Proposal for VE/VM490 Undergraduate Research Course

Semester & Year: Summer 2019 **Instructor:** Paul Weng

RESEARCH PROJECT INFORMATION:

Title of Project:

Visualizing the value function landscape of a reinforcement learning problem

Project Description (Please be sure that the information you provide is easy and detailed enough for the majority of JI undergraduate students to completely understand every relevant aspects of the project, and for the Undergraduate Research Committee to make appropriate judgement. Try to avoid using terminology without explanation. Include references if possible):

1. Project Background

Reinforcement learning (RL) is a general model for adaptive control (e.g., autonomous driving, intelligent tutoring or robotics). In such a setting, an agent learns by interacting with an environment by trial and error. Recently, the combination of deep learning and reinforcement learning (called deep RL) has proved to be extremely powerful. Using such techniques, an agent can learn to play video games from visual inputs or the game of go at a superhuman level. Currently, research on RL and deep RL has become very active in the machine learning community, mainly because of the potential of this approach. Ongoing research work notably focuses on making those techniques more practical and efficient such that they could be applied to more diverse domains.

2. Specific Role for the Student

The student will test different visualization techniques to better understand the landscape of value functions in reinforcement learning

3. Goal of the Research

To be able to design learning algorithms that are more efficient than current methods for instance, in terms of sample complexity (e.g., number of interactions with the environment in order to learn) or in terms of computational complexity, a better understanding of the value function landscape for a given RL problem needs to be reached. This could help explain why some RL algorithms work better in some problems than others. Moreover, the knowledge of properties of the value functions discovered with such visualizations could be exploited during learning.

4. Primary Approach to Achieve the Goal

The work will be performed on simulated problems (e.g., Atari games, robotic tasks). The visualization techniques used in this work will be based on those developed for deep learning [1].

The basic methodology will follow the following steps:

1) Set up an experimental environment for running deep RL algorithms on different problems.
2) Select different RL problems (e.g., Atari games, control problems)
3) Evaluate different visualization techniques on these problems.

4) Analyze the experimental results

[1] https://arxiv.org/pdf/1712.09913.pdf

Monthly Plan: (Be specific. A half-page report on how the monthly plan is followed is requested to be turned into the URC at the end of class with the advisor's signature, don't include any confidential information.)

The student is expected to achieve notable progress during the four months of working on this project:

1. May: Study deep learning, RL and the visualization techniques described in [1].
2. June: Set up the experimental environment, select some RL problems for evaluation (with the help of the advisor), and start running some experiments.
3. July: Implement and evaluate different visualization techniques
4. August: Finish running the experiments and analyze the experimental results. Prepare the final report.

Student Outcome: (Provide a list of outcomes. Be specific, don't use words like "improve research skills".)

1. Learn the steps towards performing a successful experimental research work.
2. Improve writing and presentation skills, as well as learn technical writing.
3. Become familiar with deep learning, RL and deep RL.
4. Learn theoretical methods and become able to apply them to solve a practical problem.

Grading Policy (Include a percentage on each item, weekly progress evaluation and final report must be included):

1. Weekly progress report (20%)
2. Final report (30%)
3. Final presentation (20%)
4. Source code of the algorithm (30%)

Extra points: a technical paper in a top-tier conference or journal in power systems or AI/ML (20%)

(If additional space is needed, please attach a separate piece of paper)

PREREQUISITES:

Major: ECE **(ECE/ME)** **Class:** Junior/Senior **(Junior/Senior)**

Prerequisites:

1. Strong background in mathematics (e.g., probability theory, statistics, linear algebra)
2. Strong coding skills (e.g., Python, Lua)
3. Some background in deep learning would be preferred

4. Be self-motivated towards working on the project

The following section is to be completed by JI:

☐ **Approved**

☐ **Disapproved (Reason:** _____)

Signature: **Date:**