Multi-agent System in Fire Emergencies

Project Proposal - Group 53

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ABSTRACT

Fires are a catastrophe that humanity has been dealing with for many years and most of the time it ends in tragedies with countless victims and environmental and financial damage. With the evolution of technology and artificial intelligence, the opportunity arose to use robots in this tasks. This project aims to study the behavior of agents when fighting the fires and to optimize it through cooperation.

KEYWORDS

Fire; Multi-Agents; Decision Making, Artificial Intelligence

1 INTRODUCTION

In this section we are going to discuss what the problem consists and present our project proposal for the topic, that is going to be developed in the context of the Autonomous Agents and Multi-Agent Systems course.

1.1 Motivation

What motivated us to develop our project in the theme of fires is the regularity of fires every year - especially in the summer. Although our project is designed for indoors environments, we aim to amplify our results to every fire incident, hoping that we can understand the best behavior to take in a fire situation.

1.2 Related Work

Every year, fire causes a lot of damages and, unfortunately, many lives are lost. Firefighters risk their lives trying to help those in danger and often end up injured or lose their lives as well. Fortunately, systems as a humanoid robot described in [4] are being developed to help humans combat fires.

Artificial agents can have important roles in firefighting. Bogue explores those roles and states that drones with imaging and other sensors provide situation awareness and warnings to firefighters, which is particularly important in wildfires.

To finish, [3] designed an autonomous robot with the capacity of detecting flames and also extinguish them with carbon dioxide, which is an illustration of what we aim our agents to be able to perform.

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1.3 Problem Definition and Relevance

Our problem starts with two agents inside a building. The purpose of these agents is to identify whether a fire is nearby, and if so, fight it. Fire will spread to the adjacent cells after some time and becomes a big fire. The big fires requires two agents to take it down.

The agents can not see the whole room as they have limited vision. Agents can also be damaged when crossing a path with fire. Therefore, it is important that they work together to minimize damage and maximize extinguished fires.

Modelling this problem is relevant, because in real life situations, the stress of the moment can influence people not to make the best decision, whether it is trying to run away or trying to fight the fire.

1.4 Objectives

The main goal of our project is to fight and erase all the fires from the room, with minimal damage.

In addition, we aim to understand how communication and cooperation affects the process of dealing with fires as if it was a real life situation. Having this in mind, we also desire to realize how decisions should be made when facing a conflicting and stressful scenario.

2 DESCRIPTION OF THE APPROACH

2.1 Environment

In order to make our desired system we needed to find an environment that could support our needs, and the implementation used in [2], shown in **Figure 1**, did just that.

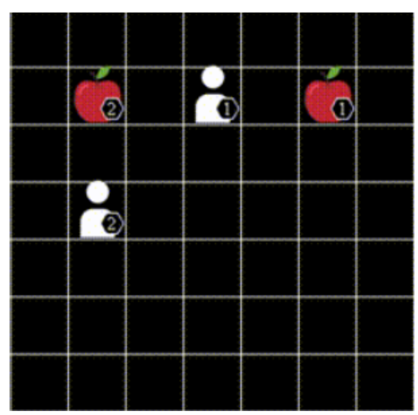

Figure 1: Base environment for out project [2]

This work is basically multiple agents cooperating with each other in order to collect food. Having this, now our base is set.

Regarding the properties of our environment: it is **partially accessible**, since the agents have a limited vision; **deterministic**, as an action has a single guaranteed effect; **dynamic**, as it can change while an agent is deliberating; **discrete**, because there is a finite number of actions and perceptions and **non-episodic** as the current action of an agent will influence the future actions of the other agent.

2.2 Multi-Agent System

In our multi-agent system, the agents have sensors to detect smoke, follow the direction of smoke, receive notifications and detect another agent. They also have actuators that enable the agents to move around the room, to erase fire and to send notifications to each other.

The agents also face a coordination problem: some fires require the help of two agents to be taken down, and to do this, our agents need to communicate with each other so they can know where is fire and when help is needed. If the agents do not cooperate, they face real danger, because some big fires can propagate and trap the agent.

Following this scenario, our agents will face situations where they need to decide whether they should fight the current fire they are facing or go help their colleague (the other agent). When opting for the second one, they need to decide what is the best way to go to the desired location: they should avoid fire, but sometimes it could be more worthy to pass trough fire and have a bit of damage and be able to save their colleague. Time is their biggest challenge.

For the decision-making process, we thought of considering a series of factors: distance between the two agents, level of fire spread within reach of each agent, presence of large fires, level of damage of each agent, speed of fire spread, in addition to some predictions about the fire's spreading directions and the emergence of new outbreaks.

2.3 System Architecture

Our agents will have a hybrid architecture meaning there will be two types of decisions being made, one is mainly reactive, when put in certain situations the agent needs to deal with them, for example when an agent asks for help our agent needs to react and help (or not depending on the decision), and the other is deliberative, since each agent main task is to stop the fire, if one agent is already fighting the fire and doesn't need help, the agent should not interfere with the other agent. This means that the decisions will depend on what is being acknowledged by the agents.

3 EMPIRICAL EVALUATION

In this section we will suggest some metrics that can be used to evaluate our agents performance, both combined and individually.

For individual performance:

- Number of extinguished fires
- Average steps needed to detect a fire
- Damage level
- Number of redundant steps
- Percentage of coverage of the map

For combined performance:

- Number of repeated actions between agents
- Number of big fires extinguished
- Whether they are communicating and asking for help
- Coverage area obtained through cooperation
- Ratio between cooperation with the other agent and firefighting

We are going to compare the behavior of agents in executions with random movements and with programmed behaviors like following the smoke to find the fire. We will also compare the performance of agents through two modes, one in which agents communicate with each other and give priority to collaboration and another in which agents do not communicate and are more individualistic.

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