A Study on the Application of the LOD Technique to Unity-based High-Resolution Aerial Images for Disaster Information 3D GIS Services

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ABSTRACT: Worldwide large-scale natural disasters such as typhoons or heavy rainfall have caused extensive human and material damage. To manage and prevent such disasters, studies for constructing a three-dimensional (3D) geographic information system (GIS) that provides multi-angle analysis of disasters and offers easy management have been conducted. Among the developed GIS engines, 3D game engines can construct 3D display systems with the GIS function depending on the capabilities of the developers, but terrain and 3D building information produced with high-precision spatial information and high-resolution images is large in capacity and requires much time for system services. In addition, the method of loading all the information of images regardless of their scale causes overload to the image processing device, making efficient image processing impossible. To overcome these limitations, this study aimed to address the loading delay problems, which are obstacles to system operation, by applying the level of detail (LOD) technique to the high-precision terrain information provided by systems based on the Unity 3D engine, which is a game engine. The LOD technique is a technique used to control large-capacity images and adjusts the details according to the scales of the images. To apply the LOD technique to the 3D engine, images with various resolutions were stored, and aerial images were segmented according to the zoom. In other words, the zoom far away from the terrain produced low-resolution images while the zoom close to the terrain produced high-resolution images. Based on this method, the loading delay time of the display system could be shortened. 3D disaster prevention GIS systems based on high-precision terrain and building information can be constructed using this developed method. In addition, the use of this method will make it possible to apply effective system functions and information services in the future.

1. Introduction

Disaster response systems dominated by two-dimensional (2D) modeling and analysis are changing into three-dimensional (3D) systems, and the main flow of spatial information services is also changing from 2D to 3D due to the advances in computer graphics technology. The advantages of the spatial information presented in 3D graphics are that the height value, which is the main factor of the space, can be provided, and that the space can be understood more quickly. Due to the recent hardware advancement and the development of software and production tools, the use of spatial information in the market is further increasing and will be expanded. The 3D flood prediction system, which is the main subject of this study, was constructed not with a commercial geographic information system (GIS) engine but with Unity 3D, a game engine. All the objects and contents, including the terrain and facilities, were constructed in 3D, and the system operates as a web system that provides efficient updates and information management. In addition, high-precision terrain information was constructed by applying high-resolution aerial images to a 3D terrain mesh. As the terrain information constructed with a terrain mesh and high-resolution aerial images, however, is high-capacity information, if such information is uploaded to a web browser without dividing it, the processing speed and traffic of the browser may be exceeded. This means that the system may go down, in which case the building and terrain information cannot be used even though the system user tries to obtain it.

In this study, mesh and high-resolution image information were divided into tile map forms to prevent such system overload and to ensure the high quality of the provided spatial information. According to the position of the system camera, a small number of mesh textures, low-resolution image information, divided high-resolution image information, and high-quality mesh textures were provided, and the images not included in the camera view were not loaded onto the system. The results of this study showed that the developed method could reduce the risk of overload of the connected devices, thereby making it possible to render high-quality 3D spatial information with relatively free specifications.

2. Unity-3D-based Terrain Information LOD Construction and Application

The 3D GIS-based disaster information 3D service system constructed in this study is based on the Unity 3D engine. Unity 3D has powerful 3D development, library, and customizing environments. It has significant advantages, such as a customizing environment and rendering speed, compared to commercial GIS software like ArcGIS in constructing a system whose main function is the 3D rendering of disaster information (Table 1). Unity 3D, however, cannot understand spatial information files as GIS engines do, and does not have the function of handling large-capacity high-resolution aerial images. As such, it was customized in this study so that it could understand and load GIS data (Table 2).

Table 1. Performance comparison between GIS engines and Unity 3D

Category	Commercial GIS Engines	Unity 3D engine
3D Rendering	Support 3Ds and ive	Provides a 3D web map plug-in Provides 3D optimization and high-quality rendering
Web Support	Use their own servers (IE, Chrome, and Safari)	Web service through Unity Web Player (IE, Chrome, Safari)
Linkage	Be able to use conventional 2D maps Support TMS	High developer attraction Various libraries and user experiences

Table 2. Development environment of the change detection module

Category	Explanation
Main Program	Unity 3D 5.3.6 f1
Subprogram	Visual Studio, Atom, 3ds Max
Program Language	C#, JSP, HTML5, CSS, JavaScript
Database	Toad for Oracle 9.7.2

For the construction of the terrain information in this system, the DEM data of the Seongseo area in Daegu with a 5X5m resolution per grid were used, and 60cm aerial images were used for the image data. To construct terrain information in the Unity 3D software, the vertex information of the x, y, z grid generated from DEM was imported and placed in Unity 3D, triangles were created, and texture mapping was performed with images. To produce the LOD of the terrain and images, the split image technique, which divides an aerial image with a modified resolution into arbitrary sizes to create small images, was applied (Figure 1(a), (b)). The object creation variable algorithm was applied to the mesh according to the camera position. The increase or decrease of the mesh polygons was determined according to the resolution of the aerial image, resulting in a high processing speed (Figure 1(c), (d)).

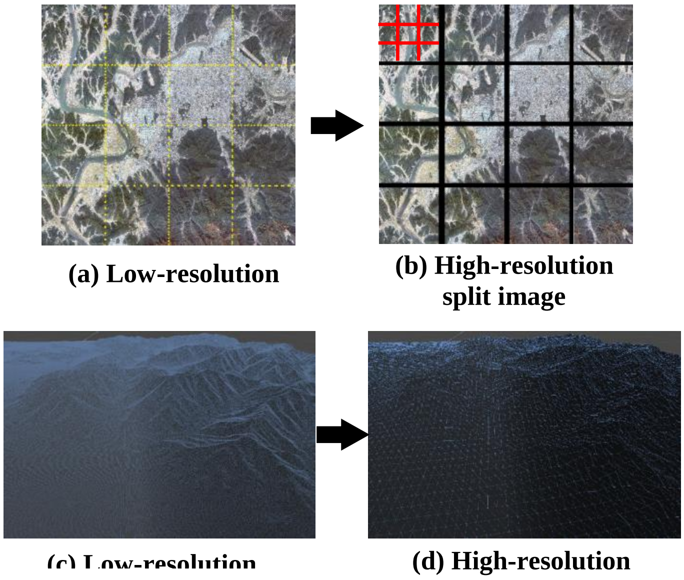

Figure 1. Resolution change of an aerial image and the terrain mesh according to the camera position.

3. Conclusion

Described in this paper is the construction of the terrain information in the Unity-3D-based three-dimensional (3D) disaster information display system for effective disaster response. In a disaster response system that requires large-capacity and high-precision spatial information such as building, levee, and road information, the terrain information must be precise and must minimize the system burden due to rendering. As aerial images and 5m-class DEM are large-capacity information, they must be converted for smooth system operation. As such, the split technique, which divides aerial images and sequentially places and applies each image in the process of constructing terrain information, was applied. The level of detail (LOD) technique was applied to change low-resolution images to high-resolution ones according to the camera position, resulting in a reduction of the load and time required for system operation. It is expected that efficient disaster response decision-making will be possible through the disaster response system based on more precise spatial information.

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