CONSTRUCTION OF 3D GIS FOR THE EFFICIENT EXPRESSION OF FACILITY RISKS AND FLOOD DATA IN FLOOD DISASTERS

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ABSTRACT: For large-scale water disasters induced by the abrupt climate change, various relevant studies on damage prediction and prevention have been actively conducted. Such disasters bring about casualties and property damage at the same time, and damage to SOC facilities that are directly or indirectly connected has continuously increased. Diverse information relevant to water disasters can be practically obtained on land, and GIS connection is essential in order to provide intuitive information. In addition, considering that the damage induced by water disasters affect buildings and citizens on the land, GIS mashup of diverse information is expected to be a solution for effective information analysis/prediction and countermeasure. The present study aims to establish a three-dimensional geographic information system that combines the facility information and damage information under a flood disaster situation that can be obtained on land, based on research in the three-dimensional GIS engine field, which is growing internationally. This could contribute to direct flood damage, and could also provide a control tower system that enables a water disaster manager to make a prompt decision.

1. INTRODUCTION

The increase in unusual weather leads to environmental and ecological changes, which induce various damages as a result of natural disasters. In particular, flood damage, which frequently occurs in the summer season, has an effect on the diverse and wide range of casualty and property damage, and also has an enormous effect on the SOC facilities that correspond to national property. For the effective management of such disasters, much of the cost has been invested in the research/development and system development at a national level. Efforts are being made to prevent natural disasters in advance through the fusion of the ICBM (IoT, Cloud, Bigdata, and Mobile) techniques depending on the development of science and technology. A disaster is a natural phenomenon that occurs on land; and for the development of a relevant system, a technique for establishing a geographic information system is essential. The height of a building, area, relation between major facilities, and attribute information as well as the height of topography, which is the simplest data obtainable from the spatial information, are useful in various aspects such as disaster prevention, countermeasure, and restoration. These are information on the three-dimensional space of the actual world. Thus, implementing them on a two-dimensional space is limited. Accordingly, three-dimensional establishment has recently been generalized for effective disaster simulation. The fact that GIS-based disaster simulation is effective was demonstrated by various studies for making an accurate flood disaster map using simulation that have been conducted since the 1990s. In particular, Lee, 2013 conducted a study for promptly servicing an inundation situation for the areas vulnerable to inundation. By continuously expressing two-dimensional inundation simulation on the three-dimensional realistic information, the damage situation was obtained through more realistic and practical simulation.

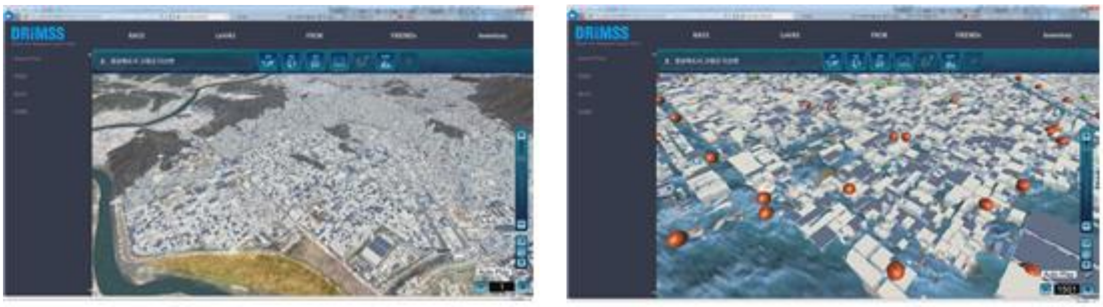
Fig. 1. Implementation of the inundation simulation function

Source: Lee, 2013

In the present study, as a method of estimating more accurate inundation damage, a three-dimensional geographic information system was established through the mashup of diverse information on land. Based on this, basic flood inundation data for flood simulation were expressed on three-dimensional land at each time zone. Furthermore, the present study aims to secure meaningful results for the person in charge of disasters or a disaster prevention expert by analyzing the simulation, rather than simply performing a simulation. The vulnerable areas that are predicted based on this and the hilly areas that can be used as a refuge can be intuitively determined, contributing to prompt political decision making.

2. METHOD

In this study, for more efficient flood information analysis, a basis of 3D GIS was established using a three-dimensional engine. For the established 3D GIS, a generally used three-dimensional GIS engine was not utilized, and instead a game engine, Unity, was used. The geographic information data used in this case has a special extension. It was made to be a grid type through pre-processing, and was inputted in an array format. The system established based on this is shown in Figure 2(a). Through the corresponding system, the topographic information that corresponds to the testbed area was established, and the mashup of facilities was performed by expressing the information of an individual facility so that it fits the grid-type array. Furthermore, considering that the size of satellite image and geographic information data is large, the image and topography were divided in advance based on the level. The appropriate image and topography by magnification and reduction were expressed. In addition, an individual facility includes diverse attribute information. Three-dimensional information for major buildings is needed in a disaster situation because it can be used as a basic data for analyzing the financial damage or the damage status when the corresponding building is an important building. If the building attribute information is established as DB in more detail, the damage can be predicted by calculating the damage of the building and the traffic volume of the corresponding area together (Gang et al.). When a three-dimensional space is established based on the topography and building information as mentioned above, a method that is most effective when combined with three-dimensional GIS in the case of disaster information is simulation. In Figure 2(b), the flood simulation information at each time zone was obtained as an array by processing the information in a grid format, and was subsequently expressed by matching the coordinates. When this information is combined with the aforementioned building information for effective visualization, location-based damage status can be expressed (Gang et al.).



(a) Three-dimensional geographic information

(b) Expression of the flood simulation for each time zone

Fig. 2. Disaster information expression system established using the three-dimensional GIS

Expressing simple damage information on a three-dimensional space indicates the acquisition of intuitive information where information can be obtained through the naked eye. Also, relevant information can be easily viewed at one time through the fusion of dispersed information. Thus, for multilateral information expression and deduction, the area with the largest final damage was obtained by calculating the cumulative sum for each different grid in the inundation information that can be obtained at each time zone. Figure 3 shows the cumulative expression method for the multilateral flood damage analysis suggested in this study. In the flood inundation map obtained at each time zone, the cumulative sum for each grid is first stored in a new array. A legend that can be easily distinguished with the naked eye is designated, and a layered structure can be made by storing the RGB value for the corresponding array. In this regard, the cumulative sum represents the amount of inundation for the corresponding grid. The cumulative sum can be the information for predicting the severity of damage when it is used as a path where water passes through. The effective method for displaying the information in a three-dimensional space is to use the difference between the perspective view and the orthogonal view by varying the three-dimensional height value. Thus, the simulation of flood inundation is expressed at the same height as it occurs on the topography, and the newly made cumulative sum array is expressed at the top using a gap.

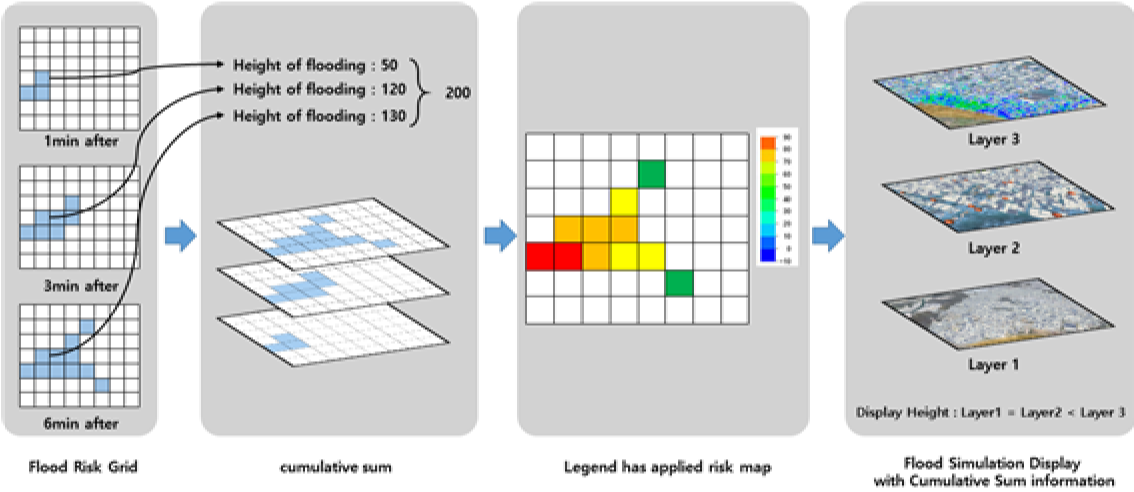


Fig. 3. Flood cumulative information expression method for intuitive flood information analysis

Figure 4 shows the system established through the method suggested earlier. When the cumulative information is displayed in a 2D format as shown in Figure 4(a), it intuitively shows the amount of inundation damage for the corresponding area. In addition, when 3D is used as shown in Figure 4(b), it can intuitively show the passage of flood for actual simulation, the current risk status of the facilities, and the cumulative inundation form, as a method of providing visually effective information.

(a) Ortho view of the cumulative information expression

(b) Perspective view of the cumulative information expression

Fig. 4. Suggested flood information multilateral analysis method

3. CONCLUSION

In this study, for intuitive information delivery in flood disasters through effective three-dimensional simulation, three-dimensional GIS was established and flood damage was expressed. In terms of geographic information, three-dimensional GIS can effectively show diverse information similar to the existing 2D GIS. It can also show the gap between heights or the heights of topography and facilities more realistically using one more dimension. Thus, to effectively utilize three-dimensional GIS, a system needs to be established in terms of providing more efficient and meaningful information, overcoming the limit of the advantage of intuitive visual expression. In the case of the method suggested in this study, effective visual display was considered, and newly obtainable data was presented using GIS between cumulative information. This information could provide the damage prediction, range and situation for each time in more detail. It could be used for establishing a system that can play the role of a real-time disaster prevention control tower. In future studies, a more meaningful system needs to be established by implementing a system that can additionally secure the cross-section of a flood including the heights of facilities, etc.

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