Simulator Complex for RoboCup Rescue Simulation Project – As Test-Bed for Multi-Agent Organizational Behavior in Emergency Case of Large-Scale Disaster

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Abstract. In the RoboCup Rescue Simulation Project, several kinds of simulator such as Building-Collapse and Road-Blockage Simulator, Fire Spread Simulator and Traffic Flow Simulator are expected to provide a complicated situation in the case of the large-scale disaster through their synergistic effects. It is called Simulator Complex. This article addresses, first, system components of the prototype version of this Simulator Complex, then, explains each of the simulators and the Space-Time GIS(Geographical Information System) as DBMS(DataBase Management System). In the demonstrations, we have shown the performance enough for a test-bed for multi-agent system development.

1 Introduction

RoboCup-Rescue Simulation Project (RCRS) is being prepared as an open-competition style research activity [8] [9] [5] [7]. In RCRS, several kinds of simulators, such as Building-Collapse and Road-Blockage Simulator, Fire Spread Simulator and Traffic Flow Simulator, are expected to provide a complicated situation of a large-scale disaster through their synergistic effects. It is called Simulator Complex. On the other hand, competitors' role is to develop teams of multi-agent system, such as Fire Brigade, Ambulance Team and Rubble Cleaner, in order to simulate their emergency behaviors in cases of the large-scale disaster, i.e. Hanshin Awaji Earthquake.

Open competitions are planned, in which the competitors make their agent teams to interact one another in this Simulator Complex, not only for evaluating the agents' performances, but also for testing and evolving appropriate strategies and tactics for organizational behaviors in the various kinds of emergency cases.

P. Stone, T. Balch, and G. Kraetzschmar (Eds.): RoboCup 2000, LNAI 2019, pp. 321-326, 2001.

Accordingly, the role of Simulator Complex is assigned to provide competitors a test-bed for development of multi-agent systems.

This article addresses, first, the system organization of the prototype version of RoboCup Rescue Simulation Project, then, explains the Building Collapse and Road-Blockage Simulator, Fire Spread Simulator, Traffic Flow Simulator, and Space-Time GIS (Geographical Information System). The GIS is organized as DBMS(DataBase Management System) in our RCRS. Demonstrations of the performance check are also referred.

2 System Organization of the Simulator Complex

Figure 1 shows the system organization. All simulators, the GIS, viewers and agents are distributed components and plugged in to the kernel, that coordinates distributed computation through a communication protocol based on UDP/IP.

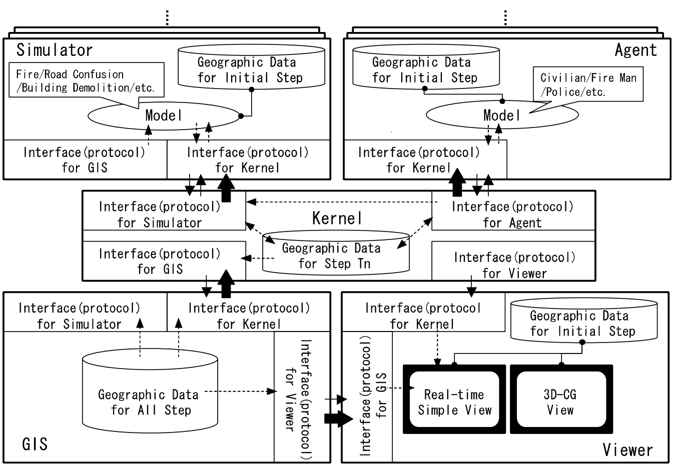

Fig. 1. System organization of the prototype version

The case area is chosen to 1.5 × 1.5 km width in Nagata Ward in Kobe city, where is an typical Japanese inner-city area, and mostly damaged by the fire in 1995's Hanshin Awaji Earthquake. The simulation covers the first three days after the occurrence of earthquake, by simulating phenomenon and activity for each minute by each simulation step.

3 Building Collapse and Road-Blockage Simulator(BRS)

BRS[1] calculates the collapse of buildings in the case of earthquake, and generates situations of the road-blockage.

Buildings and poles collapse and occupy the roads in the case of earthquake. Thus, as the seismic motion becomes stronger, the more collapse occurs. Figure 2 (a) shows ratio of collapse as a function of the strength of the seismic motion. As

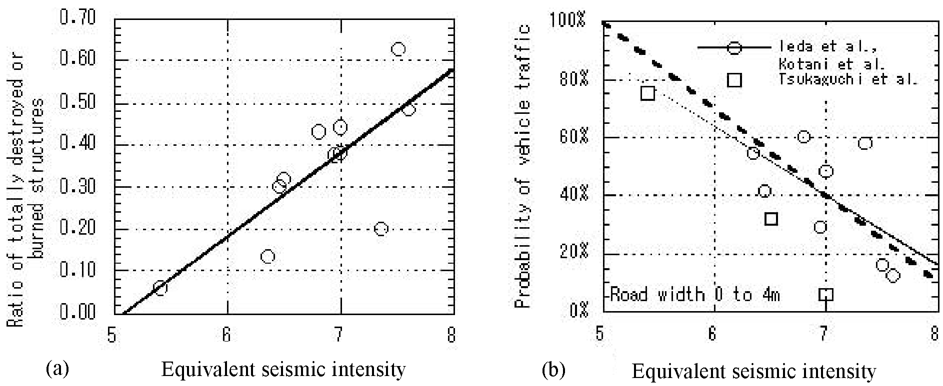

Fig. 2. Seismic intensity effects for collapse and blockade

for road width, the wider the road is, there is more possibility that a passage at the center of these roads will remain intact for traffic. The role of the blockade occurrence model is to compute the probability of vehicle traffic through the roads, which are separated into seven classes based on their width. Figure 2 (b) shows probability of vehicle traffic as a function of the seismic intensity in case of 0-4m road width [4].

4 Fire Spread Simulator(FSS)

FSS[2] calculates many fires at the same time in the case of the earthquake and simulates the spread process of the fires, and change the situations also depending on fire-fighting of Fire-Brigade agents.

FSS is designed as a general-purpose system that can be applied to the fire not only at earthquake cases but also at ordinary cases.

1 The Port and Harbor Research Institute of the Ministry of Transportation has developed BRS.

2 Applied Technology Co. Ltd. in collaboration with some academic researchers has developed FSS.

The computation is shown in Figure 3, which consists of the following processes: 1)combustion process, 2)spread process, 3)ignition process, and 4)effect of fire-fighting.

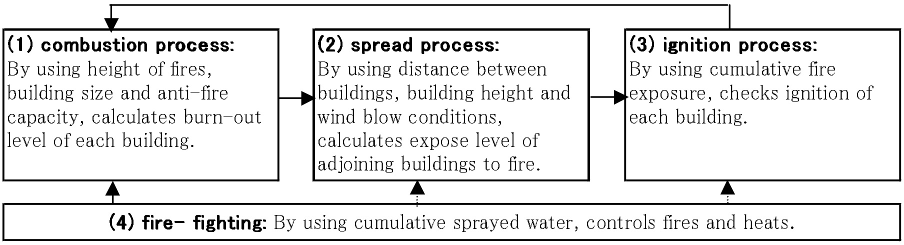

Fig. 3. Computation in each sub-process in FSS [2]

5 Traffic Flow Simulator(TFS)

Briefly saying, the role of TFS is to resolve conflicts among every agents' move @ plans. TFS aims at simulating traffic flows of not only vehicles but pedestrians, in various situations of the large-scale disaster, especially (1) blocked by rubbles of buildings; (2) blackout of traffic signals; (3) passing of emergency cars such as fire brigades; and (4) refuge in heaps of rubble.

A road consists of nodes in connection with the road, road width, blockage width of rubble, number of lanes of 'upward' line, number of lanes of 'downward' line, and width of sidewalk. A node consists of roads in connection with the node, existence of signal, 'split' pattern of the signal (if it has a signal), number of lanes of short-cut for left-turn, number of lanes of pocket for right-turn, and lane length of the pocket.

At the start of simulation and each simulation step, the simulator receives information from the kernel and renews information on location of every kinds of agents. Traffic is simulated each one second, which is the same as TRANSIMS [6] that is a cellular automata-based micro-simulator. The simulator sends back to the kernel simulated results in each step.

As further direction of development, we should incorporate mechanisms to simulate effects of emergency traffic control, for pursuing the possibilities of near future's information technologies such as personal information devices and autonomious monitoring system and so on. Much higher level of traffic control systems are expected by applying multi-agent system technology[1].

6 Space-Time GIS as DBMS

In order to manage spatial temporal information of a concerned simulation area, Space-Time GIS(Geographical Information System) is devised as DBMS(DataBase

Management System). We call this system DiMSIS [3], that conforms to KIWI format. The essential feature of DiMSIS is that spatial information is described based on topology calculation and temporal information is managed based on the space-time approach.

To manage temporal information, there exist the following two approaches (see also Figure 4)

Snapshot View Model: In this approach, each spatial data set is connected with the temporal information. Almost all the commercialized spatial temporal GISs have adopted this approach.

Space-time Approach Model: In this approach each element of the spatial data is connected with the temporal information. The spatial temporal GISs adopting this approach start studying recently.

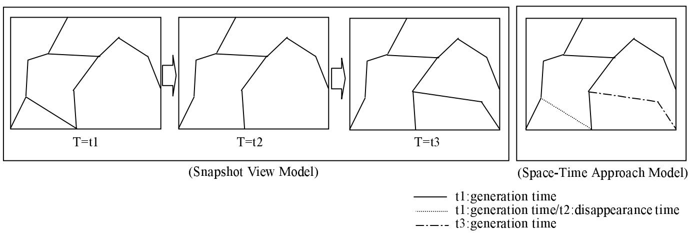

Fig. 4. Snapshot view and space-time approach for GIS data structure

Results of some theoretical study suggested that DiMSIS method (Topology Calculation & Space-Time Approach) was superior to other types.

7 Concluding Remarks

Our prototype version of the Simulator Complex had been demonstrated at RoboCup Japan Open 2000 in June, and RoboCup Workshop 2000 in August at Melbourne. In the both cases, we had connected plural PCs through 10 Base-T network, set one quarter size of the target area and near 100 agents, so it had achieved the performance one simulation step per second. It simulates a dynamic process of complicated disasters, caused by building-collapse, road-blockage and fire spread, and to evaluate various agents' activities not only refugees but also rescue organizations such as fire-brigades, ambulance teams and rabble cleaners (Figure 5). We conclude this prototype realizes the followings; (1) plug-in mechanism (changeable component); (2) distributed simulation system; and (3) comprehensive simulation of complicated multi-factor on disasters, each of which is an item of the requirements mentioned as design methodology of Artificial Society [8]. The Simulator Complex is now planned to be prepared toward Japan Open 2001 and RoboCup 2001, the first official rescue-simulation competition, through some minor revisions.

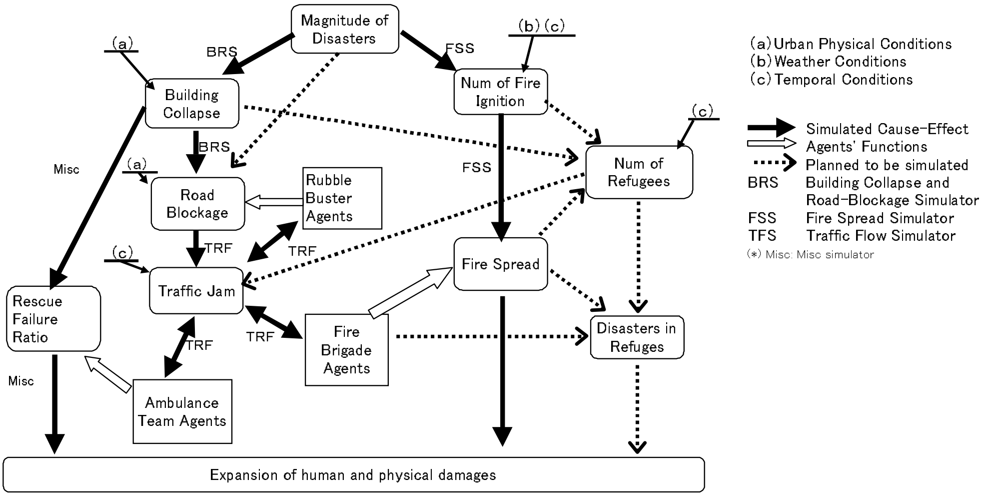

Fig. 5. Interaction among disaster simulators and agents realized in the prototype

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