

# Reinforcement Learning and Heuristic Search Laboratory at the School of Informatics, Kochi University of Technology

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## 1 Potential Research Projects

My primary research expertise lies in the field of Game AI, with a specific focus on the integration of deep reinforcement learning with heuristic search techniques. My past projects and publications can be categorized into three main directions: 1) Distributed computing game analysis; 2) Go and improvements on the AlphaZero algorithm; 3) Reinforcement learning and deep reinforcement learning applications. My publications include presentations at top AI conferences such as NeurIPS, ICLR, AAAI, and IJCAI.

I am currently engaged in an international research collaboration aimed at solving small board (6x6 and 7x7) Go. To date, we have published two journal and four conference papers in the process of achieving this overarching goal. This project combines all three directions in my research career up to this point. Distributed computing is an efficient way to exhaustively explore the extremely large state space to solve 6x6 Go. Improvements on AlphaZero help create more accurate heuristics that play a crucial role in reducing this search space. Improvements in deep reinforcement learning ensure these heuristics are learned efficiently and consistently.

While it is possible to join the Go solving research project, it is more likely that new members of my research team will work on other topics. A potential topic is applying the AlphaZero algorithm to practical applications in adjacent fields of research, such as scientific computing. Similar topics such as using Monte Carlo Tree Search with varying degrees of machine learning for industrial applications are also good research topics. I am also interested in enhancing model-based learning techniques for environments characterized by uncertainty, which is a significant issue when applying AlphaZero to real-world problems.

Recent advancements in AI, particularly exemplified by large language models like ChatGPT, underscore the utmost importance of AI safety research. I believe strongly that the utmost care is necessary in training AI agents. For

example, reward misspecification resulting in unaligned AI behaviour is a problem almost all RL researchers have experienced. I am eager to formally identify and explore these issues to contribute towards more robust AI systems.

There are other potential topics of research in RL alignment I would like to pursue. With my expertise in deep reinforcement learning, I aim to develop techniques that ensure AI systems align with human values and are accountable for their decisions. Improving interpretability of RL agents' learning processes through the analysis of classical games is a solid first step. Observing and improving how AI systems work in these smaller, well-defined settings may be a key step in ensuring truthfulness and transparency in more complex agents.

## 2 Necessary Skills and Knowledge

Prospective students who wish to join my lab should possess a strong foundation in computer science, mathematics, and machine learning. Key skills and requirements include:

- **Background in Machine Learning:** We use deep reinforcement learning in many of the projects in our lab. Experience in fundamental machine learning concepts, and algorithms are therefore necessary. Experience in deep learning will be helpful.
- **Reinforcement Learning:** Familiarity in topics including the following is preferred, but not necessary. Monte Carlo Tree Search, the AlphaZero and MuZero algorithms, Q-learning, and reward shaping. Experience in deep reinforcement learning is highly desirable (e.g. DQN, A3C, etc.)
- **Programming Skills:** Proficiency in Python (especially PyTorch) is preferred. Experience in other languages, especially C++, is a strong plus.
- **Mathematical Proficiency:** A strong understanding of linear algebra, probability, and statistics is highly desirable.
- **Research and Language Skills:** You are expected to survey and present up-to-date research papers regularly, so proficiency in English is highly preferred. You must be able to pose research questions, design and conduct experiments, and interpret and analyze experiment results autonomously. Past experience in academic writing is a plus, but not necessary.
- **Teamwork and Collaboration:** We may be collaborating with research teams in Taiwan and Canada, so you must be able to communicate clearly and work as part of a team.

## 3 Laboratory Information

Having started in March, 2024, We are the newest laboratory at the School of Informatics. Research equipment is limited at the moment, but you will be provided any necessary compute for research moving forward.