Intelligent Systems - Agent Coordination - Lab Report

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1. Introduction

Agent coordination is crucial when dealing with multiple agents to let them act smartly based on their behaviour and the others' behaviour.

In this report, we will describe our implementation of simple coordinated agents in a predator-prey chase scenario. This work aims to create the best-coordinated team so that wolves reach their goal as fast as possible. By doing so, we will understand the influence of the agent's behaviour and others' performance. We will first go into a more precise definition of the problem. Next, different methods will be explained. Then, we will describe the different experiments and discuss the results. The conclusions and future work are at the end of this report.

2. Problem Statement

This work aims to create agents that control a small pack of wolves that are trying to capture random moving preys. In order to capture one of these, two wolves need to be adjacent to it. All the entities are placed randomly on the scenario's map. The basic configuration contains three wolves and ten preys. Wolves can detect preys that are within a specific range. There are two options: a wolf can either move in 2 directions or only one at a time. The agents can not communicate with each other. The goal is to create the best wolves-team to catch the preys as fast as possible.

3. Methods

We implemented three types of teams. We will test and compare the performance of each in the next section. In each team, wolves are placed randomly on the grid.

3.1. Follower Wolves Team

In this team, each wolf starts by moving randomly. They do so until they detect a prey that is close to them. Then, they track their prey and follow it. The goal is reached once two wolves that are both tracking a prey meet each other. Therefore, the simulation's duration is based on the movements of the preys, and this is totally random.

3.2. Formation Wolves Team

The wolves start by regrouping themselves by using their wolves' sensor. Once they are grouped, they move together while keeping a certain maximum distance between each other and searching for a prey. If a prey is seen by one of the wolves, this one tracks and moves towards it. The other wolves follow this one. Thus, there are multiple wolves adjacent to the prey at a particular moment and reach their goal.

3.3. Hybrid Wolves Team

The last team that we implemented is called the Hybrid team. Each wolf starts by moving randomly in the y-direction on the grid to search for a prey. As soon as one of them finds and follows one, the rest of the team join him to catch the prey. Since there is no communication allowed between the wolves, we need a way to allow wolves to guess that one of their teammates is following a prey. This is why every wolf moves only in the y-direction and not in the x one during the searching phase. This way, once wolves detect that the x coordinate of one of them is different from the last step, they know that someone is tracking a prey. In case they all join him, but they realize that he is not tracking any prey (it can happen if he lost it, for example), they scatter to find another prey and repeat the process.

4. Experiments

We conducted many experiments in order to answer different questions:

- Building a homogeneous team vs a heterogeneous team: what is easiest? What is the best? What is the most robust?
- Can we deal with a Random Wolf in our pack?
- Does our strategy work with limited movement?
- What happens if we increase or decrease the number of wolves?
- What happens if we need more wolves to catch a single prey?
- What happens if we increase or decrease the number of preys?
- Which of our strategies is the best one?

To do so, we created some classes that run the simulation many times and export each run's characteristics and its result, which is the number of rounds needed to catch a certain amount of preys (default is 1).

We decided to run each experiment for 10 minutes. The result that we report is the average number of rounds of all runs.

4.1. Results

The table with the results is on the next page due to a lack of space in this section.

First, we tested the impact of the number of wolves in the environment. To do so, we increased the size of 2 different teams. In each of these, we observe that the number of rounds decreases as the team's size increases.

Then, we simulated the game with a different number of wolves that need to be adjacent to the prey to catch it. This value is two by default, but we tried with 3 for two different teams. For the hybrid one, the average number of rounds is significantly higher (almost twice as big) when the value is 3. The average number of rounds only increases by 12 (from 89 to 101) for the formation team. So we can say that the impact of the number of wolves needed to catch a prey is smaller on the formation than on the hybrid team.

The following experiment that we conducted is adding a random wolf in the hybrid pack. The observation is that it can deal with a random one, but since he is not cooperating with others, the average number of rounds is higher, as expected (from 49 to 83).

We also increased the number of preys in the grid (from 10 to 15 preys). The formation team's average number of rounds decreased by 36 (from 89 to 53). Again, this result is the one that we expected because there are more preys in the same area, and the wolves are moving together, so there are more chances to meet one of the preys.

In order to answer our main research question, we compared the performance of the three teams. The results show that the best pack is the hybrid one with an average number of rounds (r) of 49. The second best is the formation one with r=89. The follower one is the 3rd one with r=211. We expected this one to be last because, as mentioned in the methods section, there is much randomness in the follower strategy.

We also compared the hybrid team's performance with unlimited movements to the same one with limited movements. The results show that the average number of rounds for the limited team is almost three times higher than the unlimited one (137 to 49). Again, these numbers confirmed our beliefs and are pretty logic since, e.g. in the case where a wolf wants to go from (0,0) to (1,1), he needs two steps if he is limited while he only needs one if he is not, so it has a significant influence on the final number of rounds.

The final experiment is the one in which we mixed different types of wolves in the same team. The types are formation and follower wolves. As shown in the table of results, the average number of rounds decreases as the number of follower wolves decreases and the number of formation wolves increases. This experiment's best outcome is when the team contains a minimum number of followers and a maximum of formations. Therefore, it shows that in this case, the homogeneous team is better. This one is also easier because each wolf has the same behaviour and can react to the other's actions, while with a mixed team, all the wolves do not cooperate.

5. Conclusions

We implemented three different teams of coordinated agents, which act based on their behaviour and one of their teammates. The best performance is achieved with a homogeneous team of hybrid wolves. The average number of rounds (out of 822 runs) needed to catch one prey with two wolves adjacent to it, ten preys, and three wolves present on the grid is 49.

6. Future Work

We believe that this result is excellent but could be improved with some minor changes. For example, when a wolf is on his way to join another one that follows a prey and passes a third wolf, which is also following one, he should join the closest wolf to reach the final goal as fast as possible.

# Rounds avg	#Wolves	#Preys	Wolf_Type	Homogeneous?	#Wolves_to_catch_preys	Min_Preys_Captured
	Different # of Wolves					
49	3	10	Hybrid	TRUE	2	1
37	6	10	Hybrid	TRUE	2	1
21	10	10	Hybrid	TRUE	2	1
	Different # of Wolves					
98	2	10	Formation	TRUE	2	1
89	3	10	Formation	TRUE	2	1
84	6	10	Formation	TRUE	2	1
53	10	10	Formation	TRUE	2	1
					Different #Wolves to catch	
49	3	10	Hybrid	TRUE	2	1
95	3	10	Hybrid	TRUE	3	1
					Different #Wolves to catch	
89	3	10	Formation	TRUE	2	1
101	3	10	Formation	TRUE	3	1
			Deal with 1 Random			
49	3	10	Hybrid	TRUE	2	1
83	3	10	4Hybrids, 1Random	FALSE	2	1
		Increase #Preys				
89	3	10	Formation	TRUE	2	1
53	3	15	Formation	TRUE	2	1
			Different techniques			
49	3	10	Hybrid	TRUE	2	1
89	3	10	Formation	TRUE	2	1
211	3	10	Followers	TRUE	2	1
			(un)limited movement			
49	3	10	Hybrid - unlimited	TRUE	2	1
137	3	10	Hybrid - limited	TRUE	2	1
			Mix of techniques			
211	3	10	Followers	TRUE	2	1
208	3	10	4Followers, 1Formation	FALSE	2	1
171	3	10	3Followers, 2Formation	FALSE	2	1
107	3	10	2Followers, 3Formation	FALSE	2	1
75	3	10	1Follower, 4Formation	FALSE	2	1
89	3	10	Formation	TRUE	2	1