Generating Novelty in Open-World Multi-Agent Strategic Board Games

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Abstract

We demonstrate GNOME (Generating Novelty in Open-world Multi-agent Environments), an experimental platform that is designed to test the effectiveness of multi-agent AI systems when faced with *novelty*. GNOME separates the development of AI gameplaying agents with the simulator, allowing *unanticipated* novelty (in essence, novelty that is not subject to model-selection bias). Through the demonstration, we hope to foster an open discussion on AI robustness and the nature of novelty in real-world environments. GNOME will employ a creative audience-interaction methodology well-suited to a virtual conference, as we will expose the facilities of the simulator (including live simulation) through a Web GUI.

GNOME: Preliminaries and Novel Aspects

Multi-agent gameplaying is a difficult research challenge in AI, even with recent advances in deep reinforcement learning. In multi-agent (and typically, stochastic) board games of strategy (such as Monopoly, Risk, and also Diplomacy), the decision space can be vast, and the game environment contains both relevant and irrelevant elements. While recent work on agents has illustrated enormous promise, the prototypical agent is developed with the understanding of a 'default' game[2] that does not change during play. Therefore, the only variance is due to stochasticity (such as die rolls) or due to decisions made by other agents.

While this is a useful abstraction, real-world environments can, and do, change. Furthermore, it is not always possible in advance to anticipate such changes. Arguably, an agent that exhibits true generalization in a given domain (e.g., chess-playing) should be able to detect and adapt to novelties in the domain. This is a new area of research for which neither evaluation platforms (or simulators) nor a mapped-out research agenda exists. We address this gap by demonstrating GNOME, which is funded under the DARPA SAIL-ON program[3]. SAIL-ON is tasked with researching the underlying scientific principles and AI algorithms necessary for training agents that act effectively in novel situations that occur in *open worlds*. AI agents must start reacting as soon as the novelty presents itself, and are not allowed to go 'offline' to re-train or to observe many instances. GNOME provides an advanced simulator that evaluates candidate agents (usually developed by other organizations and teams) through generation and combination of novelties of escalating difficulty. Although GNOME is generally designed for multi-agent board games of strategy, we demonstrate its facilities using the

*Group Webpage: https://usc-isi-i2.github.io/home/

[2]Even if the rules are unknown.

[3]https://www.darpa.mil/program/science-of-artificial-intelligence-and-learning-for-open-world-novelty

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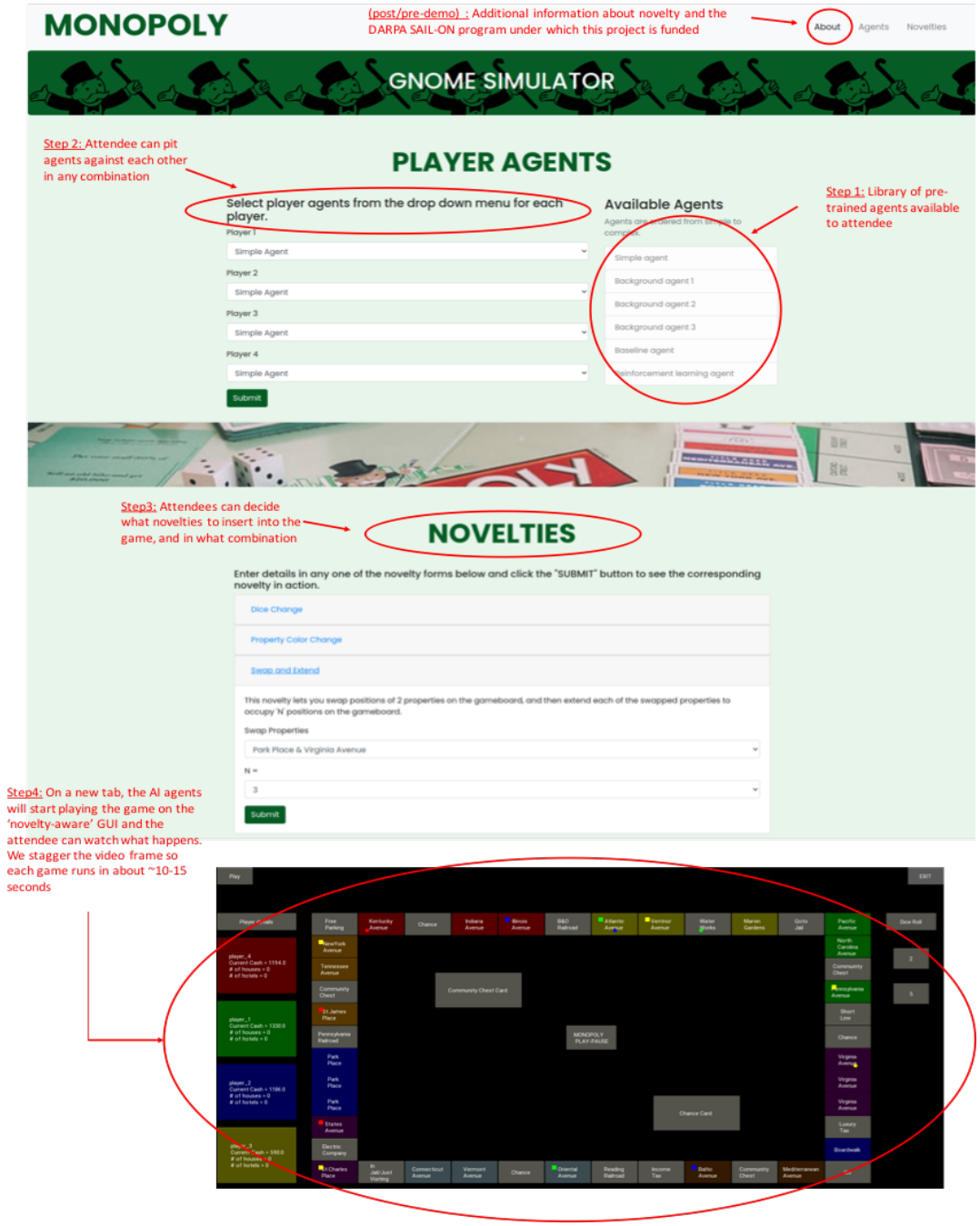

Figure 1: The Web GUI and elements of audience interaction.

classic game of Monopoly. We will also provide pre-trained agents for the attendee to choose from, including a reinforcement learning-based agent.

Demonstration Plan and Audience Interaction. We illustrate the key elements of the demonstration plan and important aspects of the audience interaction in Figure 1. This demonstration has no special needs and will not make use of special equipment. The simulator will run on servers that we will manage and commission. Attendees will only need access to a Web browser to take advantage of the demonstration during NeurIPS, 2020. All demonstrations and simulations will be conducted live.

References

[1] Panagiotis Bailis, Anestis Fachantidis, and Ioannis Vlahavas. Learning to play monopoly: A reinforcement learning approach. In *Proceedings of the 50th Anniversary Convention of The Society for the Study of Artificial Intelligence and Simulation of Behaviour. AISB*, 2014.

[2] Gavin C Cawley and Nicola LC Talbot. On over-fitting in model selection and subsequent selection bias in performance evaluation. *The Journal of Machine Learning Research*, 11:2079–2107, 2010.

[3] Karl Cobbe, Oleg Klimov, Chris Hesse, Taehoon Kim, and John Schulman. Quantifying generalization in reinforcement learning. In *International Conference on Machine Learning*, pages 1282–1289, 2019.

[4] Russell Greiner and Michael R Genesereth. What's new? a semantic definition of novelty. In *IJCAI*, pages 450–454. Citeseer, 1983.

[5] Pat Langley. Open-world learning for radically autonomous agents. In *AAAI*, pages 13539–13543. JSTOR, 2020.

[6] Philip Paquette, Yuchen Lu, Seton Steven Bocco, Max Smith, O-G Satya, Jonathan K Kummerfeld, Joelle Pineau, Satinder Singh, and Aaron C Courville. No-press diplomacy: Modeling multi-agent gameplay. In *Advances in Neural Information Processing Systems*, pages 4474–4485, 2019.

[7] Richard S Sutton and Andrew G Barto. *Reinforcement learning: An introduction*. MIT press, 2018.