

Hinomiyagura: Comparison Simulation Results to Data of Local Government

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Abstract. The agent based approach has been accepted in various areas and multi agent systems have been applied to various fields. We are of the opinion of that a multi agent system approaches constitute one of the key technologies in disaster rescue simulations, since interactions with human activities should be implemented within them. However, this makes local governments hesitate to use agent base simulation for their work. Because the results are not assured ones. In this paper, we show possibility to use agent based disaster and rescue simulations for practical usages by experiments with real maps.

1 Introduction

We are thinking that multi agent system approach is one of key technologies in disaster rescue simulations, since interactions between human activities and disasters can be implemented in them. Disaster and rescue simulation is one of social simulations. Applied tasks or fields of social simulations are different in structure and size. Some of the agents' abilities have domain-specific features while the other have task independent ones.

RoboCup Rescue Simulation System have been proposed as a comprehensive rescue and disaster simulation system [2][4]. Rescue agents and disaster simulations have been improved by doing RoboCup competitions every year [3]. And it is also necessary to show that simulation results are assured ones when they are applied at practical cases.

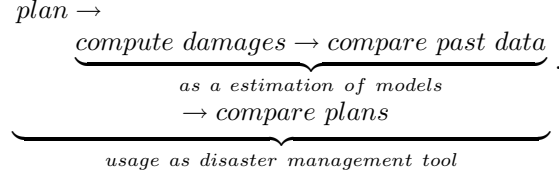
Our team, Hinomiyagura, has been showing credits by comparing simulation results with predicted damages by local governments. The work is organized as follows. Section 2 highlights components of disaster rescue simulation, and comparison between simulation results and data of local government are discussed in section 3. Finally, we show possibility of agent based social application systems to practical usages.

2 Disaster Simulation System

2.1 requirements at local government

Disaster rescue simulation system is assumed to be used before and after disasters at local governments. Before disaster, they estimate damages of their town and

make disaster prevention plans for expected disasters They will use the disaster management system to confirm the plans will decrease damages for civil lives. After disasters, emergency center will be set up to evacuate people, deliver relief goods, etc. The scheme of disaster management system is



While agent approaches are micro level simulations, local governments will use simulation results in a macro scale. Namely how many people will be saved and how much damages will be decreased rather than how good a rescue team will do at disaster are expected at local government. The disaster rescue simulation's outputs are required to be assured ones for decision making.

2.2 agents and simulation system

Human actions at disasters are so various and they range from rescue operations to evacuation activities. In disasters, we cannot do experiments physically on real scale. Agent-based simulation makes possible to simulate such interactions between rescue operations and disasters, and local government can predict damages to civil life better than using only disaster simulations.

Fig. 1 shows an image of disaster management system at local governments emergency center. Disaster-rescue simulations are used components of the system. Properties of the environment and agents are changed by various disasters. Fires burn houses and its smoke decrease the sight of firefighters. Building collapse hurts people and blocks roads with debris. These data come from real world and simulation results will be used to support decision at emergency centers.

2.3 disaster simulation components and MAS

Management systems for disasters are composed of different kinds of components. To make clear parameters setting to simulations, we present MAS system as

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

where \mathcal{G} is a set of problems that emergency center try to solve by using S . It is not necessary the same one as aims agents have.

A rescue agent team is composed of fire person agents and ambulance agents. $\mathcal{A}g$ is a set of agents who may have their own goals such as fire engine agents extinguish fire and ambulance agents help injured and bring them to hospitals. It is defined recursively as composite of heterogeneous agents as $\mathcal{A}g = \{a \mid a \text{ is an agent, or a set of agents}\}$.

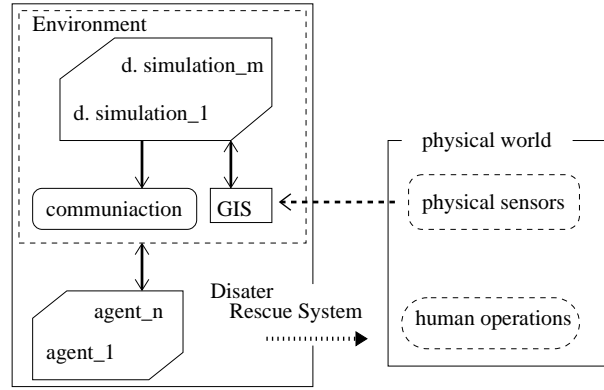


Fig. 1. Rescue Simulation as a component of Disaster Management System

\mathcal{E} is an environment where agents act. Road networks, skyscrapers, undergrounds or theaters are involved in \mathcal{E} .

Σ is a set of simulators or physical sensors. $\{s_1, s_2, \dots, s_l\}$. Some of them are disaster simulators that change properties of the environment, \mathcal{E} . Others simulate human conditions and change injury of agents. The injuries lead to death in the worst scenario without any rescue. These health properties are not to be changed by themselves,

\mathcal{A}_c is a set of actions or protocols that agents can use. Using them, agents can communicate with each other or interact with \mathcal{E} .

\mathcal{C} represents communication channel among agents and between \mathcal{E} . Seeing is a channel to get information of \mathcal{E} , hearing and speaking are other channels to communicate each other.

3 Comparison to local government's estimation

3.1 disaster estimations on various areas

Table 1 showed burned rates for sixteen wards in Nagoya city. GIS network column shows the number of nodes and edges of maps that used in simulation. The network data with 1:25.000 scale is available as open data [1]. The size of all ward is bigger than maps used at competitions.

column A : Data in column A are cited from assessment of earthquake damage by Nagoya City Fire Bureau. The values are ratio of estimated burnt out houses for an earthquakes with magnitude 7 to 8. The data are estimated with a macro model for burning.

build. : the number of wooden houses in each ward,

ig.p : the number of expected ignition points, the number is ones that was estimated by Nagoya Fire Bureau,

Table 1. Simulation results and target GIS data

ward	GIS network		A				B		C			
	node	edge	build.	ig.p	burn	burn_F	build.	burn_F	build.	ig.p	burn	burn_F
Chikusa	5,581	3,711	32,156	0	0.0%	0.0%	1,692	63%	9,924	7	2.05%	1.74%
Higashi	2,420	1,690	14,761	1	0.1%	0.1%	757	76%	4,283	3	2.09%	1.38%
Kita	6,069	3,870	39,302	22	3.9%	3.4%	1,651	31%	9,541	7	1.51%	0.99%
Nishi	6,430	4,122	44,773	58	5.8%	4.9%	1,419	71%	10,468	7	1.97%	1.74%
Nakamura	6,044	3,766	41,769	45	5.1%	4.5%	1,431	61%	8,994	6	2.16%	1.15%
Naka	2,026	2,093	18,726	5	0.9%	0.5%	905	95%	5,396	4	2.03%	1.12%
Showa	3,795	2,456	28,464	0	0.0%	0.0%	1,186	84%	6,325	4	0.78%	0.58%
Mizuho	4,053	2,563	30,092	2	0.5%	0.1%	1,062	94%	6,656	4	0.65%	0.47%
Atsuta	2,609	1,760	17,580	3	1.3%	1.0%	641	90%	4,309	3	4.32%	1.42%
Nakagawa	9,449	6,154	58,612	31	2.6%	1.7%	1,952	39%	17,327	13	0.93%	0.87%
Minato	7,127	4,892	38,694	0	0.0%	0.0%	1,378	35%	15,269	18	1.32%	1.24%
Minami	5,718	3,710	43,318	1	0.0%	0.0%	1,404	39%	10,157	7	2.11%	1.71%
Moriyama	6,651	4,413	39,821	0	0.0%	0.0%	1,422	36%	13,077	13	1.80%	1.22%
Midori	8,945	5,996	53,445	0	0.0%	0.0%	1,831	23%	18,301	15	1.11%	1.06%
Meito	5,612	3,724	27,554	0	0.0%	0.0%	1,556	46%	10,740	8	2.27%	1.66%
Tenpaku	5,986	3,951	29,584	0	0.0%	0.0%	1,553	27%	11,259	9	2.03%	1.79%
correlation between build_A							0.83		0.85			

burn : burned houses rate without fire rescues,

burn_F : burned houses rate with fire rescues.

They used the same macro fire model to calculate **burn** and **burn_F**, the difference is the number of ignition points as initial conditions.

column B & C : Data in column B and C are results of RoboCup Rescue Simulations (Ver.46). Housing data are personal properties and they are not available as road network data. They are generated under condition that the number of generated houses are to be proportional to real numbers.[5] Column B are data that Takahashi et al. used to show correlation between simulation results and environment's change.[6]

Difference between column B and C are

1. Scale of map in C is bigger than B (30 times in length), and the number of houses is increased (Fig.2).
2. The number of ignition points are 5 for all maps in column B, while the numbers are set to proportional to areas in column C.

It is natural that **burn_F** is less than **burn**, and it is worth that agent based micro simulation show this natural result at various areas.

3.2 forecasting damages at real areas

It is required to simulate rescue operations at area where earthquakes occur. Fig.3 shows an outline of such cases. The left figure shows two awards, Nishi



Fig. 2. Rescue simulation of Chikusa ward (left:Column B, right:Column C, They are similar figures, scales are different.)

and Nakamura in Table 1. The middle map is a map that is combined with two maps. The right one is middle-down part where damages are severe.

Table 2 shows simulation results have correlations with data of local government. The number of ignition points are set to the number of column A. Correlations with Nagoya fire Bureau’s data show positive values. And simulation results at composite maps show similar trend.

Table 2. Ignition points set equal to estimated Earthquake

ward	No. ignitions	no fire brigade	fire brigade
Nichi	30 (night)	8.53%	8.08%
	58 (day)	13.40%	12.96%
Nakamura	22 (night)	8.90%	8.45%
	45 (day)	15.64%	15.23%
correlation with estimated data		0.89	0.92
Clipped area		7.20%	7.14%

4 Summary

More than five years have passed since RoboCup Rescue simulation league started. Both agents and disaster simulations have been improved by RobCuppers, and it is time that simulation results will be applied to practical usages. However, we have no practical evaluation methods or data.

In this paper, we showed experiments that rescue simulation results is useful over various \mathcal{E} s and there are correlation between the simulation results and local government’s assessment of earthquake damage. These correlations support

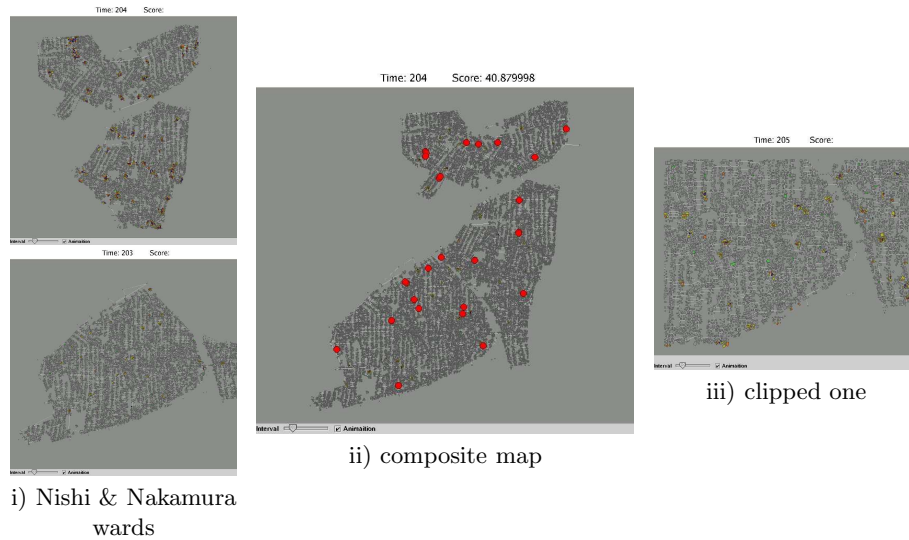


Fig. 3. Flow mage generation from open data to simulation target map.

claims that disaster rescue simulation has possibilities of being used as one tool of disaster management system at local governments.

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