

## DSA Research Experiences for Undergraduates

### Research Project

#### Section1: Faculty Information

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#### Section2: Research Project Proposal

Project Title	Reinforcement learning: theory and application
Project Description (max 800 words)	<p>Reinforcement learning (RL) can be applied in a variety of real-life applications, including improving the design of large language models[1], control towards sustainable wastewater treatment plant[2], control of traffic signals[3], control of mathematical finance[4] and so on. The success of reinforcement learning depends on the balance between exploration and exploitation.</p> <p>This project will focus on RL-related problems motivated by real-life scenarios, design and evaluate mathematically-sound algorithms analytically and numerically. Students will explore both theoretical foundations (e.g. performance guarantees of rl and bandit algorithms) and practical implementations (e.g., comparing the proposed algorithm with existing state-of-the-art algorithms with real dataset.)</p> <p>[1] DeepSeek-AI, D. Guo, D. Yang, et al. DeepSeek-R1: Incentivizing reasoning capability in LLMs via reinforcement learning. <i>arXiv: 2501.12948 [cs.CL]</i>. 2025: 1-22.</p> <p>[2] K. Chen, H. Wang, B. Valverde-Pérez, et al. Optimal control towards sustainable wastewater treatment plants based on multi-agent reinforcement learning. <i>Chemosphere</i>. 2021. 279: 130-498.</p> <p>[3] H. Mei, J. Li, B. Shi, et al. Reinforcement learning approaches for traffic signal control under missing data. <i>International Joint Conference on Artificial Intelligence</i>. 2023: 2261-2269.</p> <p>[4] Y. Dong. Randomized optimal stopping problem in continuous time and reinforcement learning algorithm. <i>SIAM Journal on Control and Optimization</i>. 2024. 62(3): 1590-1614.</p>
Proposed Research Duration	Start Date: <u>  2025  </u> / <u>  03  </u> / <u>  15  </u> End Date: <u>  2025  </u> / <u>  09  </u> / <u>  01  </u>
Student/Researcher Duties	Discover the unsolved problem regarding to RL/bandits.

	Design and analyze efficient RL/bandit algorithms and evaluate their optimality analytically. Evaluate the efficiency of RL algorithms with real dataset.
Technical Skills Required	<input checked="" type="checkbox"/> Python <input checked="" type="checkbox"/> Machine Learning <input type="checkbox"/> Big Data <input type="checkbox"/> R <input type="checkbox"/> Deep Learning <input type="checkbox"/> SQL <input type="checkbox"/> C/C++ <input type="checkbox"/> Other: _____
Preferred Student/Researcher Background	Mathematics, programming
Maximum Number of Students/Researchers	<input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2

### Section3: Pre-Application Research Exposure Meeting

Faculty members are encouraged to schedule a Research Exposure Meeting to introduce students to their projects.

Preferred Date	
Preferred Time	
Meeting Mode	<input type="checkbox"/> In-Person <input type="checkbox"/> Online
Venue (if in-person)	In-person is preferred
Meeting Link (if online)	Per request