IMPROVEMENT OF THREE DIMENSIONAL GEOLOGIC MODELING SYSTEM BASED ON WEB-GIS FOR PROVIDING THREE DIMENSIONAL GEOLOGIC INFORMATION

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ABSTRACT

The three dimensional geologic modeling system based on Web-GIS has been developed and improved to perform acquisition of the field survey data, construction of the model, and visualization of the results on Web for sharing and providing three dimensional geologic information. The base system for Web-GIS is constructed by mapping engine (MapServer), Web-GIS client (OpenLayers), GIS (GRASS) and relational database (PostgreSQL/PostGIS). And, the main system for the geologic modeling is composed by nine functional modules.

The main improvements from the prototype system are the following two points. 1) The data flow for the modeling has been rearranged according to the theory based on the logical model of geologic structure. 2) The geological profile function has been added to the "visualization module". As a result of these modification, the structure of the data flow for modeling can be defined clearly. And, the geologic section along the straight line between arbitrary two points can be shown easily and independently without the export of the model to client GRASS-GIS. Furthermore, this system has been established by the actual subsurface modeling using borehole database.

1. INTRODUCTION

Geologic information is one of the important spatio-temporal information for supporting our life. Three dimensional geologic model expressed the geologic distribution of three dimensional subsurface space is essential information in the geologic information. The prototype system for providing three dimensional geologic model on the Web has been developed using Web-GIS (Masumoto *et al*., 2008). However, there are some problems in the prototype system relating to the data arrangement for the modeling flow and the function of the visualization for geological model. For example, the geologic profiles can not be visualized without GRASS GIS.

In this paper, the basic elements of the three dimensional geologic model have been defined to providing the basic geologic information according to the arrangement data flow of the modeling. And, the visualizing function of the system has been improved in order to show the model without export data to other client system. Furthermore, this system has been established by the subsurface modeling of Western Osaka Plain using real borehole database (see Shoga *et al.*, 2010 in this proceedings).

2. SYSTEM CONFIGURATION

The three dimensional geologic modeling system has been constructed by the Web-GIS system and nine functional modules. The Web-GIS system is constructed by the integration of Web-GIS engine (MapServer), Web-GIS client (OpenLayers), GIS (GRASS GIS) and relational database (PostgreSQL/PostGIS) using the typical FOSS4G (Free and Open Source Software for Geoinformatics) products (Ninsawat *et al.*, 2008; Iwamura *et al.*, 2008; Sakurai *et al.*, 2008; Masumoto *et al.*, 2008).

The main system of the geologic modeling is composed of the following nine function modules. 1) Data acquisition module; this module imports various basic data files such as the filed survey data, the borehole data, and the elevation data. 2) Stratigraphic correlation module; this module supports stratigraphic correlation on Web-GIS. 3) Classify and arrange module; this module performs the classification and arrangement of the basic data. 4) Logical modeling module; this module creates the logical model of geologic structure and arranges the data set for the estimation of the geologic boundary. 5) Surface estimation module; this module generates the geologic boundary surfaces estimated from the data set arranged by the logical modeling module. This module has been substantially improved by Nonogaki *et al.*(2010). 6) Geologic function module; this module defines the geologic function that expresses the rule to assign the unique geologic unit to every point in the objective three dimensional space. 7) Database management module; this module manages all data of the database stored by the modules for geologic modeling. 8) Visualization module; this module exports the data and the model to the visualizing format in two or three dimension. 9) Standardization module; this module transfers the data and the elements of the model to standard format of Web-GIS. Figure 1 shows the relationship of these nine modules.

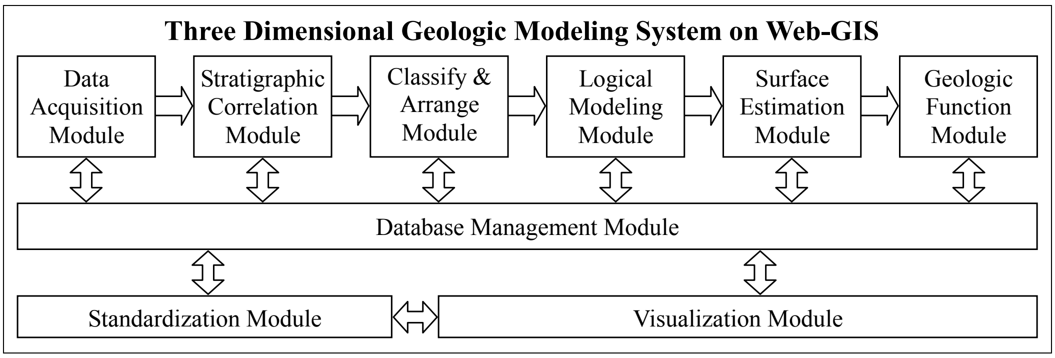

Figure 1. The relationships of the modules for the three dimensional geologic modeling system on Web-GIS.

3. BASIC ELEMENTS OF THREE DIMENSIONAL GEOLOGIC MODEL

The spatial distribution and the relation of geological units are expressed in the three dimensional geologic mode based on the fundamental field data and the knowledge of the geology. The geologic information flow for the construction process of the three dimensional geologic model is shown in Figure 2. These information can be arranged the following items.

Observed data: the data form field survey (e.g. location, attitude, attribute, lithofacies, and relationship, etc.) and the data form analyzing (e.g. dating, fossil, rock properties, geophysical prospecting, and geochemical, etc.)

Inferred information: information of geologic units (e.g. correlation, stratigraphy and structure, etc.)

Logical model: event sequence (geological history) and the logical relation between geologic units and boundary surfaces.

Boundary surface: the geometrical shapes of boundary surfaces including data and parameter for estimation.

Construction method: theory, process and analyzing method for modeling including boundary surface estimation method.

These items are the basic elements of the three dimensional geologic model. There are many difficulties to be solved in the information of the geologic map, such as the problems of objectivity, reproducibility, renewability, extensibility, compatibility, flexibility and versatility. These problems can be solved by the providing of the basic elements with the three dimensional geologic model.

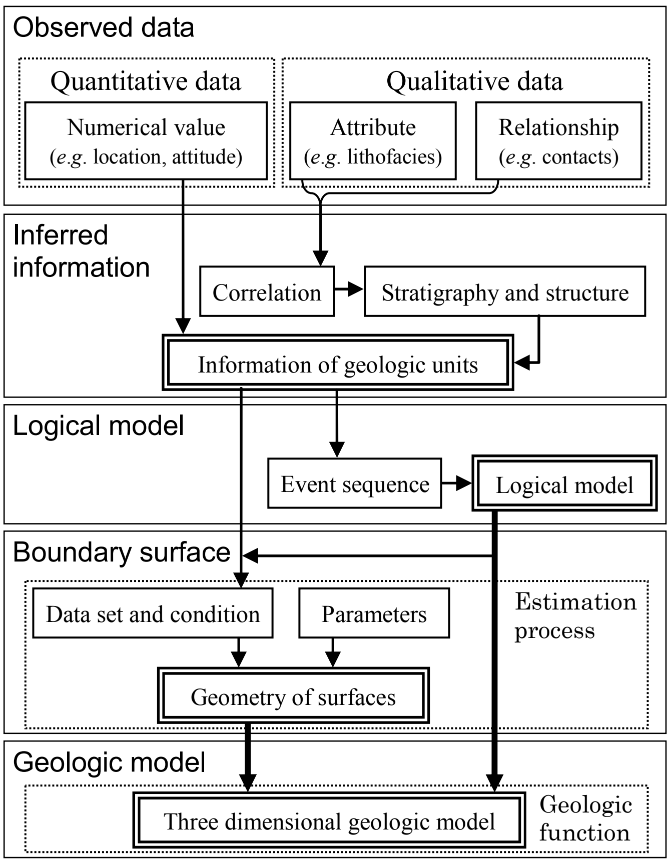

Figure 2. Data flow of the three dimensional geologic modeling.

4. IMPROVEMENT OF MODELING SYSTEM

The main improvements from the prototype system are the arrangement of the data flow for modeling and the addition of visualization function for the two modules. The data flow for the modeling has been rearranged according to the theory based on the logical model of geologic structure. The main improvements of modules were made on the stratigraphic correlation and the visualization. For example, all the geologic description of the borehole database can be display and use on the stratigraphic correlation module (Figure 3). And, the geological profiles along the straight line between arbitrary two points can be created and shown on the visualization module (Figure 4). As a result of this modification, the three dimensional geologic model can be expressed using VRML without export of the model to the desktop GRASS GIS. The several screenshots of geologic model using Cortona3D viewer plug-in for Web browser are shown in Figure 5.

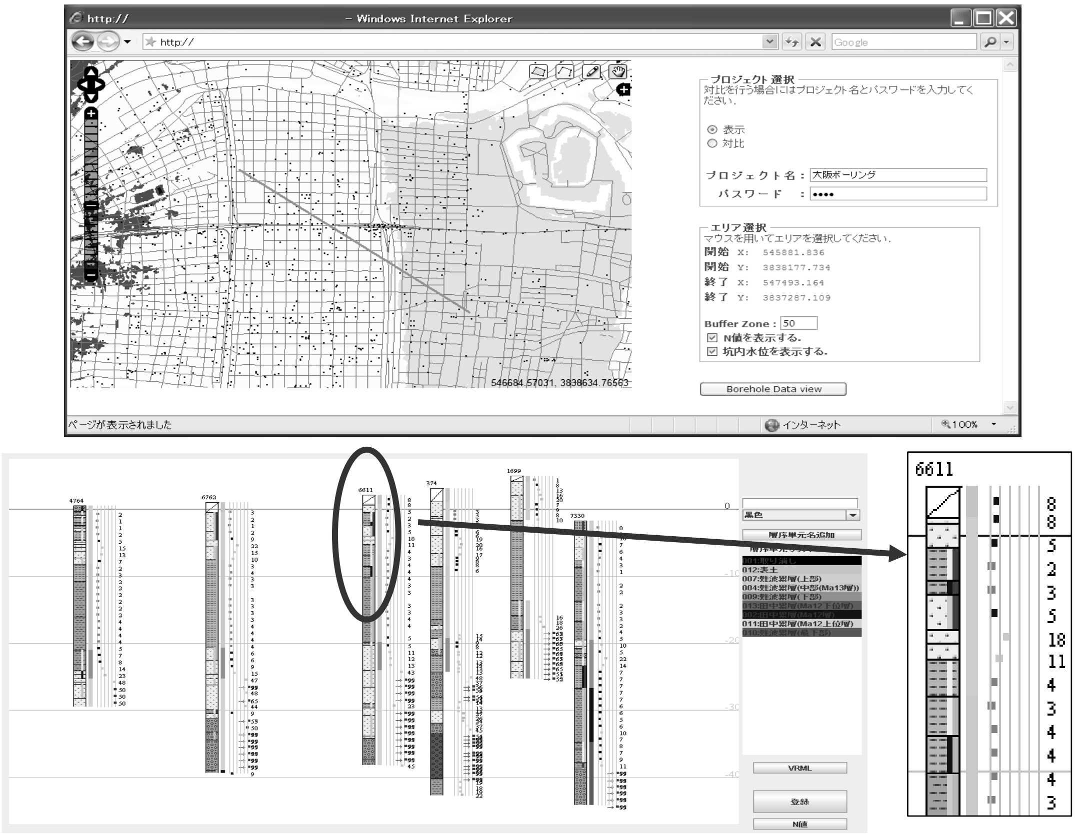

Figure 3. Example images of the stratigraphic correlation module.

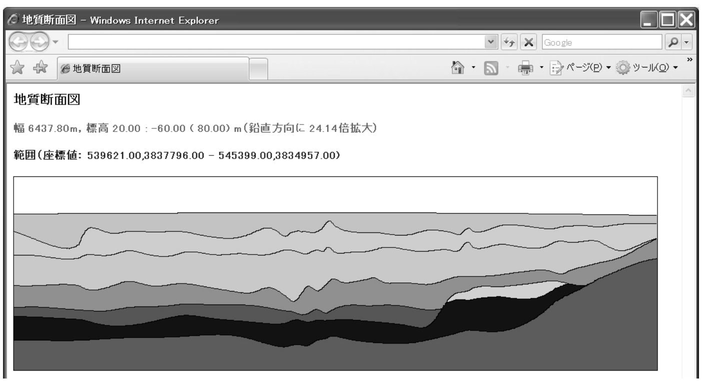

Figure 4. The example image of the geological profile on Web browser.

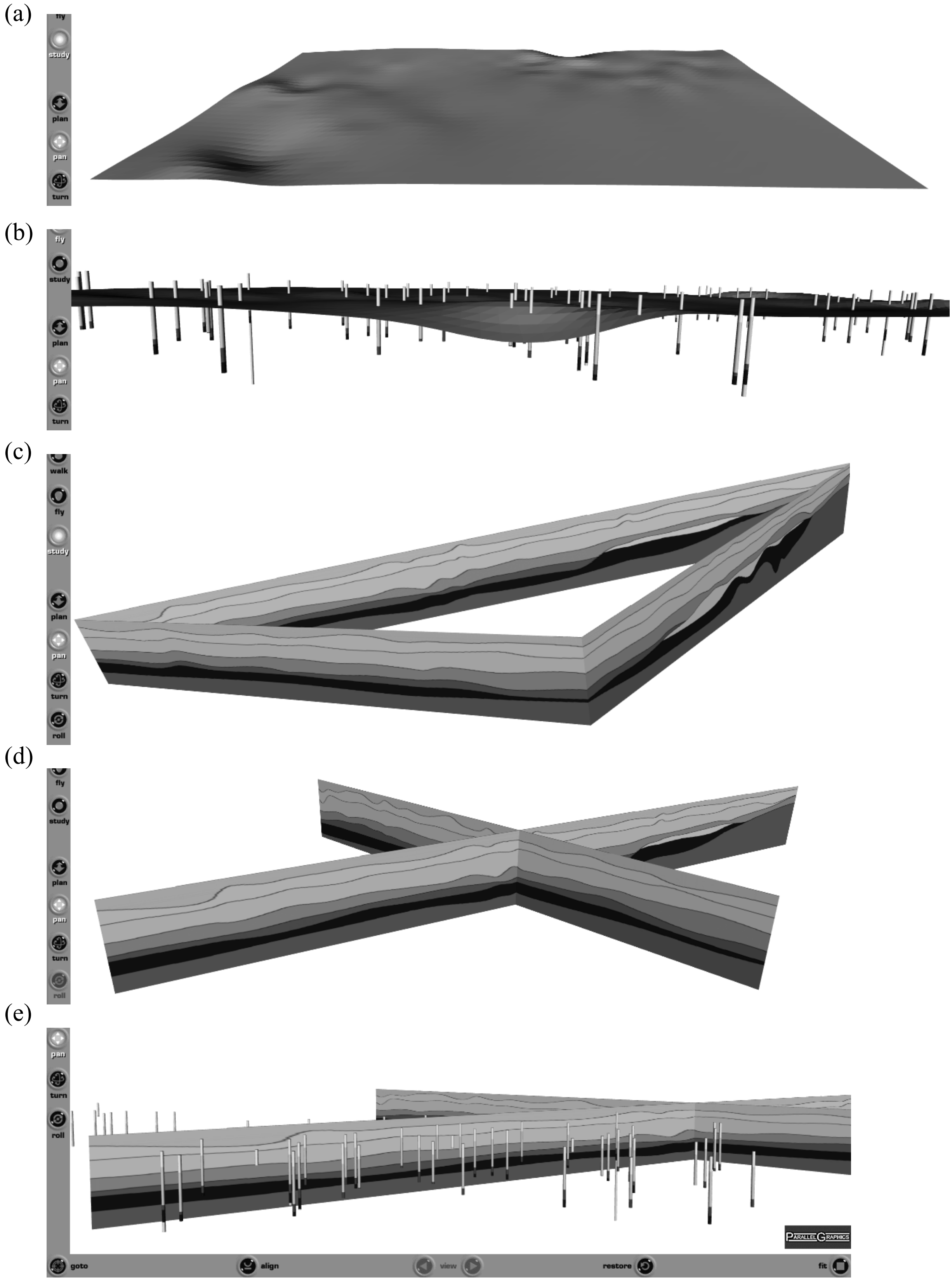

Figure 5. The example images of the three dimensional geologic model on Web browser using VRML. (a) Geologic surface, (b) geologic surface and borehole data, (c) of three geologic profiles , (d) two cross geologic profiles, and (e) profiles and borehole data.

5. CONCLUSIONS

The basic elements and the improvement of the system for providing the three dimensional geological information were presented. The basic elements and three dimensional geologic model are very important for the effective utilization of the geological information, and can provide better understanding and high reliability.

Recently, GeoSciML which is an application schema specified a set of feature-type and supporting structure for geological information was developed (Sen and Duffy, 2005; Fusejima and Bandibas, 2008). The basic elements will be considered according to this GeoSciML schema, and will be arrange to the structural information.

The visualization of geologic model in standalone Web applications can be realized by the improvement of the modeling system. For practical use, further development and improvement of this modeling system are necessary.

6. ACKNOWLEDGEMENT

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