Inplementation of flooding simulation in coastal area based on 3D satellite images and Web GIS

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ABSTRACT ... Our country's coast is vulnerable area to natural disaster which the repetitive damages occur every year including a loss of lives, the damage of facilities and erosion mostly except for the east coast because of a typhoon, tidal waves, sea water overflowing by topographic structure of low-lying gentle slope and shallow sea. However, as for prevention of natural disaster occurring every year, the situation is that it's centered on the restoration-centered measures and the general disaster prevention research to minimize damages at the time of disaster occurrence is insufficient.

This study intendedlop t to devehe techniques possible for real time sampling of damage prediction areas on Web in order to support decision making for damage prevention and establishment of disaster prevention policy. For this, the thematic map was produced related to disaster based on high-resolution satellite picture, and the environmental DB similar to real world was constructed through topographic construction of three-dimension integrating the parts of land and the sea. In addition, the system was developed possible for the expression of damageable regions by real time grasp of dangerous regions at the time of disaster occurrence through over flowing simulation of three-dimension, and it's intended to prepare a basis to minimize damages to disaster situations through it.

KEY WORDS: Coast disaster, Flooding simulation, satellite image, 3D Web GIS technology, DSS

1. INTRODUCTION

Our country's coast is vulnerable area to natural disaster which the repetitive damages occur every year including a loss of lives, the damage of facilities and erosion mostly except for the east coast because of a typhoon, tidal waves, sea water overflowing by topographic structure of low-lying gentle slope and shallow sea. However, as for prevention of natural disaster occurring every year, the situation is that it's centered on the restoration-centered measures and the general disaster prevention research to minimize damages at the time of disaster occurrence is insufficient.

This system can show the possibility of performing as DSS (Decision Supporting System) for the Korean prevention method against coast disaster by extracting damaged area and simulating disaster in real time. First of all, the thematic maps were constructed and the flood simulation was performed. For the system testing, the previous coast disaster, which is called as Maemi, was simulated and compared its damage with the result of system simulation. Finally, this service is expected to provide through web in real time.

2. RESEARCH METHOD AND DATA

Selected around of Masan harbor suffered from a typhoon, Maemi, accompanying unparalleled tidal waves on September, 2003 as a study object, the basic data was constructed while collecting the numerical data including buildings, roads, rivers, damage drawings, history data. Also, the 3D precision topography of 5m resolution using data on contour line, altitude point, coastline & water depth of numerical map was produced. Every constructed data was designed possible for real time damage area prediction on Web by reiterate using 1m IKONOS of high-resolution satellite picture to provide more accurate information at the environs similar to real world.

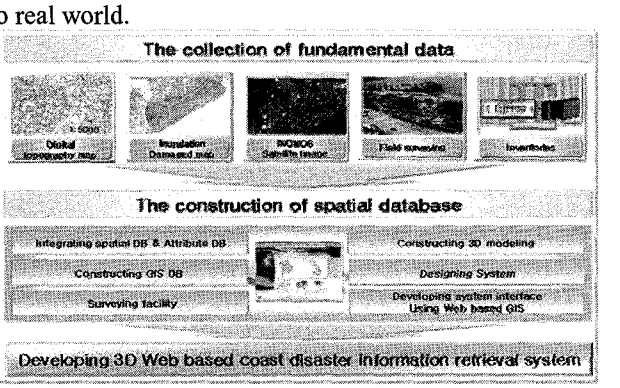

Figure.1 The study flow chart for Web based coast disaster area management system

3. THE CONSTRUCTION OF SPATIAL DB

3.1 The construction of thematic map database

To provide various information at the time of damage area prediction, the regions and locations of damages were visualized while collecting data on damages of Masan area by a typhoon, tidal waves, overflowing and erosion. Also, the basic data was constructed for the preliminary disaster prevention including predictions on damage of facilities and loss of lives at the time of disaster occurrence while measuring the height value of the building and acquiring related attribute data for verification of source data and grasp of flooding degree by field study.

Table1. Facility Layer classified table

Layer name	Layer code
Housing	4112 ~4119
Administration facilities	4211 ~ 4258
Industry facilities	4311 ~ 4346
Culture & Education facilities	4411 ~ 4435
Service facilities	4511 ~ 4534
Medical treatment facilities	4611 ~ 4637
etc.	4111

3.2 3D based detail topography modeling

In order to construct 3D based detail topography modeling, 5m DEM (Digital Elevation Model) considering contour, DTM, coast al line and water depth was constructed using scaled on 1:5000 topography map. Moreover, in order to improve the precision of topography information, the interpolation and overlay based on satellite images were used as show in Figure. 3.

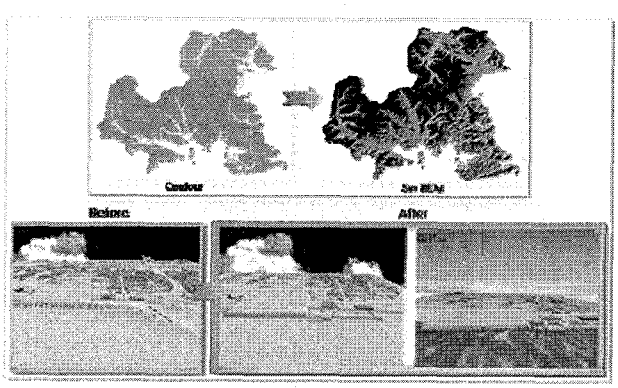

Figure.2 DEM modeling

3.3 The construction of satellite images DB

The satellite images, IKONOS, was used to acquire the better precision and remove the location error, and processed through radiometric correction and orthorectification. Also, the various fusion and mosaic methods were tested to present natural color of forest, land, coast and urban.

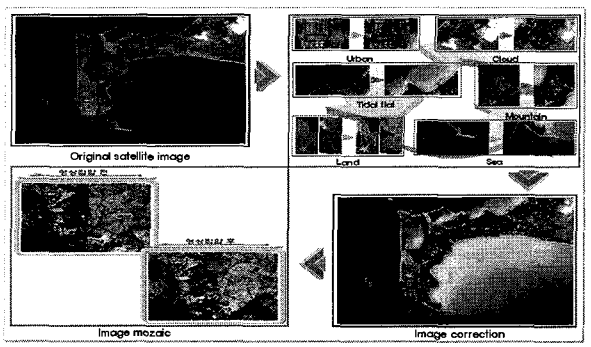

Figure.3 Satellite images DB construction

3.4 Implementation of flooding simulation

In measuring the coastline height of Masan of a study object, sea level was generated by setting Mean sea level of observed tide value as standard value considering the regional properties and applied to overflowing simulation. For system verification, the accuracy of simulation was measured by comparative analysis with damage map made after a typhoon 「Maemi」 in 2003.

Figure.4 Inundation Damaged Map of typhoon Maemi

The overflowing water level occurred at a typhoon 「Maemi」 in Masan area was damage of about 4.3 m from Mean sea level, and overflowing of 4.3m was occurred by adding the height of Mean sea level provided by National Oceanographic Research Institute <Figure 5>, observed tide location value by time<Figure 6> and the maximum tide location deviation according to the factors including wind velocity, wave height of deep sea and rising height of air pressure at the time of a typhoon occurrence.

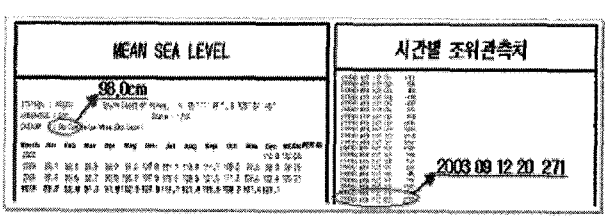

Figure.5 Mean Sea Level Figure.6 Observed tide location balue by time

For height value of tidal waves at the time of a typhoon 「Maemi」 , 98cm of Mean sea level, 271cm of observed

tide location value by time and 258cm of maximum tide location deviation by wind velocity, wave height of deep sea & rising height of air pressure were applied (National Oceanographic Research Institute), and the height of Mean sea level calculated from overflowing water level of damage map was deducted because overflowing simulation used in this study makes sea level rise as a standard of the present Mean sea level.

71cm(Observed tide location balue by time)+258cm(maximum tide location deviation by wind velocity)-98cm(Mean Sea Leve)= 431cm (1)

For verification of damage map by a typhoon 「Maemi」 & the expected damage region of overflowing simulation, 4.3m of overflowing water level was applied on system, and each damage area and damage degree of facilities were compared.

Figure.7 Flooding simulation

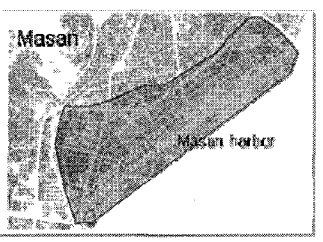

Figure.8 Inundation map

Table1. The result of accuracy verification of overflowing simulation

	Inundation map		Flooding Simulation		accuracy
Area	817,920 ㎡		741,403 ㎡		90.6%
Facility	1,838		1,531		83.3%
	Housing	1,161	Housing	884	
	Administration	4	Administration	1	
	Industry	50	Industry	47	
	Culture&Education	12	Culture&Education	9	
	Service	87	Service	86	
	Medical treatment	41	Medical treatment	39	
	etc	483	etc	465	

As a result of accuracy verification of overflowing simulation, 90.6% accuracy of overlapping area & 83.3% of facility was shown. More accurate result of area than facility was because that residential regions are distributed at the areas overflowing simulation can't show. Despite of error from not considering the various factors effecting on simulation including 178cm of heavy rain at 「Maemi」, wind velocity, wind direction & tide, about 90% of accuracy was shown.

It's difficult to apply this consistently because of the differences between Masan region as a damage area by a typhoon and tidal waves at full tide and other regions as damage areas by flooding & overflowing. However, it's thought to be possible for using it as the basic data for damage area predicting and information providing through the various factors application on Web hereafter.

4. THE FLOW CHART OF SYSTEM DEVEPOPMENT

In this system the wavelet image compression was used to process the large sized satellite images in real time through the web. Also, the system operation structure is consisted of client side, middle ware and server that is corresponding on users, map server, web server, respectively (3-tier). System users request their desired results through web server using certain browser to map application server, which is located in map server.

In this paper the system interface development is focused on API (Application Programming Interface) methodology. To implement this system, HTML, JSP, and Java scrip are used to construct web server and Oracle 9i is used for database construction, respectively. Also GIS component, which is called as XDWORLD, is used to serve dynamic 3D map on web

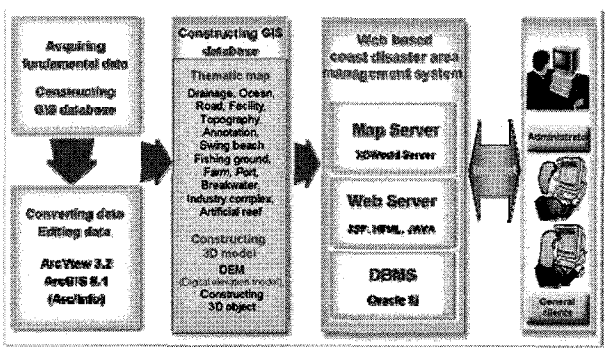

Figure.9 The design of system

4.1 The construction of 3D facility information

The various thematic maps, especially 3D facility thematic map, were constructed by cooperating with their attribute data and retrieved on high-resolution satellite images (1m). This is considered as very useful data to extract the amount of damage during coast disaster.

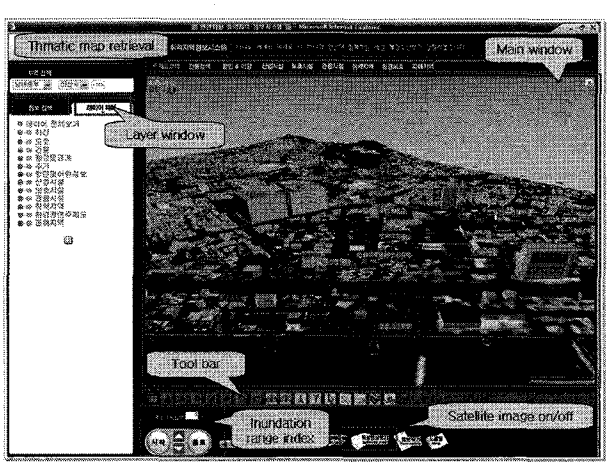

Figure.10 The construction of 3D facility information

4.2 The measurement of 3D based topography

This interface was implemented mot only to measure the distance and area considering 3D topography but also basic GIS view functions such as Zoom in/out and Pan as show in Fig. 6. Partially, the aerial photos (20cm) and site photo were used to provide the more detail topography.

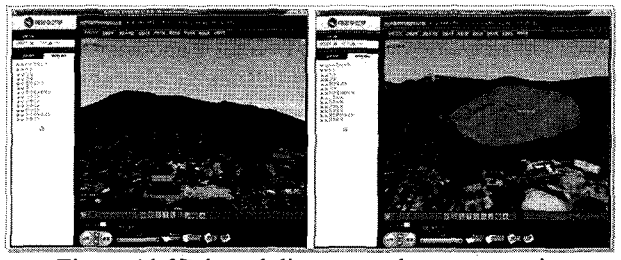

Figure.11 3D based distance and area measuring

4.3 The flooding disaster simulation

The 3D flood simulation could be performed on 3D viewer and its flying and rotation from various angles on desired maps also could be also implemented. Especially, the 3D flood simulation could present the overflowed status depending on the height of sea in study area and indicates the high hazard area.

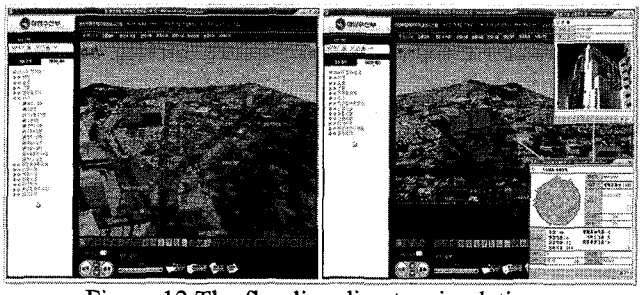

Figure.12 The flooding disaster simulation

5. CONCLUSION

In this study, Masan city along the Korean coatal area were selected in order to manage in the coast vulnerable area. The various thematic layers such as topography, 2D or 3Dfacility, road, stream, administrative boundary, labeling, harbors, fishing port, breeding ground, national industry area, swimming beach were classified from national digital map based on 1:5,000 and 1:25,000 scale and the attribute data, which is based on disaster annual report, disaster white papers and inventories for recent data, has been constructed in DBMS.

Also, the coast disaster area management system was developed to retrieve spatial information, control map view, provide related to information such as weather and ebb and flow and simulate inundation after heavy raining through using 3D web GIS technology. Finally, this system can show the possibility of performing as DSS (Decision Supporting System) for the Korean prevention method against coast disaster by analyzing spatio-temporally related to damaged area.

Furthermore, the system integrating the coast & land area to provide more realistic 3D information was developed while reiterating DEM and high-resolution satellite picture. As a result of comparison with damage map made at the time of a typhoon 「Maemi」 based on this, about 90% of accuracy was shown. Though there's error from not considering the various factors effecting on simulation including heavy rain, wind velocity, wind direction and tide, it's regarded to be possible for using it as the basic material for damage area predicting and information providing through the various factors application on Web hereafter.

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