Hinomiyagura as a pacemaker in evaluating GIS environments

Hironori Takahashi, Takayasu Suzuki, and Tomoichi Takahashi

Meijo University, Shiogamaguchi Nagoya 468-8502, JAPAN,
ttaka@ccmfs.meijo-u.ac.jp

Abstract. Our purpose is to develop simulation environments that will be used to plan disaster prevention of local governments. This year, we simulated rescue simulations for various local cities using Hinomiyagura as a standard rescue team. We shows there are some correlation between ward's size and simulation results.

1 Introduction

Our team name "Hinomiyagura" comes from traditional Japanese fire tower. The tower has been used since middle of 15 century and been used to lookout tower for fires. When persons in the tower detect fire, they ring a bell repeatedly to alarm people. The system becomes obsolete at present, however, its principle - early detection and swift announcement - still survives. Hinomiyagura this year serves to a pacemaker to check disaster prevention plans of local governments.

Evaluation of agent's behavior and teamwork among heterogeneous agents become necessary to show how well they are better than other ones. At RoboCup rescue agent competition, rescue agent's performance are evaluated. A. Farinelli et al. proposed a project that uses RoboCup Rescue to support a real time rescue operations in disasters[1]. They tried to provide a methodology for evaluation of multi agent system in terms of efficiencies of agents or their robustness.

Our approach is different from them. Our purpose is to check whether the rescue simulation system itself can be used as something like a tester that to see disaster prevention plans of local governments are good, instead of not evaluating rescue agent's performances. Simulations are used to see the simulated areas are safe places for us, and Hinomiyagura is used as a standard rescue agents team.

2 Framework of evaluating rescue simulations

When multi agent systems are applied to social activities, we have not got any practical evaluation methods for social agents so far. The agents' behavior has been analyzed ad hoc and evaluated. Because, the social activities are composed of various kind of tasks and their evaluations are task dependent.

2.1 RoboCup Rescue Simulation

RoboCup Rescue simulation is used as an earthquake disaster simulation system. Rescue agents work in environments that change dynamically. The environment is composed of various components. Fig. 1 shows its system architecture. To make clear its structure, we use a 6-tuple presentation

$$S = \{\mathcal{G}, \mathcal{A}g, \Sigma, \mathcal{E}, \mathcal{A}c, \mathcal{C}\}$$

The components are followings. $\mathcal{G}$ is to save human lives and extinguish fires. $\mathcal{A}g$ is a set of agents. They are civilians who evacuate from disasters and rescues - fire brigades extinguish fires, ambulances carry hurt civilians to refugees and polices repair damaged roads. Their corresponding center offices are also agents. $\mathcal{E}$ specifies environments where disasters occur. They are GIS data, such as roads, crossings, buildings (including refuges) and the initial locations of agents. Σ is a set of earthquake simulators, fire simulator, building & road collapse simulator, traffic simulator and human health simulator. $\mathcal{A}c$ are languages that agents in $\mathcal{A}g$ use in simulation. The commands are move, extinguish, load, rescue and tell commands. $\mathcal{C}$ represents communication channel among agents and interaction between agents and $\mathcal{E}$. This represents oral communication, telephone or wireless communication.

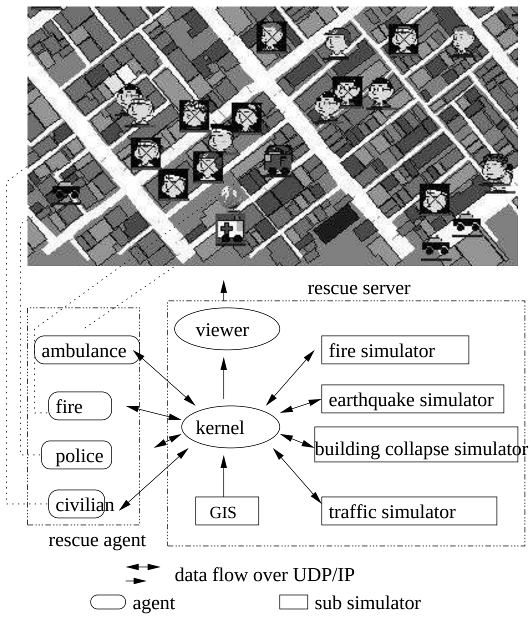

Fig. 1. Architecture of Rescue Simulation

2.2 RoboCup rescue agent evaluation

In RoboCup Rescue competitions, following is a score formula used in ranking teams [5].

$$V = (P + \frac{H}{Hint}) \times \sqrt{\frac{B}{Bmax}} \tag{1}$$

where P is the number of living civilian agent, H is HP(health point, how stamina agents have) values of all agents and B is the area of houses that are not burnt. $Hint$ and $Bmax$ are values at start, the score decrease as disasters spreads. This scalar value is one of indexes that represents $\mathcal{G}$ of whole agents. Higher scores show that rescue agents operate better.

This standard is to find $\mathcal{A}g$ such that maximize $\mathcal{G}$.

3 Comparison of rescue simulations at different cities

Our approach is to change $\mathcal{E}$'s feature such that improve $\mathcal{G}$. For that, simulations are tested with real data and the simulation results are analyzed systematically.

3.1 Map generation from public data

Tools such that generate $\mathcal{E}$ from scratches or edit existing maps have been provided from RoboCup Rescue community [4]. And various organizations provides free data for real urban road networks[3][2].

In Japan, GSI national surveying and mapping organization supports digital maps of Japan in XML form. Left two columns of Table 1 show map data of ward in Nagoya where our university is. It shows statistical data (area(km^2) & population). Middle three columns are network properties (number of roads, nodes and buildings of networks). [1]

Building information is essential data for disaster simulations such as fire simulation, building collapse simulation and so on., however, they are privately-owned properties and are not included in the XML form. Building data are automatically generated. The numbers of generated buildings are set to be proportional to households.

3.2 Simulation Results Comparisons

Fig. 2 shows snapshots of RoboCup Rescue simulations. Initial positions of fire ignition and civilian locations are important factors for rescue simulations. As the figures show, the shapes, size of wards are different so some normalizations are introduced as follows:

[1] RoboCup Rescue uses three maps at competitions. Foligno map is the biggest of the three maps. It has 1,369 roads, 1,480 nodes and 1,078 buildings.

Table 1. Data of real wards

	statistical data		network properties			number of agents			
ward	area	population	road	node	build.	Civilian	Fire	Amub.	Police
Chikusa	18.24	152,162	5,581	3,711	1,692	142	9	5	10
Higashi	7.72	67,788	2,420	1,690	757	63	7	4	10
Nishi	17.9	142,387	6,430	4,122	1,491	133	9	5	10
Showa	10.93	104,789	3,795	2,456	1,186	98	7	4	10
Mizhuho	11.23	104,690	4,053	2,563	1,062	97	5	3	10
Meitou	19.42	155,836	5,612	3,724	1,556	145	9	5	10

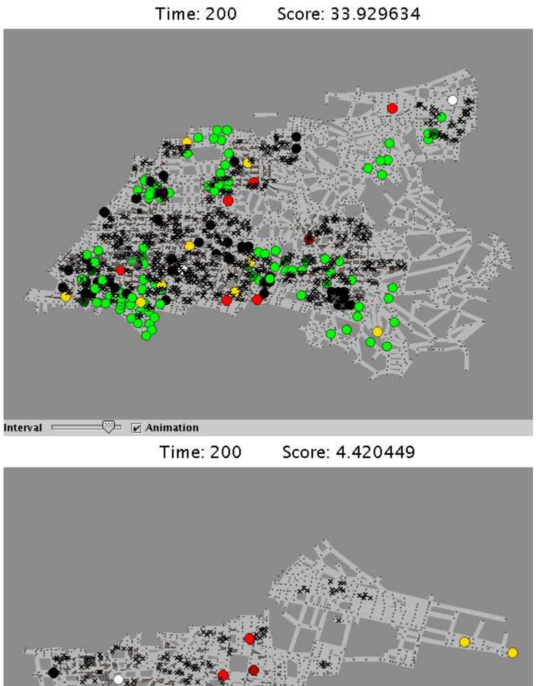

Fig. 2. Rescue simulations for Chikusa(up) and Higashi(down)

agent numbers : The number of civilians are set to be proportional to real population. [2] Three fire engines and two ambulances are deployed to a central station and two fire engines and one ambulances to a substation. Real number of central stations and substation are used. Ten police agents are deployed to every wards.

agent location : They are uniformly distributed over the maps. This setting is assumed that earthquakes occurs in the daytime when people work outside.

fire ignition : Fires break out simultaneously at five points. One setting (α) is that the points are uniformly distributed over the maps. The other setting (β) is that the points are distributed at center of the maps.

Table 2 show the results of Sample rescue teams and Hinomiyagura under two conditions. The sample rescue team is one that included in RoboCup Rescue package.

To make problems clear, no center agents and no refuge is set. Unlike V in eq.1, rescue performances are listed individually. Values in upper rows are surviving rates($number\ of\ alive\ agents/P$) and in lower rows are not_burned rates ($B/Bmax$) . Bigger values indicate that the agents performances are better than others. Hinomiyagura shows better performance than sample agents in general.

Table 2. Simulation results

	surviving rate				unburned rate			
	Sample		Hinomiyagura		Sample		Hinomiyagura	
ward	α	β	α	β	α	β	α	β
Chikusa	41%	51%	33%	50%	52%	71%	52%	71%
Higashi	35%	48%	58%	45%	15%	52%	74%	53%
Nishi	43%	58%	45%	60%	51%	70%	51%	70%
Showa	24%	40%	45%	42%	13%	51%	57%	54%
Mizuho	21%	46%	22%	43%	7%	60%	7%	60%
Meitou	40%	50%	40%	50%	43%	59%	43%	60%

3.3 Discussions

Table 3 show positive correlations coefficients between rescue operations and network properties. Among size properties of $\mathcal{E}$, the number of roads is a key property.

Table 4 show correlations coefficients between rescue operations and network properties. While S(Sample agents team)'s performances are correlated between

[2] The numbers of civilian are small compared to the real population. The agents are implemented as programmed. One agent corresponds to one process or a thread. The number of agents is proportional to the resources of computers.

α and β conditions, H(Hinomiyagura)'s are not. Performances under β conditions are correlated, however, under α conditions are not correlated. This mismatch in correlations indicates the similar results of experiments that A. Farinelli reported that different agents are selected when standards are efficiency or reliability [1].

Table 3. Correlations between properties and rescue operations

	surviving rate				unburned rate			
property	S-α	S-β	H-α	H-β	S-α	S-β	H-α	H-β
building	0.59	0.48	-0.36	0.61	0.87	0.76	-0.12	0.8
road	0.61	0.69	-0.35	0.81	0.86	0.83	-0.22	0.86
node	0.66	0.7	-0.31	0.81	0.89	0.83	-0.17	0.86
area	0.69	0.63	-0.3	0.72	0.9	0.76	-0.14	0.78
populations	0.58	0.52	-0.41	0.63	0.85	0.74	-0.22	0.77

Table 4. Correlations between teams and condition

		surviving rate	unburned rate
correlation between	S-α & S-β	0.82	0.81
same teams	H-α & H-β	0.13	-0.18
correlation between	S-α & H-α	0.34	0.21
same conditions	S-β & H-β	0.94	0.99

4 Conclusion

We have been investigating how rescue agents' performances are affected by urban road networks ($\mathcal{E}$). In the process, we have recognized (i) rescue operations are evaluated with various standards, so it is hard to establish universal performance standard, (ii) normalization of $\mathcal{E}$ is necessary to compare rescue agent's performances, however it is also difficult to have index for $\mathcal{E}$'s structure.

After some normalization of conditions, we shows there some correlation between $\mathcal{E}$'s structure and simulation results. This correlation indicates disaster rescue simulation has possibilities to be used to measure environment's disaster resistance.

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