Innovation in Gaming Technology: A Course Proposal Using Machine Learning to Improve Gaming Infrastructure

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract
Within the University of Virginia's (UVA) computer science electives, Artificial Intelligence focuses on AI agents in gaming, yet doesn't expand on highly developed agents. A new proposed course offering, Reactive Game Agents, would combine elements from the existing classes CS4710 Artificial Intelligence and CS4774 Machine Learning to describe how game developers can employ the power of machine learning. This course would teach students the process of making intelligent game agents capable of learning over time from their environments and from user input. Additionally, the course could introduce students to modeling machine learning systems to create adaptive worlds, render dynamic graphics, or implement other game development concepts. The proposed course would teach students how to make intelligent game agents and would put students on the cutting edge of game technology.

1 Introduction

Video games are one of the largest entertainment industries in the world in terms of global revenues, with video game industry revenue estimated at $160 billion at the end of 2020. As such, it wields significant market power. Not only this, but it still has room to grow as one of the fastest-growing industries [1]. As the market grows, the development of technologies associated with games, including software, will continue to develop, increasing the need for programmers with the skills necessary to be on the cutting edge. At UVA, there are currently no electives covering video games development using machine learning. After completing their classes at UVA, students wishing to join the video game market would benefit from being put at the forefront of the expanding market.

2 Background

As video games develop, one of the associated evolutions is the use of machine learning in a variety of ways to improve the gaming experience. Game agents such as Non-Player Characters (NPCs) can be developed to determine attack and defense, enact strategies, or determine pathing using various machine learning methods [2]. Content generation, including unique levels, weapons, and music, has also been experimented with [3]. Also, neural nets have been used to help develop better graphics rendering, most notably by NVIDIA [4].

3 Related Works

Redesigning or adding new classes is possible, as shown by UVA's redesign of the current Bachelor of Science CS curriculum, which combined courses from a previous curriculum to make them more efficient [5]. This proposed course would implement ideas used in CS4710 Artificial Intelligence, which is focused on an introductory exposure to AI implementation methods [6]. It would also use CS 4774 Machine Learning concepts, covering introductory supervised and unsupervised machine learning techniques [7]. Other students have also published Technical Reports focused on developing new computer science courses [8].

4 Proposed Design

This course proposal includes a breakdown of content among a 12-week schedule and a final project design.

It is not explicitly designed for a specific class period length, as the professor could decide the best fit for teaching this course. The prerequisites for this course would include at least CS4710 Artificial Intelligence and CS 4774 Machine Learning, to reduce the time introducing these topics.

4.1 High-Level Course Objective

By the end of the course, students would be able to:

1) Leverage a variety of machine learning techniques to help develop games
2) Understand how different machine learning techniques can be utilized for different results
3) Apply machine learning to computer graphics and game agents
4) Design their own intelligent machine learning-based game agent

These course objectives are based on combining ideas from Machine Learning and Artificial Intelligence and applying them to modern game development. These goals will enable up-and-coming video game developers to be on the cutting edge of contemporary technology and aim for high technique-level jobs in the gaming market. Also, the concepts covered while reaching these goals can be applied to other fields, as the methods for understanding, developing, and training machine learning models specifically for games can be generalized to cover broader topics such as digital image scaling or better language processing. These goals should allow the students to utilize a diverse range of techniques while encouraging them to search for the best option given the task at hand.

4.2 Topic Breakdown

The weekly topic breakdown allows the students to ease into the topics, so they are not overwhelmed. The first two weeks would be focused on reviewing critical topics covered in machine learning and artificial intelligence. This would both refresh the students' knowledge on prerequisite topics and allow students to all be on the same level for the following topics. The next four weeks would focus specifically on using machine learning to improve video game graphics. This would focus on machine learning-based resolution upscaling tasks to improve frame rate, a topic that large scale companies like NVIDIA and AMD are currently interested in [4][9]. The final six weeks would focus on the broad topic of game agents. The best way to go about this would be to spend the first half of this topic on machine learning-driven reactive and intelligent game agents. This would include single adversarial NPCs, groups of adversarial NPCs working together, and player supporting NPCs. The second half of this topic would focus on game agents utilizing machine learning-based content generation, such as using trained machine learning models to provide unique missions based on loose parameters or generating player interactions for world-building. This type of content generation would allow for realistic and efficient content generation that still follows a plan and allows for relatively unique gameplay between instances of a game.

4.3 Coursework

Students would be expected to participate in class throughout the semester by asking and answering questions, submitting five homework assignments, and completing one final project.

4.3.1 Participation (15%). The structure of participation would be based on Jack Davidson's participation grade in the class CS 4630 Defense against the Dark Arts. When students ask or answer a course-related question, they receive a card which would be totaled at the end of the semester; and if they have enough cards, they will receive the full 15% credit.

4.3.2 Homework (50%). The structure of the homework will be loosely based upon Lu Feng's CS 4710 Artificial Intelligence class. Each homework assignment would be worth 10% and evenly spaced throughout the semester. Each assignment would be done on a given computer game code that the professor provides.

4.3.3 Final Project (35%). The final project would be worked on over the entire semester. It would be split into four main parts: Proposal, Checkpoint, Final Submission, and Video Demonstration. This project would be done as a

group of 2-4. The project is broken down into more detail in the next section.

4.4 Project

The semester-long final project would be designed to allow the students to practice the things learned in class. The students must utilize a machine learning technique to implement a game agent in some game. They must develop a concept, choose a viable technique to fit the task, refine the model, and present it.

4.4.1 Proposal. The proposal would allow the students to select what they want to work on, such as reactive enemies or content creation, and how they plan to implement it. This is not concrete and can change as more techniques are learned. Students would be encouraged to use open-source games if they want a challenge but will also be provided with video game source code to use.

4.4.2 Checkpoint. Halfway between the proposal and the final submission, there would be a checkpoint which is a way for the professor to gauge how well students are progressing on their projects. The students should have a reasonable idea as to what technique they will be using and have some rudimentary results.

4.4.3 Final Submission. The final submission should be the trained model that produces the results that the students desired, along with a description of the results, if they were in line with what they expected, and any unexpected challenges they encountered during development.

4.4.4 Video Demonstration. The students would submit a video demonstration of their machine learning game agent performing along with the final submission.

5 Expected Outcomes

This proposed computer science course would fill a gap in the UVA curriculum. The people who take this course would likely be those who have taken CS 4730 Game Design or special topic courses focused on game theory as it would pique their interests. This course would allow students at UVA who are interested in going into video game development after graduation, to be on the cutting edge of machine learning techniques in video games, providing them with desirable skills for employers.

6 Conclusion

This course was designed to provide an edge to UVA students who wish to pursue a career in video game development's ever-changing and advancing market. CS4710 Artificial Intelligence and CS 4774 Machine Learning were used as a topic basis, with other current CS electives providing a base for the structure of the class. The resulting course plan consists of a 12-week topic breakdown and a coursework structure, including a final project plan.

7 Future Work

To continue this project, the next step would be implementing this course into the UVA curriculum. This would consist of a few steps, starting with fully designing the course, complete with assignment designs, syllabus creation, and lecture content. Additionally, it would benefit the course if a professor with a background in either machine learning or game development, or preferably both, would be available to teach it. After this, it would be important to offer this course with an elective pilot status to continue to develop the program with student feedback for the first few times it is offered.

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