Universitatea Alexandru Ioan Cuza Iași

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**BACHELOR THESIS**

**Application of K-means Clustering in Video Games**

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1.INTRODUCTION

From the day I started my studies at the faculty of computer science I knew I wanted to pursue a career in game developing. To be one step closer to my career of choice I decided that for my bachelor thesis I would combine my passion for game developing and the limitless applications of machine learning. Using the Unity engine I developed a simple game that showcases the K-means algorithm by using it to train an Artificial Intelligence adversary for the player.

The game has a simple premise, the player controls a blue square that can only move on a grid in the 4 cardinal directions and must reach the goal, the AI adversary, with the same movement constraints as the player and only moving at the same time as the player, must intercept and bump into them to end the game. The adversary doesn’t know the position of the player at all times, he has a vision radius in witch he can detect the player, acquire his position and save it in a file for later use. The K-means algorithm uses the saved player locations to form clusters and determine an advantageous position from where the adversary can intercept the player, the using the A star algorithm the adversary will find a path to this more advantageous position and follow it.

2.SIMILAR APPLICATIONS

Information on the use of machine learning techniques in video games is mostly known known publicly through research projects as most gaming companies don’t publish specific information about their intellectual property. The most popular application of machine learning in games is the use of deep learning agents that compete with professional human players. Another popular type of agent is the computer vision-based AI player. The most significant application of machine learning has been done on games such as Dota 2, the StarCraft series, Pong and Doom. Games that did not originate as video games such as Chess and Go have also been subject to machine learning research.

2.1. Deep Learning Agents

Deep learning focuses heavily on the use of artificial neural networks that learn to solve complex tasks. Deep learning uses multiple layers of artificial neural networks and other techniques to progressively extract information from an input. Due to this complex layered approach, deep learning models often require powerful machines to train and run on.

**Chess** is considered a difficult AI problem due to the computational complexity of it’s board space, it’s state space being 10^120 possible board states. Similar strategy games are often solved with some form of a Minimax Tree Search. These AI agents have been able to beat professional human players, such as the historic 1997 Deep Blue versus Garry Kasparov match. Since then, machine learning agents have only shown even greater success.

**Go** poses an even more difficult AI problem then chess. The state space of Go is approximately 10^170 possible board states, much greater then the state space of chess.

Google’s 2015 AlphaGo was the first AI agent to beat a professional Go player. It used a deep learning model to train the weights of a Monte Carlo tree search. The deep learning model consisted of 2 Artificial Neural Networks, one network to predict the probability of potential moves made by the opponent and the other network to predict the win chance of a given state. The combination of the deep learning model and the Monte Carlo tree search allowed the agent to explore the state tree much more efficiently than if it was using just the Monte Carlo tree search.

AlphaGo was initially trained on games against human players and later on games against itself. Later, in 2017, another implementation of AlphaGo, AlphaGoZero, was made public. This implementation was able to entirely train by playing against itself and it would train much faster then it’s predecessor. In the final stages of it’s training AlphaGoZero would develop new advanced strategies that, until then, were never used by a Go player.

**The StarCraft series** is a series of real-time strategy video games that have become very popular environments for AI research. Blizzard, the game’s developer, and DeepMind have collaborated to release a public StarCraft 2 environment for AI research.

Alphastar was the first AI agent to beat a professional StarCraft 2 player without any in-game advantages. Initially for it’s deep learning network the agent used a simplified zoomed out version of the gamestate as imput, but later it was updated to play using a camera like other human players. Up to the date of writing this document the code or architecture of the model have not been publicly released by the developers of Alphastar, but they have listed several machine learning techniques that they used, such as relational deep reinforcement learning and long short-term memory.

Initially Alphastar was trained with supervised learning, it watched replays of many human games in order to learn basic strategies, later it trained against different versions of itself an was improved trough reinforcement learning. The final version was successful but it was only trained to play on a specific map and matchup.

**Dota 2** is a multiplayer online battle arena (MOBA) game. Because of it’s complexity traditional AI agents have not been able to play at the same level as professional human players. The only widely published information on AI agents attempted on Dota 2 is OpenAI’s deep learning Five agent.

OpenAI Five utilized separate Long Shor-Term Memory networks to learn each hero in the game. It trained using a reinforcement learning technique known as Proximal Policy Learning. It trained against itself on a system containing 256 GPUs and 128,000 CPU cores accumulating 180 years of game experience each day. OpenAI Five's first public appearance occurred in 2017, it won a one-on-one game against a professional Dota 2 player known as Dendi. The following year the agent advanced so much that it could performe as a team and in a 2019 series of games beat the 2018 Dota 2 champion team.

2.2. Computer vision-based agents