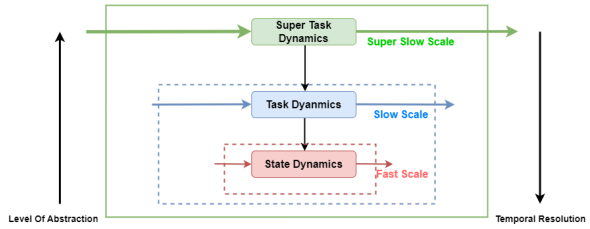

Figure 1: Hierarchical / multi-time scale models the world at multiple temporal abstractions.

Intuitively, low-level temporal abstractions should contain precise details about the input so as to predict accurately in the short term, while high-level, abstract representations should simplify accurate long-term predictions. Both abstractions must also interrelate with each other at least in the sense that the higher-level predictions/plans can be turned into low-level moment-by-moment predictions. For example, in robotic manipulation, the robot must be able to perform precise and coordinated movements to grasp and manipulate the object at a fast time scale while at a slower time scale, the robot must also be able to recognize and utilize higher-level patterns in the task, such as the shape, size and location of objects, and the overall goal of the manipulation task. Coming up with such hierarchical models is an active area of research.

In this thesis, we look at learning such hierarchical world models via variational inference based on a generative model from [3] that used linear Gaussian dynamics models. This allows us to overcome certain limiting assumptions with original work [3] that the dynamics have to be linear and distributions have to be unimodal Gaussians.

Tasks

Depending on the scope of the project the tasks in this project will involve:

- Review state-of-the-art: Literature review on the latest works on multi-time scale / hierarchical world models.
- Derivations: Derive a principled variational lower bound for the learning objective with the help of supervisors and prior works [1].
- Learning Perform learning by maximizing the objective via stochastic back-propagation.
- Compare the results with exact inference methods: Compare the prediction performance on atleast 2 datasets with prior exact inference based method [3].

References

[1] Rahul G Krishnan, Uri Shalit, and David Sontag. Deep kalman filters. *arXiv preprint arXiv:1511.05121*, 2015.

[2] Yann LeCun. A path towards autonomous machine intelligence version 0.9. 2, 2022-06-27. *Open Review*, 62(1), 2022.

[3] Vaisakh Shaj, Saleh GHOLAM ZADEH, Ozan Demir, Luiz Ricardo Douat, and Gerhard Neumann. Multi time scale world models. In *Thirty-seventh Conference on Neural Information Processing Systems*, 2023.

[4] Richard S Sutton. Td models: Modeling the world at a mixture of time scales. In *Machine Learning Proceedings 1995*, pages 531–539. Elsevier, 1995.