A Multi-agent System For KAZ

AASMA 2023 Project Proposal

Tomás Pereira 95682
Maria Campos 95629
Sofia Bonifácio 92559

ABSTRACT

Knights Archers Zombies (KAZ) is a game from PettingZoo where a group of Archers and Knights have to prevent an endless spawning swarm of Zombies from reaching the bottom of the screen. The game ends when either a Zombie reaches the bottom or all the players are killed by colliding with Zombies. We will be addressing this game as a multi-agent coordination problem, where we'll have to find the best way to make a Knight and an Archer coordinate and cooperate in order to achieve the best results possible. To reach the desired solution, we will be analyzing different experiment results.

KEYWORDS

Multi-agent system; Coordination; Cooperation; Negotiation; Environment; PettingZoo

1 INTRODUCTION

1.1 Motivation and Related Works

This game is a prime example of a multi-agent scenario. Archers and Knights can attack Zombies with long ranged arrows or a close ranged mace, respectively. Knights can hit multiple Zombies at the same time, while Archers can only hit one per arrow. Not only that, Archers have a limit of max arrows on the screen. This makes it so each different type of player has their own strengths and weaknesses, making so that coordination is essential for a good performance in the game.

Given this, the Knights and Archers when controlled by AI have a lot of underlying potential to have somewhat interesting performances. In the untouched PettingZoo game version, the AI that controls these characters acts on semi-random actions, not detecting the enemies properly for both attacking and survival measures, meaning that they don't have or don't properly take advantage of any sensors. An example of proper coordination would be for the Archer to focus on far away enemies while the Knight took care of enemies within the Archer's range. But to achieve solutions like this, we need to experiment different rule sets for the agents.

Coordination based video game agents are already a heavily studied topic in the field of AI, meaning that there may be similar cases that we can base our solutions from and study.

1.2 Problem Definition

In terms of game mechanics, as we have described before, the game abids by the following rule sets:

AASMA Project, IST, 2023, Lisbon, Portugal

https://doi.org/

- Zombies spawn from the top border of the screen and make their way down to the bottom border in random, unpredictable paths.
- Archers spawn on the left side of the lower third of the screen and Knights spawn on the right side of the lower third of the screen.
- There may be any number of Archers and/or Knights.
- Each agent can attack to kill zombies, rotate clockwise or counter-clockwise and move forwards or backwards.
- Knights swing a mace in an arc trajectory in front of their current heading direction and Archers fire arrows in a straight line in the direction of the archer's heading.
- Game is over when all agents die or a zombie reaches the bottom.
- Other settings of the game may be customizable, such as agents dying if they hit the lateral borders of the screen, the spawn rate of the zombies and the max amount of zombies on screen.

1.3 Problem Relevance

This game provides a lot of room to develop a multi-agent system in which the agents can achieve the following traits:

- Cooperation: the agents can work together as a team to achieve a common goal (that is preventing the Zombies from reaching the bottom)
- Coordination: the agents can manage the inter-dependencies between activities such as not attacking the same Zombie so that the potential for coverage from Zombies is maximized.
- Negotiation: the agents can reach an agreement on a common goal if they differ initial goals, such as one wanting to retreat to a certain spot in the map while another wanting to move towards enemies. In such situations, they may see if it's more beneficial to act together.

1.4 Objectives of the Project

As stated before, our main goal in this project will be to flesh out and model the game as a multi-agent problem to solve various coordination tasks. We will have to ponder which coordination strategies are the best and most effective to last longer in harder iterations of the game.

2 APPROACH

2.1 Environment Specifications

The environment has the standard setup of a PettingZoo "Butterfly" environment, in the sense that it is an Atari-esque Pygame visual space. The environment can act both as an Agent Environment Cycle (AEC), meaning that it acts on sequential agent observations and actions (Static Environment), or as a Parallel Environment, based on Partially Observable Stochastic Games (POSGs), where all agents take actions and observations in parallel (Dynamic Environment).

KAZ's environment is seen as **accessible**, since any agent can obtain a complete and accurate up-to-date state of the environment during their observation, and **deterministic**, since actions have single, guaranteed effects. To add to that, since the game space is limited in both actions and fixed two dimensional movement, the environment is also **discrete**. Similar to a lot of game based environments, KAZ's environment is **episodic**, since the different runs of the environment are different and independent from one another.

2.2 Multi-Agent System

In terms of **sensors**, agents can see the position of zombies and other agents, and in terms of **actuators**, they can choose to rotate, move or attack.

The agents in our system can be seen as **proactive**, as they have goal based behaviour, where they take initiative and recognize opportunities (e.g when a zombie is in range, a Knight can attack it). They also have, as expected, **social ability**, since they are able to communicate and interact with other agents through cooperation, coordination and negotiation requests. In terms of properties, agents in this system will be **autonomous**, since they are able to execute actions and infer goals by themselves. This is especially important in the case of the other agent dying, where the agent should be able to still fend off against zombies independently. They will also have **mobility**, as they are able to change their location in the environment, that is to say, in the map.

With this, we can say that in terms of agent architecture, they will be hybrid agents, more specifically, deliberative-reactive agents, as they formulate a defined goal, but can react to unprecedented and unexpected situations, negotiating and deciding towards more efficient goals.

The deliberative aspect of the architecture is reflected in the fact that, to fend off the Zombies for as long as possible, the agents must formulate a plan, either to kill the closest Zombie to them or another player or to kill Zombies that are too close to the border. The reactive aspect arises from the fact that agents will have to change their plan throughout the environment's transformation.

3 EMPIRICAL EVALUATION

In this game, there are 3 main metrics that we can infer performance from:

- Amount of zombies killed.
- Amount of agents that died.
- How long the game "run" lasted.

At first, the number of killed zombies may seem unnecessary since it is expected that the amount is proportional to the length of the game. But in different contexts and in different settings, these two metrics may have less correlation than what might be inferred at first. So, to this effect, we deemed important to keep them both as separate performance statistics. This ends up reinforcing the fact that it is also of interest to run the game in different settings, to create different contexts of difficulty, such as runs where the zombie density is much higher than normal or where the archer has less maximum arrows shot at once.

We also have to differentiate runs that end due to agents failing to protect themselves from runs that end due to agents letting zombies escape. Tuning their goals towards avoiding these two different "game over" states could be better studied through the amount of agents that died in the run: Did a zombie escape when one agent died? Or while two were alive? Is the most frequent game over state from both agents dying? And so on.

Through analysis of various cases using these 3 metrics, we will be able to infer the strengths and weaknesses of each coordination strategy.