Capture The Flag

Project Proposal
Autonomous Agents and Multi-Agent Systems

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ABSTRACT

In this project, the game Capture The Flag will be developed. This game is a multiagent system where the environment is dynamic and unpredictable. For that reason, the agents have to be reactive, have the capability to learn and cooperate with others. This is what we call multi-agent learning: many individual agents must act independently, yet learn to interact and cooperate with other agents. With this game, agents can learn teamwork, an ability needed to solve various real-word problems.

CCS CONCEPTS

• Artificial Intelligence • Machine Learning • Statistics

KEYWORDS

Multi-Agent System, Reinforcement Learning, Capture The Flag, Communication, Cooperation, Reactivity

1 Introduction

1.1 Motivation

It is important that an intelligent system learns social ability to solve real-world problems. Online games and traditional sports are great systems for this purpose. For that reason, the game Capture the Flag will be the system of this learning due to the complex cooperation that it contains.

1.2 Related Work

Multi-agent systems are difficult to coordinate due to the complexity of the systems. As opposed to purely reactive agents, logic-based reasoning may lead to an optimal performance [1]. Also, Reinforcement Learning comes in place to help agents learn and discover new solutions [2].

1.3 Problem definition

Capture the Flag is a team-based multiplayer that owns multiple variations. In our approach, the game considers players distributed among two teams of different colors, **red** and **blue**. There are multiple **red** and **blue** flags as well as colored defensive and 2 delivery areas. The flags are initially spawned in the defensive areas with the respective color, as well as the agents. Each team needs to capture as many flags as possible of the opposite color and deliver them. Let **A** and **B** be red or blue opposite colors. The game complies to the following rules:

- An **A** agent can steal a **B** flag from a **B** defensive area.
- An **A** agent can steal an **A** or **B** flag from a **B** agent.
- An **A** agent can freeze a **B** agent inside an **A** defensive area. A frozen agent cannot move until being unfreezed by a teammate.
- An agent that captures a flag get's its movement decreased by 0.2x until its stolen or delivered
- An agent can catch a boost that increases its movement for 0.2x for 2 seconds.
- An **A** agent must return an recovered **A** flag to a defensive area
- An **A** agent delivers a **B** flag in an **A** delivery area to gain 1 point. One team wins if they reach 50 points.
- After delivering an **B** flag, it is spawned again in an **B** defensive area.
- Agents have to decide between delivering flags, defending areas or unfreezing teammates.
- There are more agents than defensive areas to avoid camping and force them to move

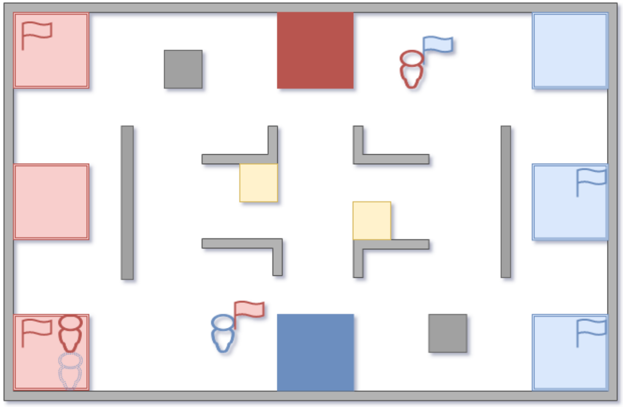

Figure 1: **Capture the Flag board**
(frozen agents are represented with dash lines; collapsed areas and walls are marked as gray; boosts are marked as yellow; defensive/delivery areas are marked with lighter/darker colors)

1.4 Objectives

The project focuses on creating and evaluating on how agents cooperate together as a team to achieve the same objective. Ultimately, we try to design an optimal system with intelligent agents that make the best decisions in order to reduce the time that a team takes to win a game.

2 Approach

2.1 Environment

The environment contains randomly spawned boosts and obstacles such as walls and units of area that may randomly collapse. The environment is characterized as:

- **Fully accessible**: agents obtain accurate information;
- **Deterministic**: every action has a guaranteed effect;
- **Dynamic**: world may change due to a stolen/delivered flag or new obstacles when an agent is deliberating;
- **Discrete**: there is a finite number of agent actions;
- **Non-episodic**: each match is independent.

2.2 Multi-Agent System

2.2.1 Properties

- **Reactivity**: agents react to environment changes;
- **Proactiveness**: agents take initiative and decide;
- **Social ability**: agents interact with others;
- **Cooperation**: agents work with their team to achieve the same objective - win the game;
- **Coordination**: initially, agents distribute objectives;
- **Communication**: agents communicate within the board, regardless of the range they are a part of;
- **Adaptatively**: agents learn from previous actions;
- **Rationality**: agents make a decision;
- **Mobility**: agents move through the environment.

2.3 System Architecture

The environment has the states of the following type: (Pos, C ,F ,M, B, Poi). Pos is the position of the agent, that is, the coordinates (x,y) of agent in the map, C is the color of the agent, F indicates whether or not the agent has the flag, M indicates whether the agent is frozen or not, B indicates if agent has boost and Poi are points of team C.

2.3.1 Sensors

Agents have a variety of sensors to detect and interact with other agents:

- Verify if the agent/flag/defensive area is red or blue;
- Verify if the agent is frozen/unfreeze;
- Verify if there is a wall at the front;
- Verify if there is a boost;
- Inspect and verify if the unit of area is empty or not.

2.3.3 Actuators and Actions

Agents have different actuators to act using their sensors:

- Steal red/blue flag from opposite team agent;
- Defend own team's defensive area;
- Freeze the opposite team agent;
- Unfreeze team agent;
- Move to a given unit of area;
- Get a boost.

2.3.4 Observation space

Agents have a well defined observation space. They have an unlimited **observation (A)** range, within the area of the map, that reveals positions of all existing defensive, delivery areas and team members. They also have limited **observation (B)** of opposite team, boosts and obstacles.

2.3.5 System requirements

Capture The Flag is a dynamic fast paced game. Thus, we need to take into account the following requirements:

- A system that operates effectively in time with low computational complexity and fast decision time;
- Intelligent behavior combining coordination within a team and interaction with the environment;
- A system where agents can learn;
- An unpredictable environment with new obstacles and boosts to test the reactivity of the agents

Agents shall learn using Reinforcement Learning technique that rewards and punishes certain behaviors.

To complement this, agents receive new information from teammates regarding new states of the environment.

To conclude, a hybrid architecture is the one that best matches the requirements. It takes advantage of the reactivity of agents upon changes in the environment and provides a good learning opportunity for agents to adapt from perceived and communicated experiences.

3 Empirical Evaluation

We evaluate different characteristics of the system by tuning different parameters. For the first method, we have two configurations. The first concerns limiting the **observation A** capacity of one team which should dramatically decrease the communication and coordination. Similarly, the second configuration varies the **observation B** capacity. Both configurations should affect the decision making due to the limited observation space of components in the map. For a second method, we cover an extra game mode where both teams have a strict objective. The first must attack (steal and deliver flags) and the second must defend (freeze enemies and recover flags), which helps to understand how agents adapt to the best strategy. The winning time and steps taken in a team will be used as a metric to comprehend how different configurations affect the effectiveness of decision making.

REFERENCES

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