Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Personal information

Name	Jair Lemmens
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Studio

Studio		
Name / Theme	Deep Generative Design	
Main mentor	Charalampos Andriotis	Structural Design
Second mentor	Michela Turrin	Design Informatics
Argumentation of choice of the studio	I want to explore the possibility of using deep learning frameworks to enable designers/engineers to go beyond what is achievable using traditional workflows.	

Graduation project

Graduation project	
Title of the graduation project	Deep reinforcement learning for performance-based design.

Goal	
Location:	Not applicable
The posed problem,	The complexity of design requirements is becoming ever greater: climate concerns, housing shortages and ongoing debate about the function of public space are just a few examples. Engineers and designers are at risk of becoming underequipped for dealing with these issues in meaningful way.
research questions and	How can deep reinforcement learning (DRL) agents be used to assist designers in resolving performance-based design criteria?
design assignment in which these result.	To develop a tool which can assist designers by enabling collaboration with DRL agents in an intuitive way. Within the context of this thesis, the framework will be applied to the challenge of floorplan generation. Additionally, the tool may be used in a simple design exercise to highlight it's potential, and analytically compare the result to more typical designs (Swiss Dwelling Dataset/RPlan)

Process

Method description

Based on literature research a framework will be proposed. This framework will then be developed and experimented upon to determine whether it satisfies the condition of being able to assist designers. These experiments will consist of simulations, data analysis and a case study.

Literature and general practical references

Huang, Z., Heng, W., & Zhou, S. (2019). Learning to paint with model-based deep reinforcement learning. In Proceedings of the IEEE/CVF international conference on computer vision (pp. 8709-8718).

Clavera, I., Rothfuss, J., Schulman, J., Fujita, Y., Asfour, T., & Abbeel, P. (2018, October). Model-based reinforcement learning via meta-policy optimization. In Conference on Robot Learning (pp. 617-629). PMLR.

Nolte, F., Melnik, A., & Ritter, H. (2022). Stroke-based Rendering: From Heuristics to Deep Learning. arXiv preprint arXiv:2302.00595.

Regenwetter, L., Nobari, A. H., & Ahmed, F. (2022). Deep generative models in engineering design: A review. Journal of Mechanical Design, 144(7), 071704

Jayasinghe, A., Orr, J., Ibell, T., & Boshoff, W. P. (2021). Comparing the embodied carbon and cost of concrete floor solutions. Journal of Cleaner Production, 324, 129268.

Mathieu, M., Ozair, S., Srinivasan, S., Gulcehre, C., Zhang, S., Jiang, R., ... & Vinyals, O. (2023). AlphaStar Unplugged: Large-Scale Offline Reinforcement Learning. arXiv preprint arXiv:2308.03526.

Haarnoja, T., Zhou, A., Hartikainen, K., Tucker, G., Ha, S., Tan, J., ... & Levine, S. (2018). Soft actor-critic algorithms and applications. arXiv preprint arXiv:1812.05905.

Lillicrap, T. P., Hunt, J. J., Pritzel, A., Heess, N., Erez, T., Tassa, Y., ... & Wierstra, D. (2015). Continuous control with deep reinforcement learning. arXiv preprint arXiv:1509.02971.

Zhang, K., Yang, Z., & Başar, T. (2021). Multi-agent reinforcement learning: A selective overview of theories and algorithms. Handbook of reinforcement learning and control, 321-384.

Reflection

1. The graduation project attempts to implement a novel design informatics technique to facilitate integrated design. Integrated design is one of the key values of the building technology track. Additionally, the use of Deep Reinforcement Learning is fitting for the studio Deep generative design.
2. A well implemented design assistant based on deep reinforcement learning could be useful for a wide range of problems ranging from engineering to medicine. This could be used even in areas with significant data scarcity given that an objective evaluation of performance is available.