2. DEVELOPMENT OF PRACTICAL SCENARIO SIMULATOR FOR DISSEMINATION OF DISASTER INFORMATION

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Abstract: Until now, for studying the efficiency of dissemination of disaster information, we have been developing the simulation model. Based on the simulation model, we built the general-purpose system that has made it possible for users to efficiently study dissemination of disaster information the process used, and the scenario for transmitting information. This simulation system makes it possible to express the situation in which information is transmitted using various media. This system uses GUI to simplify operations for general users. And updating and adding new features to this system is very easy.

Keywords : *Dissemination of disaster information, Support of disaster prevention plan, Scenario Simulator, The research planning support system, Object Oriented*

1. INTRODUCTION

At the time of a disaster originating, from the viewpoint of minimization of death and injury, it is very important to transmit disaster information such as an evacuation order, promptly and efficiently to residents. In order to transmit information promptly and efficiently before the disaster occurs, these points become important; performing decision making of information transfer quickly by collecting information quickly and transmitting information during an organization, efficiently, and performing information transfer quickly and correctly to all residents by sending disaster information in a timely fashion. That is, in order to satisfy these criteria, it is necessary to fulfill the three requirements of the completeness, speed and the accuracy of the transfer of disaster information, by fixing organization for the information transfer at the time of a disaster.

With regard to the problem of the increase in efficiency of organization of the information transfer at the time of a disaster, Monma et al.(1997), Shiiba et al.(1998), etc. explore the method of examination by the simulation. In these studies emphasis is put on parallel correspondence between disaster-prevention organizations, the decision-making in a disaster-prevention organization and the information transfer between organizations. In these studies, the examination of the process of information transfer between an organization and residents and the process of the information transfer between residents is insufficient. However, if based on the assumption that the final purpose of transmitting disaster information is to guide suitable action of the residents who receive that information, it will become evident that the importance of examination of the process, by which disaster information is acquired, is great.

From this point of view, we gained an understanding of information transfer action of the residents at the time of a disaster by investigation, and studied the method of evaluating the efficiency of information transfer by modeling it. In the study, we examined the following matters; Firstly how to express information transfer action of residents as a simulation model reflecting the property of information transfer action of the residents as it changes with damage grades. Secondly, how to build disaster prevention administration radio systems into a model. Thirdly, basic technology, which is based on the above, and carries out the simulation of the information transfer to residents on a computer.

Then in this study, we developed a simulation system that expresses the information transfer of residents and information transfer performed by various media based on the knowledge obtained from the studies so far. The system developed by this research has the following features. It is processes development of various situations, which change in real time, and it makes it possible to summarize the situation of information acquisition and the operational situation of the information transfer media as it changes moment to moment. Secondly, it is structured such that functional extension by adding other transfer media can be performed easily. Thirdly, by giving an operation

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function equivalent to general computer software, the common user who does not have specific knowledge of the system is able to perform a simulation easily.

Since the disaster information transfer simulation system developed by this study has the above functions, it can be used in a wide variety of situations as a scenario simulator for performing examination of the maintenance plan of information transfer media. Such as the arrangement plan of a disaster-prevention administration radio system, the official-announcement timing of the evacuation order in response with the development of a disaster scenario and so on.

2. DISASTER INFORMATION TRANSFER SIMULATION MODEL

2.1 The Outline of the Simulation Model

This model has the following features.

1. The information transfer in realistic space is reproduced by arranging an individual's position to an x-y-z coordinate system.
2. Since the properties of various transfer media (such as the information transfer action of an individual and disaster prevention administration radio) are incorporated as parameters it is possible to set up various scenarios about the function of media by operating these parameters.
3. It is possible to set up the scenario about the generating time of a disaster the dispatch timing of disaster information, etc. by having improved the model which we developed until now, as a system in which time control is possible.

2.2 Information Transfer among Residents

Modeling of the information transfer among residents involves modeling of the oral communication and the information transfer by telephone among residents. The oral communication among residents is expressed by modeling the process of oral communication of the information starting from the arbitrary residents who acquired information by a certain means as a network generating process. Basic structure of the simulation model is constituted according to Biased Net Model, which is the human network formation theory in mathematical sociology. Biased Net Model is the probability-theory-network generation model developed by imitating the information transfer structure of a nerve cell. Biased Net Model is applied to the research for a friend selection problem by Fararo,T.J.(1981), Skvoretz,J.(1985), etc. in social science.

Fundamentally, the network of the information transfer among the residents in this model is expressed by the random selection of partner expressed in the position by x-y-z coordinate system. On the basis of this network, the process of the information transfer among the residents reflecting the grades of damage is expressed by operating the parameter expressing the property of information transfer action of the residents who change with the grades of damage. In this study, the property of oral communication of residents is caught from three viewpoints (the number of partners per information transfer, the distance to the partner for information transfer, and the relation of selection between the residents with some biases). The time property for oral communication of residents is expressed from two viewpoints; the time of the standby required by the transmission action, and the time required to transfer. In order to express the above viewpoints in a simulation model, the following parameters are defined.

(1) The parameters expressing the property of oral communication of residents

a) The number of partners for information transfer

This parameter signifies number chosen as a partner for information transfer of one household. A distribution of the value of this parameter is based on a distribution of the number of partners for information transfer found by investigation conducted in the object area of a simulation.

b) The distance to the partner for information transfer

This parameter signifies a distribution of the distance to partner for information transfer that the household chose. A distribution of the value of this parameter is based on a distribution of the distance to partner for information transfer grasped by investigation that conducted in the object area of a simulation. By introducing this parameter into a model, we can grasp influences of the spatial spread of the area and the relation of the position of the residents on a spread of the network of information transmission among residents.

c) The relation of selection between the residents

This parameter signifies probability that bias occurs at the time of choosing the partner for information transfer between residents. Generally if a selection of transfer partners was not performed at random, between some persons who were chosen by the same partner, it can be considered that they are biased toward choosing each other. This parameter expresses the generation probability of the selection of partner involves such bias.

(2) The parameter expressing the time property of oral communication.

a) The standby time required by the transmission action

This parameter signifies the time from initial acquisition of information to coming out of a house. With regard to information transfer action while performing refuge preparation action of residents, it was found by investigating whether information transfer action is performed while performing refuge preparation action. With regard to information transfer action while performing refuge action, it is expressed with reference to the timing of coming out of a house for refuge.

A distribution of the value of this parameter is found by investigation conducted in the object area of a simulation, too.

b) The time required to transfer

This parameter signifies the time required from coming out of a house to the timing of transmission. A walking speed and a distance to partner for information transmission are used to calculate the distribution of the value of this parameter. Transfer action using telephone is modeled by a similar method to that used in modeling of oral communication. Although it is not necessary to take into consideration the distance to the partner for information transfer and the time required to transfer, it is required to take into consideration the probability of telephone convergence and a distribution of the time required to convergence, because of the properties of telephone. For these reasons, the model is created introducing these parameters expressing these properties.

2.3 Expression of Media

The situations at the time of an actual disaster are varied. It is assumed that disaster information is transmitted in varying situations, too, such as the situation where two or more pieces of information are transmitted with time lag to residents by two or more means of communication. For this reason, various media for disaster information, which function simultaneously with an information transfer among residents at the time of a disaster, can be included in this model. So, it is possible to evaluate the efficiency of the information transfer attained by their cooperation in this model.

The media in this model are included in the formation process of a network and are expressed so that the property of each medium may be reflected. For example, the property of the outdoors loudspeaker (while it has advantage that the information from the disaster-prevention organization of an area can be simultaneously transmitted to many surrounding residents) is problematic in that the probability that it can be heard tends to be influenced by the weather. In this model, in order to express such a property of transfer, the parameter "the range of voice attainment" which means the range with in which the resident can hear an outdoors loudspeaker and the parameter "the rate of listening" which means the rate by which households can actually obtain information from an outdoors loudspeaker in the area. With regard to the time which transfer takes, the timing of an outdoors loudspeaker running is given based on the set scenario. A transmission of the information by the outdoors loudspeaker that starts from that time is added to a network.

As mentioned above, for the outdoors loudspeaker, it is possible to set up the scenario of arrangement position, the range of voice attainment, the rate of listening, and running timing. Based on the scenario, the network of information transfer is performed under the cooperation with the information transfer among residents and media.

2.4 The valuation basis of the efficiency of information transmission

In this study, we consider the efficiency of information transfer from the three viewpoints completeness, speed, and the accuracy, and define the following three indices of the rate of information acquisition, the time of information acquisition, and the number of transfer steps, in order to evaluate the efficiency of information transmission based on the situation of information transfer to the residents expressed.

(1) The rate of information acquisition

This index signifies the rate by which the residents who have acquired information recount it to all the residents in the object area of information transfer. It is shown that when spread of information is small that this value is small, and conversely that when spread of information is large that this value is also large. The standard deviation of the rate of information acquisition computed when performing a simulation two or more times under the same conditions estimates the stability of acquisition of information. It is shown that when information is circulated stably this value is small.

(2) The time of information acquisition

This index signifies the time required for each resident to acquire information. An average and a maximum of this index are calculated.

(3) The number of transfer steps

This index signifies the number of the transfer processes required by the time residents acquire information. This index is posited as a substitute index of the accuracy of information transfer. Because it can be assumed that the qualitative change of information depends on the number of times the information is transferred.

3. EXPRESSION BY THE PROGRAM OF A SIMULATION MODEL

3.1 The Design Object of a Program

We expressed a disaster information transfer simulation model by programming language with the following objects.

1. This simulation model must express the situation wherein various information transfer media transmit two or more information such that the contents differ with time difference. Therefore by positioning time processing in the nucleus of a program, processing of the timing in a simulation is expressed succinctly. This time processing has synchronous processing of the timing at which each medium starts information transfer etc.
2. The program enables the introduction of new information transfer media into a simulation easily, as there is room for expansion.

In order to realize the above object, we used the object-oriented technique in programming. Using this technique, in order to express information transfer media, the program is described for every function, which media have. And in order to express new media, the existing media can be used, describing only a new function. This enabled it to perform an addition and management of information transfer media easily. Moreover, the program was built according to event drive type processing structure. This processing structure describes every event, which generates a program within a simulation. It was able to carry out coding of the processing expressing time briefly by exchange of the message used as the cause of this event combined with time progress, and was controlled.

3.2 Program Structure

The class structure of a program is as follows (figure-1 reference). The base class of the best layer is

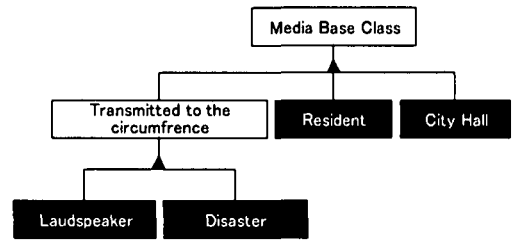

Figure-1 The class structure

equipped with the procedure used as the receiving window of the message transmitted between an object and fundamental data attributes common to information transfer media. The media base class, which is in the low rank and collects the features common to each medium. The media class which is in the lowest rank and expresses actual information transfer media. This program expresses information transfer action of area residents and the function of information transfer media by making the object take charge of the process of exchange of the message of each class object and the event corresponding to the message.

This program is expressing the situation where "a city office makes an outdoors loudspeaker start information transfer" and "certain residents tell other residents information", by exchange of the demand message of objects. Moreover, this program is expressing the situation " When residents get information, determine to take refuge after five minutes", by the demand message send to itself.

Furthermore, a program must be expressed (when there is time lag after an object transmits a message) before actually being transmitted. For this reason, this program has introduced the management class, which takes charge of the processing of time in a simulation. This management class has the function of managing an exchange of the message between objects on the basis of the time within a simulation. When a certain object transmits a message to other objects, the object registers the time lag until it is actually transmitted and a transmitting partner's recognition number transmits the message to a management class. A management class confirms whether the message, which must be transmitted at the present time, exists. And when the message, which should transmit, stops existing, it is time 1 unit forward. A management class advances a simulation by performing the above processing (figure-2 reference).

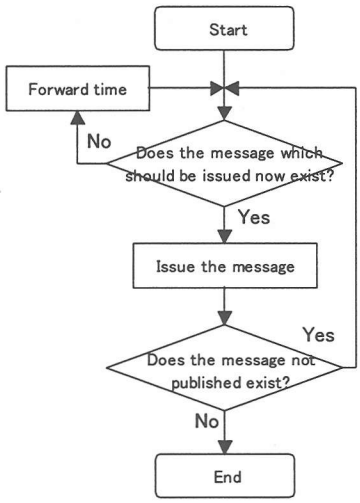

Figure-2 Management Class Flow

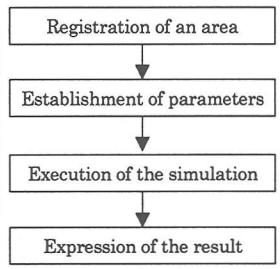

Figure-3 System Flow

Figure-4 Area Registration Wizard

4. The outline of a system, and structure of the function

4.1 The outline of the system

On the system developed by this research, that the disaster-prevention person in charge of an area can easily perform examination of the increase in efficiency of a disseminate of disaster information has set in mind. For that, consider the following. First, the creation and input of area data must be able to be performed simply. Secondly, it must be possible to simply perform a setup of the scenario of a simulation. Finally, there must be an intelligible display of a simulation result.

In this research, the interface, which supports the general work for performing a simulation, was also developed. The development of the system is premised on a user not having the special knowledge about a computer, so that it might become a user-friendly system. For example, the display uses the dialog form by the GUI for a parameter setup of a simulation, the value to set up, and the output result of a simulation in graphical form.

4.2 Composition of a function

In this system, a series of work, which the simulation performs regarding the dissemination of disaster information, is shown in figure-3.

(1) Registration of an area

This involves registering data of the area of the object of a simulation. In order to do this, "area registration wizard" is selected from a menu. After selection data (area name, explanation of an area, the file name of household coordinates data, the scale of coordinates data, and so on), which should be set on each page displayed, are input. Since the technology with which map data is read has been improving remarkably in recent years, household coordinates data was made using a file different from the system.

Table-1 Parameters

Items	Parameters
Random numbers	Occurrence of random numbers, A sort of random The sort of random numbers
A characteristic the household	The characteristic of the information transfer The time of preparing evacuation The timing of the information transfer
Oral communications	The distribution of partners for information transfe The distribution of the distance to partner for information transfer A walk speed
The information transfer using telephone	A distribution of partners for information transfer The rate of the telephone convergence The distribution of the telephone convergence time
Outdoors loudspeakers	The range of the voice attainment The rate of listening The installation place of outdoors speakers The number of setting up outdoors speakers Running timing
Television and radio	The audience rating The broadcast timing
The city hall	The place The determination timing of their intentions
The point of the generating calamity	The place of the generating calamity The number of generating calamity points The rate of finding to generate the calamity The range of being possible to find the calamity The timing of the generating calamity The rate of reports

(2) Establishment of parameters

A dissemination-of-disaster-information simulation model can change the characteristic function which various information transfer media have, and the characteristic of action by area residents, by operating a parameter. Moreover, a dissemination of disaster information simulation model can also perform various scenario setup by setting up the timing to which each medium operates. The parameter, which can be set up, is in this system as displayed in table-1. These parameters are set up in the first stage as a standard value, which calculated from the actual investigation result, and they are freely changed in wizard form. For example, in the parameter which expresses origination of a calamity on a simulation, there are the number of happening points, a

range which can be discovered, discovery probability, coordinate values which show the position of each happening point, happening time, and so on. A setup of the parameter by the parameter wizard of this system is performed by inputting a numerical value into a dialog as shown in figure-5. Moreover, specification of places, such as a happening part, can also be set up by clicking the displayed area screen and once set up, it is possible to change a happening part by dragging the icon of the happening point currently displayed on the specified map.

Timing of a happening can also be changed by dragging the happening point icon currently displayed on the timing window on a screen (figure-6 upper part). The timing window is an icon showing the starting time of a happening point or various information transfer media are arranged on the numerical-value axis showing the lapsed time which made simulation start time zero. These icons can be moved with a mouse drag, and in conjunction with this, the operation parameter of each transfer media is also changed. Using this window, it is possible to perform a scenario setup, finding the time relation of each transfer media visually.

(3) Execution of a simulation

If execution of a simulation is chosen from a menu or a tool bar, the simulation based on the scenario setup is performed. During execution of a simulation, the scroll display of the timing window is carried out with time progress within a simulation. When events, such as generating of a disaster, occur on a simulation, the contents of an event are displayed on an event window (figure -6 lower part). Inside a system, by supervising the motion of each object within a simulation, the household that acquired information is recognized, the position of the household is displayed each time, each index such as the rate of information acquisition each time, information acquisition time, and the average and the maximum of information acquisition steps and maximum, are calculated in real time, and output display on a screen and updating are performed. By checking these screen displays, a user can grasp the effect of information transfer media, and the situation inhabitants' information acquisition by animation.

(4) Expression of the result of a simulation

When a simulation is completed, the value of each evaluation index of information transfer efficiency will total automatically and the change with the result display mode is performed on a system. In the result display mode, the result which expresses each index of

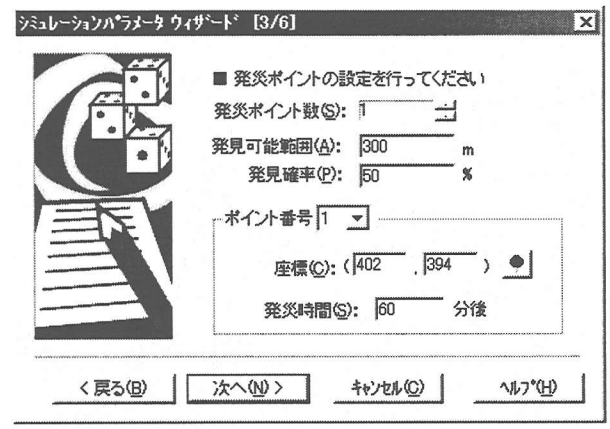

Figure-5 Establishment of parameters on Area Registration Wizard

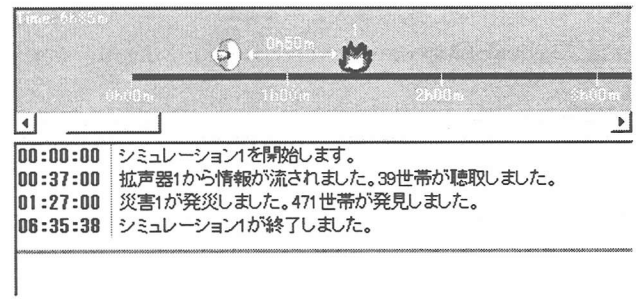

Figure-6 Timing Window and Event Window

information transfer efficiency, such as the final rate of information acquisition of an area, mean information acquisition time, and the number of mean information acquisition steps, is displayed in the result display mode. On the map of the area currently displayed on the window, a distribution of the information acquisition result of each household classified by introductory notes by color is displayed. And it is possible to display and print various results, such as the rate change of information acquisition for every time and the transfer number of cases by medium. On saving these results, one can perform easily comparison and examination of the simulation result obtained from each scenario.

5. The Application Example of a System

As an application example of this system, this chapter examines the effect by having introduced the disaster-prevention speaker as disaster-prevention administration radio in the area between Watarase River and the Kiryu River in Kiryu city, Gunma pref.

The number of households in this region is 8,260, and this area was heavily damaged by typhoon Kathleen in Showa 22 (1947). At present, disaster-prevention

speakers are not installed in this area.

The scenario setup in the application example of this system is represented by the following two cases. Case 1: A disaster-prevention speaker does not exist in an area, but information transfer is performed only by the oral transfer between inhabitants. Case 2: When 17 disaster-prevention speakers have been arranged in the area (the installation points are shown in figure-7). We examine the introductory effect of a disaster-prevention speaker by comparison of both cases. The difference between both cases is solely the existence of installation of disaster-prevention speakers.

Setup of the scenario common to both cases is as follows.

1. Information transfer media other than disaster-prevention speakers do not function.
2. Let the happening point be the levee breach of Watarase River at the Kathleen typhoon.

Disaster information is sent 1 hour before levee breach. Other conditions are as shown in table-2 and table-3 and trial of a simulation is 100 times.

The example of a screen display as a result of a simulation is shown in figure-7 and figure-8 and collection of a simulation result is shown in table-4. Figure-7 is a figure over which the information acquisition situation of each household; in the case of having arranged the disaster-prevention speaker-was classified by color, and was distributed for every acquisition time. Figure-8 shows the information transfer number of cases for every time zone in the case of not arranging a disaster-prevention speaker and the rate of information acquisition. These figures display visually the result of table-4 showing the last result of a simulation numerically, and they examine a

Table-2 Establishment of Conditions of the Simulation

Items	Parameters	The value
Information transfer among inhabitants	The walk speed	80m/min
	Using telephone	nothing
	Bias parameter	0.2
The point of the generating calamity	The range of being possible to find the calamity	300m
	The rate of finding to generate the calamity	50%
	The timing of the generating calamity	1 hour later

Table-3 Establishment of Conditions of the Outdoors Loudspeaker

Items	Parameters	The value
The city hall	The determination timing of their intentions	Immediately after beginning of the simulation
Outdoors loudspeakers	The number of setting up	17 points
	The range of the voice attainment	250m
	The rate of listening	15%

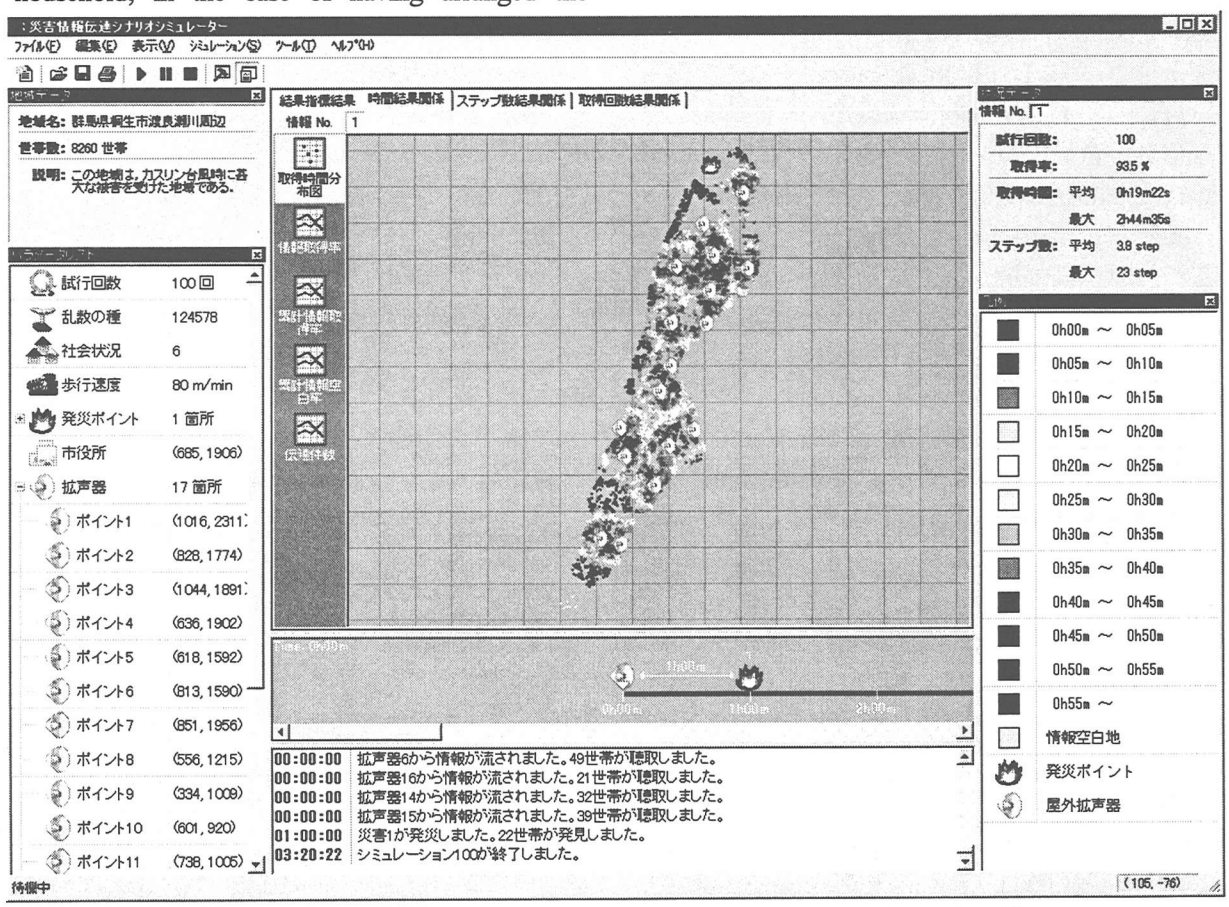

Figure-7 The Example of a Screen Display as a Result of a Simulation (1)

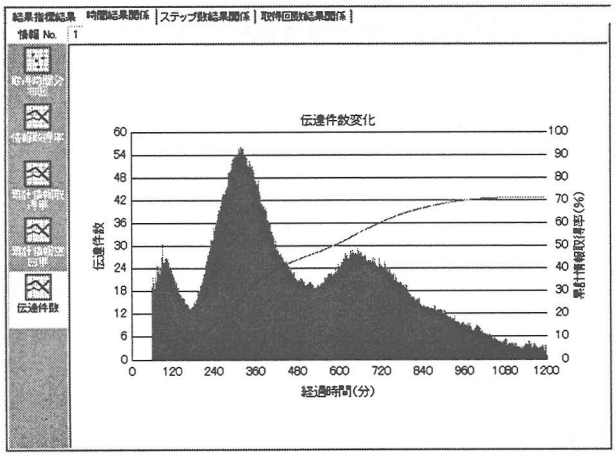

Figure-8 The Example of a Screen Display as a Result of a Simulation (2)

Table-4 A Numerical Results of a Simulation

Outdoors loudspeakers	nothing	17 points
The average of information acquisition	71.22%	93.76%
The maximum of information acquisition	14 hours	3hours and 14 minutes
The number of average steps	60.57 step	3.91 step
The number of maximum steps	140.24 step	25.50 step

simulation result as these figures represent time local information transfer situation and the information transfer situation one time.

From the result of table-4, when we examine the effect by having introduced the disaster-prevention speaker, the following observations can be made.

1. Since the rate of information acquisition is increases by introduction of a disaster-prevention speaker, and the zone where information is not given decreases, the improvement in completeness is achieved.
2. Since the maximum information acquisition time is as remarkable as 3 hours and 14 minutes and means information acquisition time is shortened by 19 minutes, the speed of transmission improves greatly.
3. Since the number of mean steps and maximum steps also decrease sharply, the number of repetitions transfer process of the information which inhabitants acquire becomes fewer, and it comes to the situation that an informational accuracy is also easily secured.

These observations make it expedient to be introduced for this system. So, if examining the introductory effect of a disaster-prevention speaker, it needs to be repeated many times using this model in a more realistic scenario.

In these circumstances, this system can perform evaluation of information transfer organization in advance from various viewpoints since a scenario setup can be easily performed with many items, so we consider that this system is useful also in the business of the disaster-prevention administration of the region.

6. Conclusion

The ideal method of the information transfer in the event of a disaster is an important problem, which influences the scale of death and injury. Recently, the way that should be of a dissemination of disaster information argues here and there. Many cases where correspondence is performed in connection with the dissemination of disaster information, (that is, the disaster-prevention person in charge of a local self-governing body performs maintenance of the transfer media including a disaster-prevention administration radio system and the prior consultation with a report organization), are also seen.

The value of the scenario simulator of dissemination of disaster information developed by this research is great since it can examine in advance the state of the information transfer during a disaster by various scenario set ups. However, it is considered that disaster information has a big difference in the situation in connection with informational transfer since the contents are different from development and form of a disaster. In the simulator developed by this research, there is a problem in that a scenario other than the place of the disaster cannot be set up.

The subject which should be examined in the future of this research is improving practicality by making it operate as a part of GIS, which can be used to deal with a disaster as it progresses.

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