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CONSTRUCTION OF DISASTER PREVENTION DATABASE FOR COUNTERMEASURES AGAINST EARTHQUAKE DISASTER

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ABSTRACT

Disaster prevention database can be classified into two, from the viewpoints of data content and data form. When constructing the database, the former are related to database stricture and the latter are related to data editing and saving. Both kinds of data classification should be unified for effective use of the database. The aim of this paper is to design the basic framework for the disaster prevention database that can deal with the data as unified one by using an object-oriented computer language. Only the basic framework for the construction of disaster prevention database is discussed by using the object-oriented language. Though a simple problem is examined by making use of the database of the object-oriented language, it is confirmed that the method is effective to construct an expert-system as to the prevention countermeasure of natural disaster, regardless of a scale and a classification of the problem.

KEYWORDS

Database of disaster prevention; object-oriented language; natural disaster; damage distribution; object modeling; prevention countermeasure; class hierarchy.

INTRODUCTION

The administrative enforcement plans of disaster countermeasures against earthquake in Japan are based on local plan made by each metropolitan and prefecture government as well as each local government. Since the local plans are made according to the Disaster Countermeasures Basic Act, they need to cover all the enforcement plans for the earthquake disaster in order to be systematized as a low. The local enforcement plans and their enforcement guides, therefore, are forced to be edited by enumerating points of countermeasures in parallel. From the viewpoint of more efficient administrative policy, they should be rearranged or another guide book should be prepared, so that more appropriate and effective

countermeasures can be taken against actual earthquake disaster. Namely, it is desirable to devise practical manuals or scenarios for disaster prevention plans.

Typically, plans for disaster prevention must be examined multifacetedly on administrative, socioeconomic and humanitarian grounds against expected earthquake disaster situations including problematic situations caused by practicing countermeasures. A large scale earthquake in a large city will cause different types of widespread disaster without interruption. Considering that interwoven functions of the large city tend to bring about secondary disaster, the plans should be made to cope with not only each damage but regional disaster as a whole. Naturally, the plans made according to the various disaster situations should be connected with each other, and so administrative adjustment and control over the plans might influence effectiveness of their implementation.

In this administrative context, it is important to prepare practical manuals or scenarios for disaster prevention plans. At different stages of making and implementing the plans, various forms of basic data are necessary, and these data must be arranged and unified to make effective use of them. The goal of this paper is to examine the basic form of database useful for making the manuals or the scenarios and for supporting administrative division by using Smalltalk, an object-oriented computer language.

BASIC CONSTRUCTION OF DATABASE

Database for disaster countermeasures is generally used at the following two stages: (1) the stage of making disaster prevention enforcement plans including their manuals or scenarios, and (2) the stage of coping with actual disaster. At the former stage, the database is used as the basic data for examining each plan as well as related plans as a whole. At the latter stage, it is used for supporting decision making in practicing countermeasures based on the plans.

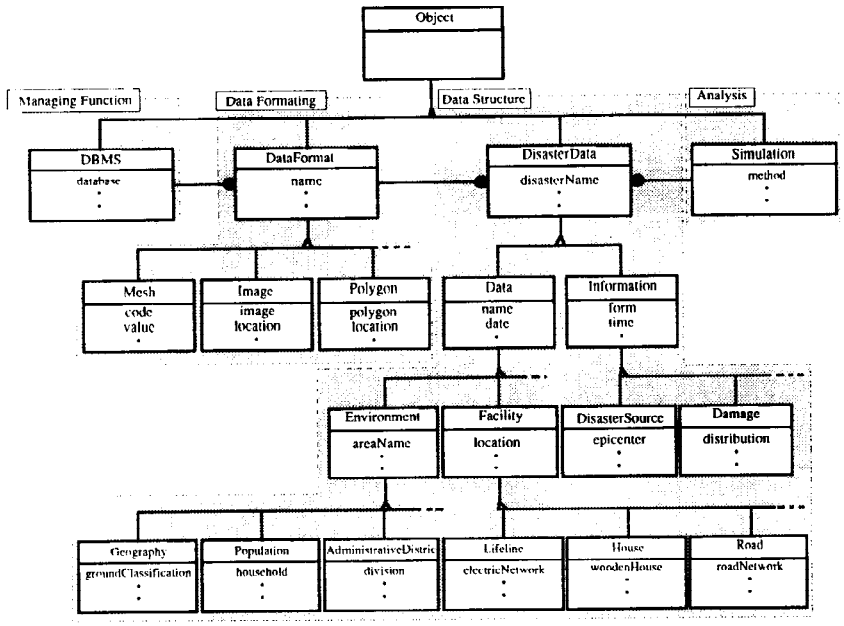

Fig. 1. Data structure of disaster prevention database and its object modeling.

The basic points to be examined at these stages are: (1) The organization of headquarters for disaster countermeasures and the number of the personnel appropriate for dealing with actual disaster situations. (2) The kind of disaster countermeasures to be taken and the time of the decision making. (3) The process of grasping mutual relationships of enforced plans for disaster prevention and that controlling conditions of their enforcement. (4) The system of supplying and securing material and mechanical equipment.

From these points of view, the following should be put under concrete examination by using the database:
(1) Mechanism of gathering information on disaster prevention such as a source of disaster and earthquake damages through multimedia.
(2) Material and mechanical equipment necessary for implementing actual disaster countermeasures, the evaluation of their effectiveness and the decision-making process of taking such measures including the process of deciding priority.
(3) Design of intelligent base concerning evaluation of information on disaster and that on degrees of damages for urban activities and standards of evaluating effectiveness of countermeasures.
(4) Simulation analysis on damage distribution of urban residences, damage conditions of lifelines and so on.
(5) Simulation analysis of restoration on lifelines, urban activities and so on.

The outlines of basic structure of data and their contents is shown as an object-model of the class "DisasterData" and its subclasses in Figure 1. The contents of the database are divided roughly into two: "Information" and "Data". "Information" here is obtained at ordinary times and at the time of disaster as well in different kinds of data forms. The contents of the information are classified into the following three categories: (1) stationary information collected at ordinary times by observing meteorological phenomena (atmosphere temperature, atmosphere pressure, wind direction, etc.), water phenomena (tide levels, water levels of rivers, etc.) and terrestrial phenomena (crust movement, earthquake records, etc.) by using various kinds of sensors, (2) information of a source of disaster obtained at the time of disaster, such as location of epicenter, earthquake magnitude, outbreak of tsunamis, and (3) information of damages, such as casualties, damage distributions of houses and urban facilities, etc.

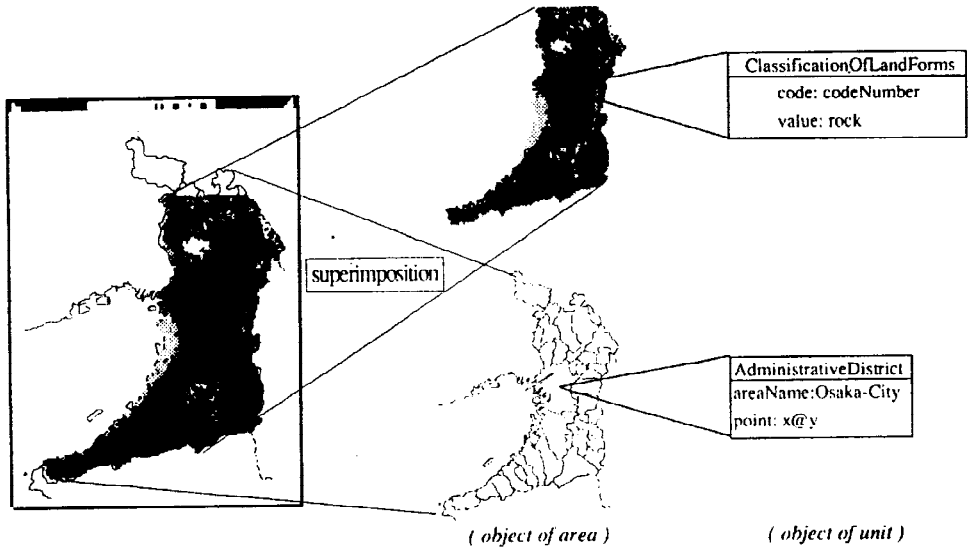

Fig. 2. Conception diagram of data structure constructed by object .

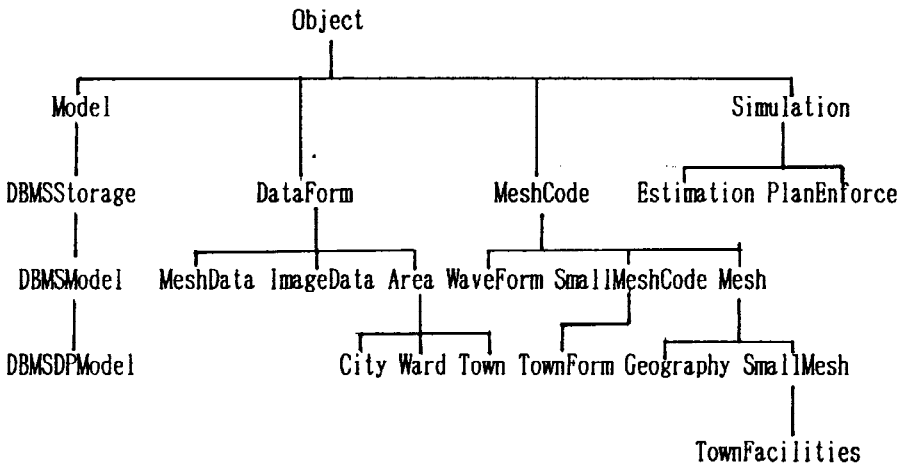

Fig. 3. A class hierarchy as to an evaluation of damage distribution of wooden houses.

On the other hand, "Data" are divided into two: "Environment" and "Facility" The contents of the former are topography and ground, statistics of population, administrative districts, etc., and those of the latter are lifeline networks, statistics of houses, road networks, dangerous facilities, etc. These data are provided in literal and numerical forms as well as in pictorial and photographically forms, so a database-management function is essential to deal with them as unified data.

OBJECT MODEL

To unify various forms of data, disaster prevention database should have the function of processing pictorial and photograph data obtained through multimedia in addition to ordinary functions of processing literal and numerical data, such as data detection, data generation and renewal, data conversion, data management and so on. This is why an object-oriented language which can deal with different forms of data as unified ones is used here as a database-management tool. The database also shelled have "developmental" construction; namely, the database is useful as a support tool in making or implementing plans for disaster prevention and also helpful to construct such expert systems as information management system for disaster prevention and enforcement support system for disaster prevention. This is another reason why "Smalltalk" is used for constructing the effective database.

As is shown in figure 1, there are three object classes besides "Information" and "Data": (1) "DBMS" is a function class of saving the generated object, (2) "Simulation" is a class which is set up to make a simulation analysis method function, and (3) "DataFormate" is a class whose function is to put data of local areas into such forms as mishaps, polygon maps, images of line drawing and so on.

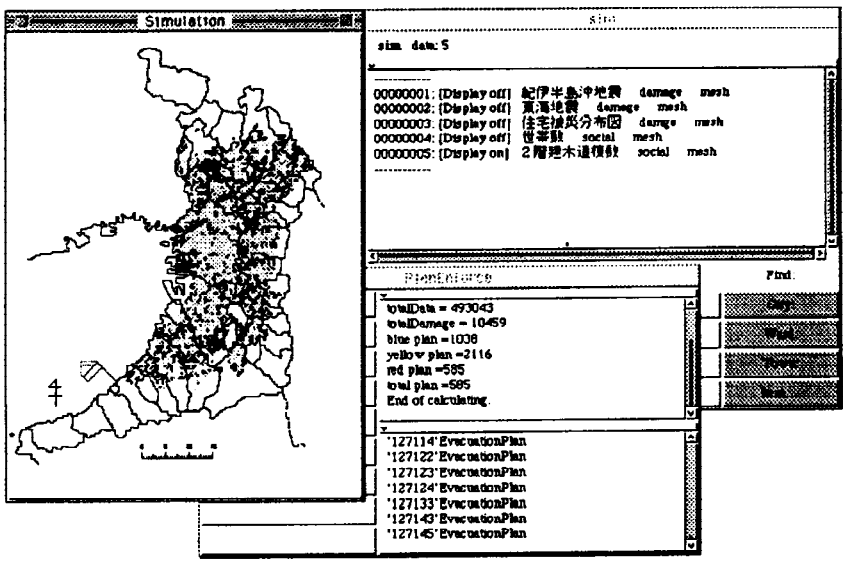

Fig. 4. An evaluation result of damage distribution of wooden houses in the Osaka prefecture.

Figure 2 is a conceptual diagram of data-structure by "object". A specific size of an individual mesh in a mishap or an individual polygon in a polygon map where the smallest administrative districts such as streets, blocks or towns are expressed as closed areas is considered to be an objects with such attributes as names of towns and streets, statistics of houses, statistics of population, data of ground and so on (see figure 1). This makes it possible to deal with each pictorial object in the same way with literal and numerical data, which is the greatest advantage of using an object-oriented language. As is shown in Figure 2, the superimposed image on the left is expressed by adding two objects : an object of picture expressed by polygon image of an administrative district and that expressed by mesh image of ground data. These objects are composed of an individual objects expressed by a single polygon or a single mesh, each of which has literal and numerical data as its attributes, such as names of administrative districts and streets, ground classification, etc.

MOUNTING OF PROGRAM AND ANALYSIS

By using the data-structure shown in Figure 1, various problems in the specific fields of the prevention countermeasures of natural disaster could be discussed from the viewpoints of a virtual evaluation of damages and a validity of prevention countermeasures. As a fundamental prototype to this approach, a mounting of program and some analytical results are described in regard to an estimations of damage distribution of wooden houses in the Osaka prefecture. A procedure of estimations in this problem is as follows:

(1) The basic values necessary to evaluate virtual damage distributions of wooden houses are assumed regarding to parameters of an earthquake and regional information, such as location of origin, mechanism of origin, magnitude of earthquake, and so on.

(2) An intensity distribution of earthquake ground motion for this earthquake is estimated by consideration of the characteristics of wave propagation and geographical effect.

(3) The regional information used in an evaluation are refer to data-base in respect to site characteristics of

surface geology, regional distribution of wooden houses, structural characteristics such as age of construction, number of story and so on.
(4) An evaluation method of damage of wooden houses is determined from the knowledge basis of computing system and damage analyses are carried out.

In order to describe a procedure of intermediate steps extended to final estimation, a class hierarchy mounted as a executing program is shown in Figure 3. A class of Model in this figure is assigned generally to take a part of operations among whole classes and a class of DataForm has a role of generating an Object of map and mesh-map. In a class of MeshCode and in a class of Simulation, the regional information concurring to the wooden houses are stored and damage analyses are evaluated, respectively.

An analytical result is shown in Figure 4. In this figure, a virtual estimation of damage distribution in the Osaka prefecture is indicated as a mishap of 500 meters. The assumed parameters of earthquake used in the evaluation are that of 1944 Tounankai earthquake and an analysis is executed by the class hierarchy shown in Figure 3, according to the above mentioned procedures. As for a precision and its validity of the evaluation result, they are dominated essentially by data and methods of each phase of the evaluation procedure, but various problems to the prevention countermeasure of natural disaster are analyzed effectively and intensively by this methodology.

CONCLUDING REMARKS

Only the basic framework for the construction of disaster prevention database is discussed by using the object-oriented language. Though a simple problem is examined by making use of the database of the object-oriented language, it is confirmed that the method is effective to construct an expert-system as to the prevention countermeasure of natural disaster, regardless of a scale and a classification of the problem. Advantages of this methodology can be summarized to the following points:
(1) Data processing to unify the different data types such as numerical, pictorial and character type.
(2) Data presentation in any phase of evaluation process by pictorial data form or by superimposing several pictorial data forms.
(3) Usefulness as a tool of expert system.

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