Acquiring Method for Agents' Actions using Pheromone Communication between Agents

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Abstract: We have known that an algorithm of Ant Colony System (ACS) and Max-Min Ant System (*MM*-AS) based on ACS are one of powerful meta-heuristics algorithms and some researchers have reported their effectiveness of some applications using then. On the other hand, we have known that the algorithms have some problems when we employed them in multi-agent system and we have proposed a new method which is improved MM-AS. This paper describes some results of evaluation experiments with agents implemented our proposed method. In these experiments, we have used seven maps and scenarios for RoboCup Rescue Simulation system (RCRS). To confirm the effectiveness of our method, we have considered agents' action for fire-fighting in simulation and their improvements of scores.

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 et al., 1996). Some researchers have reported the effectiveness of systems installed the algorithms and their improved algorithms (Dorigo and Stützle, 2004), (Bonabeau et al., 1999), (Bonabeau et al., 2000). Ant Colony Optimization (ACO) and Ant Colony System (ACS) have become a very successful and widely used in some applications. These algorithms have been used in some types of application programs (Hernandez et al., 2008), (D'Acierno et al., 2006), (Balaprakash et al., 2008). The system based on ACO and ACS are used artificial ants cooperate to the solution of a problem by exchanging information via pheromone.

Stützle, T. and Hoos, H.H. have proposed MAX-MIN Ant System (*MM*-AS) (Stützle and Hoos, 2010). It derived from Ant System and achieved an improved performance compared to AS and to other improved versions of AS for travelling salesperson problems (TSP).

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.

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 (Skinner and Ramchurn, 2010), (RoboCup Rescue Simulation Project), (RoboCup Japan Open, 2013). We have done some evaluation experiments and we report the results of experiments.

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2 BASIC IDEA

2.1 Our Method

We have proposed an algorithm of method based on *MM*-AS (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 formula (1) in the initial steps. This ρ_{init} aims to cut down effect from the noise and the value is also decided by hand.

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

2.2 Preliminary Experiment

To confirm the effectiveness of our proposed method, we have done some preliminary experiments with a grid-world task. Figure 1(Nikkei Software, 2011) shows the grid-world and a blue grid means a place of start and a yellow grid means a place of goal in the figure. Moreover light-gray parts mean a pathway for an agent, light-green parts mean walls and an orange grid means a position of a moving agent. The shortest number of step by a agent is 22 steps in this task.

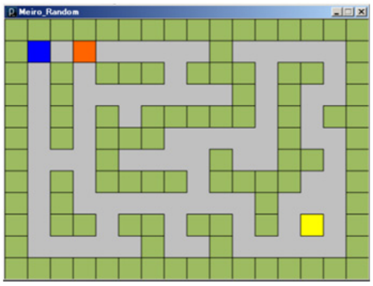

Figure1: A task of grid-world in this experiment.

We prepared three types of agent to resolve this task and we have repeated 50 times by each agent. They are below,

agent A: moves randomly on the pathway.

agent B: is implemented an algorithm of **ACS** and runs on the pathway.

agent C: is implemented an algorithm of **our proposed method** and runs on the pathway.

Table 1 shows averages of steps, maximum numbers of steps and minimum numbers of steps in the experiments. Figure 2 shows improving number of steps by agent C. From these results, agent C has achieved the best result in the trials. Moreover, agent C has found its shortest path at the 146th trial. From the results and the figure, we confirmed the effectiveness of our method. We have considered that agent C has depressed negative effects on its initial learning process. Agent B has not placed them under the control. In this task, there are some loop ways on pathway. For the loop way, agent B has run the same loop way on numerous times. The reason is that agent B has sprayed pheromone on pathway and it has selected the highest concentration of pheromone. However agent C has not get the same situation as agent B.

Table1: Results of preliminary experiment.

	Average	Maximum	Minimum
agent A	969.46	4302	78
agent B	1445.62	8217	78
agent C	**470.92**	**2612**	**42**

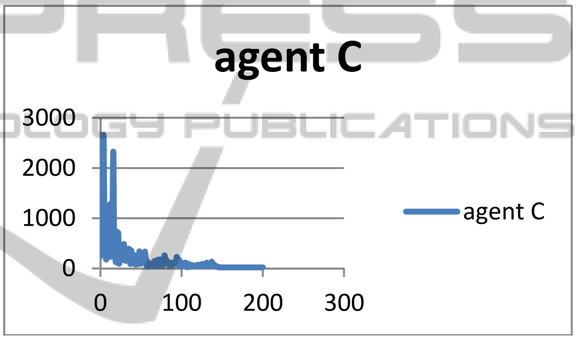

Figure2: Results by agent C (from 1st to 200th trial).

3 ABOUT 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 3 shows a screen shot of a performance of the simulation system. It shows a map of city and deep gray rectangles indicates buildings and light gray 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.

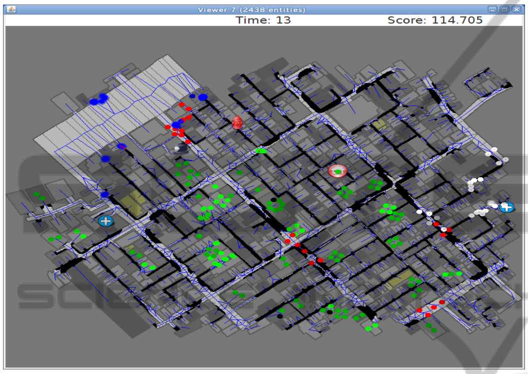

Figure 3: An example of simulation map in RoboCup Rescue Simulation system.

RCRS server program has evaluated actions by each type of agents and it has calculated scores. The score is calculated by formula (2).

$$score = a\ number \text{ of surviving civilian agent} \times \sqrt{rate \text{ of building damage}} \quad (2)$$

4 OUR PROPOSED ALGORITHM FOR FIRE-BRIGADE AGENTS

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,

(1-a) in the case that the agent has known a way to a water supply position, it heads along the way.

(1-b) 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.

5 EVALUATION EXPERIMENT

5.1 Procedures

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 (Sasaoka, 2013). 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.

With these agents, we have prepared these four different teams of fire-brigade teams based on the agent Type-A, Type-B and Type-C. They are below,

Team A: has fire-brigade agent Type-A(50%), Type-B(25%) and Type-C(25%).

Team B: has fire-brigade agent Type-B(50%), Type-A(25%) and Type-C(25%).

Team C: has fire-brigade agent Type-C(50%), Type-A(25%) and Type-B(25%).

Team D: has fire-brigade agent Type-A(33%), Type-B(34%) and Type-C(33%).

From previous research (Sasaoka, 2013)., we confirmed that Team C can achieve the best score among them on only one map. In this research, we have compared between this Team C and Team E. Team E has been organized by sample agents which are included RCRS simulator-package file and are our base-agents.

Moreover we have prepared seven maps and scenarios for RoboCup rescue simulation. They have used in RoboCup 2012 international competition (RoboCup Rescue Simulation Project) and RoboCup Japan Open 2013 competition (RoboCup Japan Open, 2013). They are below,

Map 1: a map is a central part of Kobe and a score is 121.000 at the start of simulation.

Map 2: a map is Ritsumeikan University area and a score is 84.772 at the start of simulation.

Map 3: a map is Virtual City and a score is 150.948 at the start of simulation.

Map 4: a map is a central part of Paris and a

Table 2: Results of evaluation experiment.

	A score at the start	Team C	Team E
Map 1	121.000	**87.198**	72.030
Map 2	84.772	**12.350**	6.976
Map 3	150.948	**20.401**	10.787
Map 4	140.000	**38.408**	27.640
Map 5	67.000	**28.078**	15.136
Map 6	106.000	**39.808**	35.785
Map 7	183.000	**47.298**	24.902
Average	121.817	**39.077**	27.608

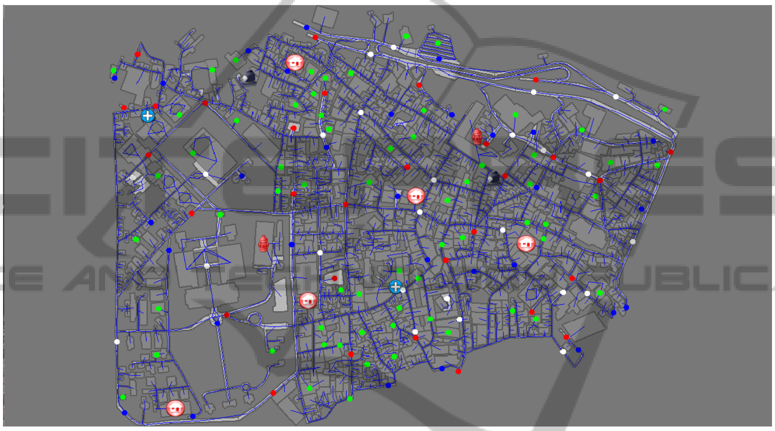

Figure 4: Map 5 before start of simulation.

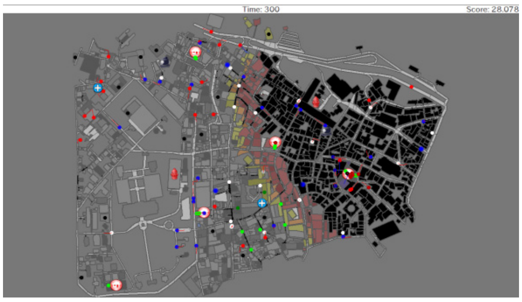

Figure 5: Map 5 after 300 steps of simulation time by Team C.

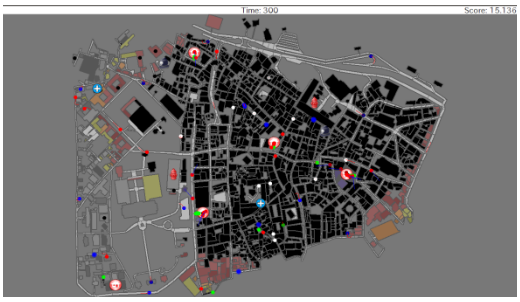

Figure 6: Map 5 after 300 stepsof simulation time by Team E.

score is 140.000 at the start of simulation.

Map 5: a map is a central part of Istanbul and a score is 67.000 at the start of simulation.

Map 6: a map is a central part of Mexico City and a score is 106.000 at the start of simulation.

Map 7: a map is a central part of Eindhoven and a score is 183.000 at the start of simulation.

5.2 Results

Table 2 shows the results of this experiment. The average score of Team C is 45.427 and it is better than the average score of Team E. Moreover each score which is achieved by Team C is better than score which is achieved by Team E.

6 CONSIDERATION

Figure 4 shows a situation in Map 5 before start of simulation. Figure 5 shows a situation in Map 5 at the end of simulation by Team C and Figure 6 shows a situation in the same map at the end of simulation by Team E. In these figures, black parts means

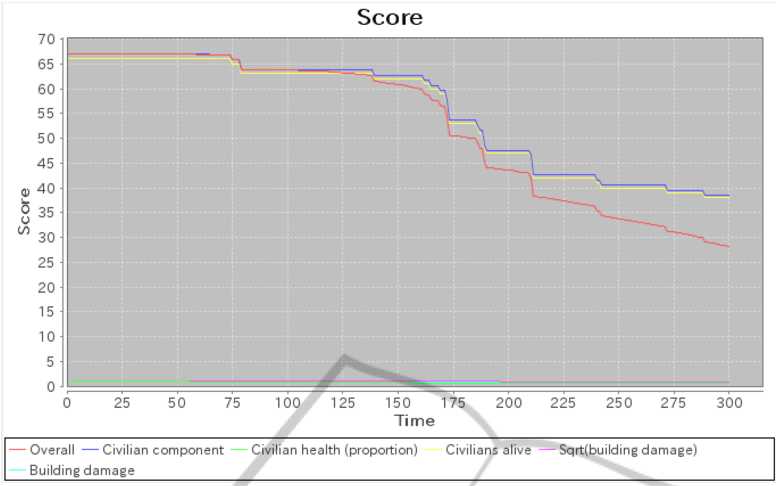

Figure 7: Score chart in Map 5 by Team C.

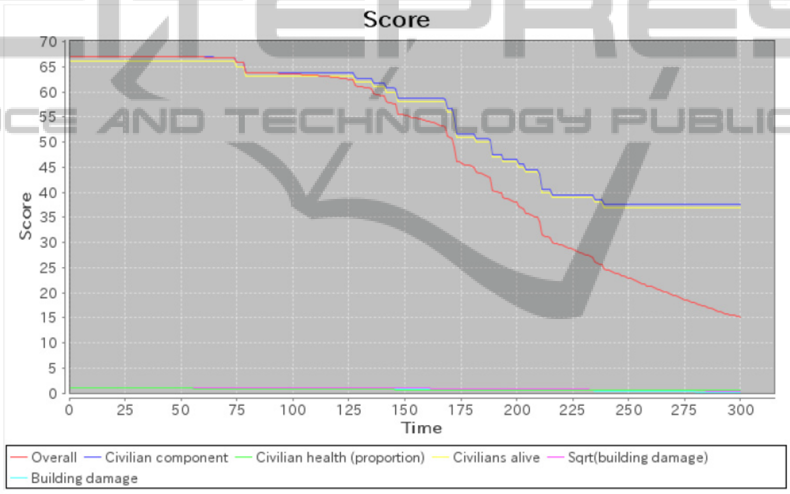

Figure 8: Score chart in Map 5 by Team E.

burned buildings, deep red parts means buildings which are burned almost, red parts means buildings which are burned half, yellow parts means buildings burned a little and gray parts means buildings which are not burned yet. From them, we can confirm that fire-fighting actions by fire-brigade agents in Team C are more effective than ones in Team E.

Figure 7 shows a score chart in Map5 by Team C and Figure 8 shows a score chart in Map5 by Team E. They are calculated by a RCRS server program. 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 root of buildings damage and aqua line mean building damage. We have considered that actions of preventing damages by fire-brigade agents in Team C are more effective than ones in Team E.

However fire-brigade agents in Team C have not prevented damages, perfectly. One of reasons is the shortage of co-operation between hetero-types of agent. For example, we can see that there are some blockades on road in Figure 5. In this figure, black parts on roads means blockades and police-force agents need to remove blockades. However they do not know what blockade 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.

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