Introduction for Instructions Hetero Sensitivity of Pheromone with Ant Colony Optimization

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Abstract: We have known that Ant Colony System (ACS) is one of powerful meta-heuristics and some researchers have reported the effectiveness of some applications using the algorithm. On the other hand, we have known that the algorithms have some problems when we employed it in multi-agent system and we have proposed a new method which is based on Max-Min Ant System (*MM*-AS), which is improved on ACS. This paper describes results of evaluation experiments with agents implemented our proposed method. In these experiments, we have prepared some different types of agents, which have hetero sensitivity of pheromone. The pheromones are deposited by agents and they help to search the shortest path for agents. The reason that we employ the agents are inspired by the report by researcher in the field of biology. Then we have prepared some conditions for RoboCup Rescue Simulation system (RCRS). To confirm the effectiveness, we have considered agents' action in the simulation system.

1 INTRODUCTION

We know that real ants are social insects and there is no central control and no manager in their colony. However each ant can work very well (Gordon, 1999),(Keller and Gordon, 2009),(Wilson and Duran 2010). Dorigo *et al.* have inspired real ants' feeding actions and their pheromone communications. Then they have proposed the algorithm of Ant System (Dorigo, 1996). We have proposed a new method which is based on Max-Min Ant System (*MM*-AS) (Stützle and Hoos, 2000), which is improved on ACS (Bonabeau, Dorigo and Theraulaz, 1999), (Bonabeau, Dorigo and Theraulaz, 2000). Some researchers have reported the effectiveness of systems installed the algorithms and their improved algorithms. *MM*-AS derived from Ant System and achieved an improved performance compared to AS and to other improved versions of AS for travelling salesperson problems (TSP).

This paper describes results of evaluation experiments with agents implemented our proposed method. In these experiments, we have prepared some different types of agents, which have hetero sensitivity of pheromone. The pheromones are deposited by agents and disappear in time. Then they help to search the shortest path for agents. The reason that we employ these agents is inspired by the report by researcher in the field of biology.

Moreover we have done some experiments for evaluation. We have prepared some conditions for RoboCup Rescue Simulation system (RCRS) (RoboCup Web site). To confirm the effectiveness, we have considered agents' action in the simulation system.

There are a lot of distributed constraint satisfiability problems and researchers tackle problems by their method. For example, TSP, network routing problems and so on. However, they have no noise when they are solving problems and information to resolve problems, for example distances between visiting cities in TSP, are given in advance. Moreover their situations have never changed for each simulation steps. To resolve problems in the real social, situations in environment are always changing, dynamically. In some cases, we are disable to know cues to resolve the problem in advance. In other case, some outer noise gets information erased or interpolation them.

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2 BASIC IDEA

2.1 RoboCup Rescue Simulation System

We have employed RoboCup Rescue Simulation system (RCRS) as a test-bed. This system has its server and four different types of agents. They are a fire-brigade agent, a police-force agent, an ambulance agent and a civilian agent and they hold correspondence with each program and they have been able to simulate a situation of a city's disaster. Moreover the system has been able to simulate different situations in each conditions and maps for simulators.

The RoboCup Project System intends to promote researches which scope the disaster mitigation, search and rescue problems. Then we need to develop three types of agents, which are a fire-brigade agent, a police-force agent and an ambulance agent. Figure 1 shows a screen shot of a performance of the simulation system. It shows a map of city and deep grey rectangles indicates buildings and light grey rectangle shows roads. Black parts on the roads means blocks on the road and agents cannot go through the place at the block. In the figure, red circles indicate fire-brigade agents and a mark of fire plug means a centre of fire-brigade. Blue circles indicate police-force agents and a mark of policeman helmet means a centre of police-force agents. White circles indicate ambulance agents and a mark of white cross means a centre of ambulance agents. Green circles indicate civilian agents and a mark of red house means an emergency refuge centre.

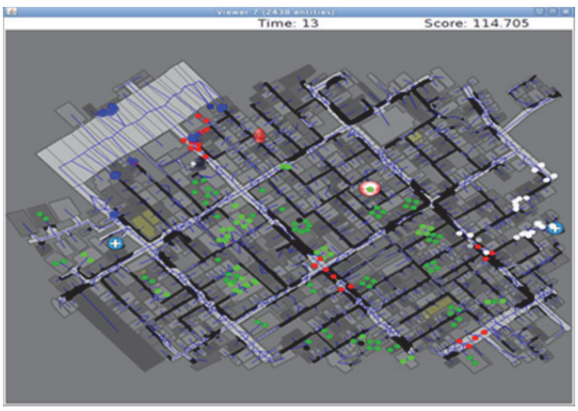

Figure 1: A Screenshot of Running RoboCup Rescue Simulation System.

RCRS server program has evaluated actions by each type of agents and it has calculated scores. The score is calculated by equation (1).

$$score = the\ number\ \text{of surviving civilian agent} \times \sqrt{rate\ \text{of building damage}} \quad (1)$$

On the other hand, in a situation of RoboCup rescue simulation system, agents need to handle huge amount of information and take actions dynamically. Therefore, this simulation system of RoboCup rescue is a very good test bed for multi-agent research and we have used it in this research. This paper addresses a problem of ACS and *MM*-AS and we propose our proposed method based on *MM*-AS and apply to agents of fire-brigade agents in my team on RoboCup Rescue Simulation System.

2.2 Algorithm for Depositing Pheromone

We have proposed an algorithm of method based (Sasaoka, 2013). In our method, the range of pheromone trail value is decided by hand from preliminary experiment. Moreover, we have confirmed that there is a noise of pheromone trail in the initial steps of updating pheromone trails. Then, our algorithm has calculated by equation (2) in the initial steps. This ρ_{init} aims to cut down effect from the noise and the value is also decided by hand.

$$\tau_{ij}(t) \leftarrow (1-\rho)\tau_{ij}(t) + \rho_{init}\Delta\tau_{ij}^{\ k}(t) \quad (2)$$

3 ALGORITHM FOR FIRE-BRIGADE AGENTS

3.1 RoboCup Rescue Simulation System

We have applied our algorithm to searching actions to a water supplying point for fire-brigade agents. The searching algorithm has two steps. It has shown below,

1. In the case that the agents has no water to extinguish a fire,
   - i. in the case that the agent has known a way to a water supply position, it heads along the way.
   - ii. in the case that the agent has not known a way to a water supplying point, it heads a way in random order.
2. In the other case, the agent has enough water, it heads for a fire point.

Moreover, the action of updating pheromone has two steps. It has shown below,

1. After the agent is able to get water, it does "say" command to broadcast a point of water supply position.
2. Other agents who do not have water track back.

3.2 Preliminary Experiment

We have developed experimental agents based on sample agents whose source codes are included RCRS simulator-package file. We have prepared three different types of fire-brigade agents . They are below,

Type-A agents: are equal to base fire-brigade agents.
Type-B agents: are implemented our proposed algorithm.
Type-C agents: are implemented our proposed algorithm. Moreover they select only best path calculated by pheromone's concentrate.

We have developed three teams for this experiments. One of them is Team A whose fire-brigade agents are Type-A agents. Another team is Team B whose fire-brigade agents are Type-B agents. The other team is Team C whose fire-brigade agents are Type-C agents. We have run simulation programs in 1500 steps, which is for five times on simulation term. The map for this experiment is also included RoboCup Rescue Simulation simulator-package file. A score of the map is 121.000 point at the start of simulation. Table 1 shows results. Other types of agents are equal to sample agents in RoboCup rescue simulation simulator-package file.

Table 1: Results in preliminary experiment.

	Team A	Team B	Team C
1	18.172	17.351	20.326
2	16.795	17.509	19.320
3	13.521	17.743	18.591
4	16.521	18.126	21.968
5	17.950	20.508	18.372
Averages	16.594	18.247	19.715

The scores of Team B and C have achieved better than the score of Team A. From them, we have confirmed the effectiveness of our proposed method. A system implemented an algorithm of Ant Colony Optimization aims to converge optimized solutions quickly. At the same time, the system aims to grow in diversity for candidates of optimized solutions. One of problems in this algorithm is that the system need to make an adjustment between them.

Then we have consider the effectiveness of an introduction of agents which have hetero sensitive of pheromone and suitable for each environment. The reason of this introduction has been inspired from a report by researcher in the field of biology (Ishii and Hasegawa, 2013). In this research, the proportion of agents which have hetero sensitivity of pheromone is decided in advance.

4 EVALUATION EXPERIMENT I

4.1 Procedures

To confirm the effectiveness of this introduction of agents with hetero sensitivity of pheromone, we have developed seven teams. The proportions of agents are shown in Table 2. The other condition of the experiment is the same as the previous preliminary experiment.

4.2 Results

Table 3 shows scores of these teams in each times and averages scores of them. The scores were calculated by RCRS server programs according to equation (1), which we described in the previous chapter. A team which has achieved the higher scores has taken more effective actions than teams which has done the lower scores. The effective actions have mean that agents' action reduced damages from disasters and fires. From them, we have confirmed that Team J can achieve the best score of them.

Table 2: Proportions of types of agents in each teams.

Names of Team	Type-A[%]	Type-B[%]	Type-C[%]
Team D	34	33	33
Team E	50	25	25
Team F	25	50	25
Team G	25	25	50
Team H	20	40	40
Team I	40	20	40
Team J	40	40	20

Table 3: Results of scores in evaluation experiment I.

	Team D	Team E	Team F	Team G	Team H	Team I	Team J
1	21.163	20.190	17.967	21.163	20.833	16.428	21.161
2	17.845	19.787	21.036	17.845	19.505	16.429	22.308
3	19.760	18.853	21.612	19.760	18.743	16.419	20.850
4	19.610	18.634	19.024	19.610	18.126	16.869	22.391
5	18.663	17.827	18.818	18.663	20.508	21.128	22.936
Averages	19.408	19.058	19.691	19.408	18.247	17.453	21.929

5 EVALUATION EXPERIMENT II

5.1 Procedures

We have prepared six maps and scenarios for RoboCup rescue simulation. They have used in RoboCup 2012 international competition and RoboCup Japan Open 2013 competition (RoboCup Web Site), (RoboCup Japan Open Web Site).

Map 1: a map is a part of Ritsumeikan University area and a score is 84.772 at the start of simulation.

Map 2: a map is Virtual City and a score is 150.948 at the start of simulation.

Map 3: a map is a central part of Paris and a score is 140.000 at the start of simulation.

Map 4: a map is a central part of Istanbul and a score is 67.000 at the start of simulation.

Map 5: a map is a central part of Mexico City and a score is 106.000 at the start of simulation.

Map 6: a map is a central part of Eindhoven and a score is 183.000 at the start of simulation.

5.2 Results

Table 4 shows results. In this table, Team J and Team A are equal to previous teams in Preliminary experiment and evaluation experiment I.

Table 4: Results of scores in evaluation experiment II.

	Team J	**Team A**
Map 1	12.350	6.976
Map 2	20.401	10.787
Map 3	38.408	27.640
Map 4	28.078	15.136
Map 5	39.808	35.785
Map 6	47.298	24.902
Averages	39.077	27.608

6 CONSIDERATION

Figure 2 shows a score chart in Map4 by Team J and Figure 3 shows a score chart in Map4 by Team A. They are calculated by a RCRS server programs. In these score chart, red lines mean total scores in each step of simulation time, blue lines mean numbers of civilian agents' component, green lines mean rates of civilian agents' health, yellow lines mean number of civilian agents alive, pink lines mean a rate of buildings damage and aqua line mean building damage. We have considered that actions of preventing damages by Fire-brigade agents in Team J are more effective than ones in Team A.

However Fire-brigade agents in Team J have not prevented damages, perfectly. One of reasons is the shortage of co-operation between hetero-types of agents. For example, we could see that there are some blockades on road in simulation map. Police-force agents need to remove blockades on the road. However agents do not know which blockades other agents want to remove first. Then the agents need to exchange information each other.

7 CONCLUSIONS

We have reported results of evaluation experiments in multi-agent system using our proposed method. From comparing between two teams in RoboCup Rescue Simulation system, we have confirmed the effectiveness of our method and we have considered agents' actions which are decided by our algorithm. However there are some problems to resolve in our method. Then we have a plan to develop agents installed our proposed algorithm on hetero-type agents and realize co-operation between hetero-type agents using pheromone communications.

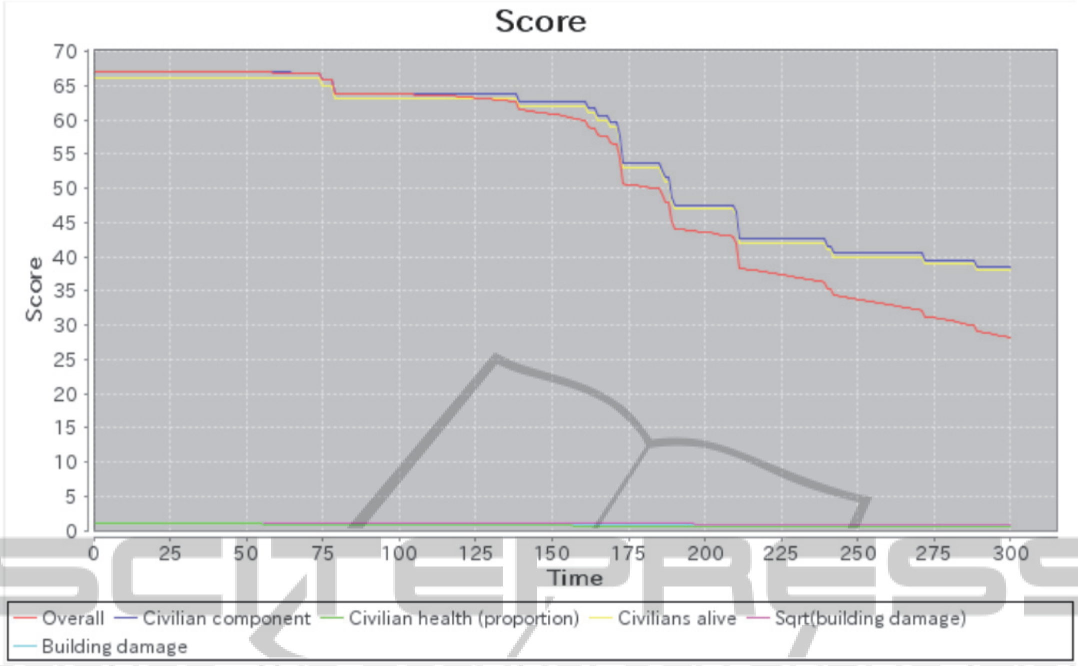

Figure 2: Score of Team J in Map4.

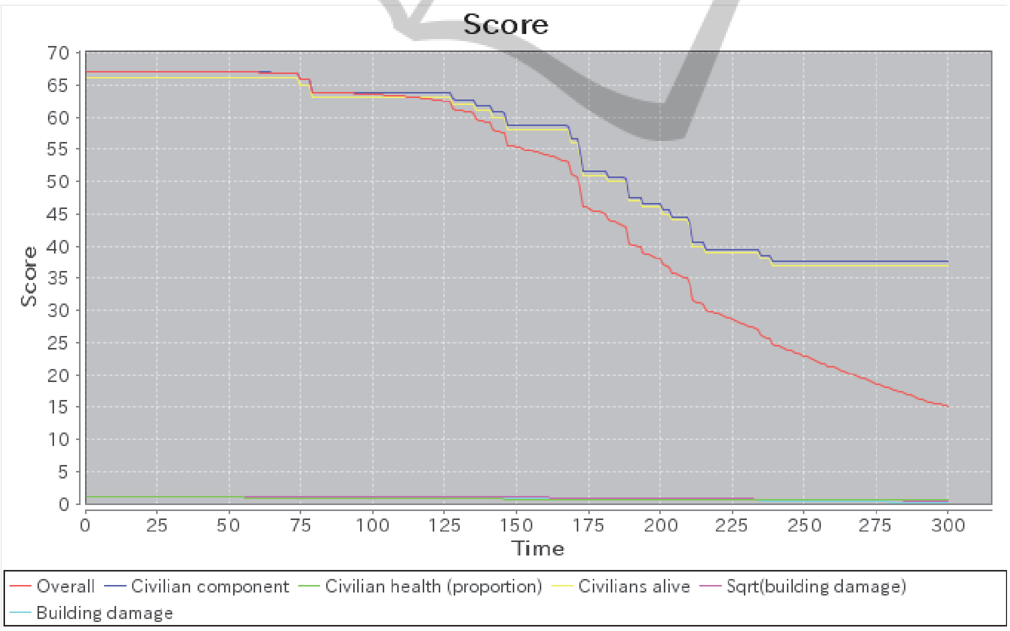

Figure 3: Score of Team A in Map4.

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We developed our experimental system with the agents, which are based on source codes included in packages of simulator-package file. Moreover we employed some maps for RoboCup Rescue Simulation system in evaluation experiments.

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