A Study on a Customized 3D River Information System Architecture Using High-Resolution Image Information

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ABSTRACT: Waterfront spaces have undergone various changes of late in terms of space utilization. This means that the function of rivers is changing from a means of preventing disasters to a leisure space for the general citizens. Due to these changes, development considering the accessibility of the waterfront space to the public or design considering various water-friendly environments is under way. Therefore, the provision of water-friendly information has become important for constructing river management systems. Information on the control functions, utilization functions, and specifications of general rivers is actively being provided through the national websites. Such information, however, is important only to some river managers and researchers, and the services systems for the citizens related to water-friendly information are insufficient. In this study, research was conducted on a system architecture that collects the data from the existing river-related databases and displays them as three-dimensional (3D) spatial information as well as provides information according to the needs of the user. The architecture considers not only river managers but also users who want to utilize the water-friendly information of rivers. Furthermore, 3D commercial engines and open-source engines capable of mashing up high-resolution satellite and aerial images were compared and analyzed. The analysis criteria were defined as the spatial information understanding and rendering efficiency of the 3D engines. Based on this, a geographic information system (GIS)-based system that can provide river information as 3D spatial information and can analyze water-friendly information from multiple angles was constructed. It is expected that the proposed system can be utilized for facility management and information retrieval, thereby contributing to decision-making.

Keywords: High-resolution image information, customized system, 3D engine

1. Introduction

River management systems have been constructed of late to provide various three-dimensional (3D) data on rivers as well as comprehensive 3D data on rivers with excellent visibility. The concept of life cycle management is actively used in the design and maintenance of river facilities. The life cycle concept was devised to calculate the average operational age of the constructed facilities, and maintenance and repair works can be carried out before the structure and functions of the facilities begin to break down. In addition, the river and watershed space are designed by adding the traditional functions, such as the separation and governance of the water and waterfront. Such transformation can be realized by adding hydrophilic elements in the form of a leisure space for the citizens to the existing waterfront of the rivers, and the landscape of cities and the urban function of a resting place can be improved as well by adding the elements of attraction. Although systems for displaying the various hydrophilic data of river facilities have been established, most of such systems provide data in text and two-dimensional (2D) map forms considering the operational efficiency, such as the geographic information system (GIS) load and speed. Textual and 2D data, however, demonstrate poor visibility in terms of location awareness, failing to provide satisfactory answers to inquiries on the detailed facility status. Furthermore, it is difficult to collect such data because each system provides its own database (DB) stream. In this study, a 3D terrain map was constructed based on high-resolution aerial photographs as well as a system architecture that displays buildings and facilities in 3D images. It is believed that the users can be given easy access to river information through the construction of a system that can obtain information on facilities by reconstructing the 3D terrain information on a web browser that

supports easy update and integrated management, and then mapping 3D buildings onto the constructed terrain.

2. 3D River Information System

The architecture of the 3D river information provision system constructed for this study can be subdivided into three phases. First, an engine that will be used in the 3D display system to display high-resolution aerial images based on geographic and facilities information was selected for the construction of the system. Then a web language to be published on web browsers was selected, and a DB list was linked from the integrated river database management system (DBMS). Finally, the customized information provision system was completed by estimating the demands of the consumers and segmenting these into several categories.

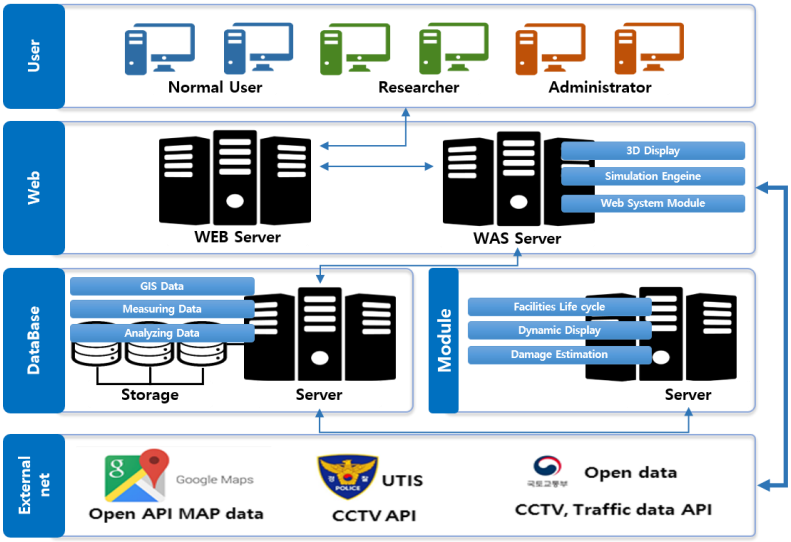

Figure 1. Architecture of the system.

2.1 Construction of a high-resolution 3D terrain information system

To construct the 3D terrain information system, the engine of the system first had to be selected. The criteria for engine selection include a high degree of freedom in customization, the provision of a powerful user library, and an uninterrupted rendering speed of high-capacity information, including high-resolution aerial images. After comparing several commercial GIS and 3D engines used in other fields, it was concluded that the 3D GIS expression method in the 3D engine would enable the more effective construction of a 3D terrain information system than the 3D representation method in the GIS engine. The Unity 3D engine (Table 1), which facilitates the construction of a new module with a high degree of freedom and supports customizing, library, and user experience, was selected.

Table 1. Comparative analysis of 3D engines

System	3D Support	Web Support	Inter-operability	Application Function	Remark
Esri ArcGIS	Supports 3Ds, ive, and many other formats	Can share web maps via its own server; supports IE, Chrome, and Safari	Interoperable with TMS GIS tools (existing 2D data can be used)	Supports the utilization of the internal API functions, the video-based real-time analysis function, and facilities management	No related content
OSGEO QGIS	Support 3D modeling and real-world representation	Supports 3D spatial information Web server upload using Plug-In	Data link through plug-ins that can be linked in Open Source Cloud environment	Supports the recreation of situations using the 3D virtual reality technology and simulation; supports the continuous processing of large-volume 3D spatial information	No related content

EGIS XD World Builder	Supports Java-based 3D representation	Supports web server connection through XD World Java; supports IE, Safari, Firefox, etc.	Supports real-time 3D web service in connection with the XD World web server (own web server)	Supports Web browser event handling and external DB linkage; basic analysis function	Based on XD World Builder; V-World production
V-World	Supports the 3D format and 3D building API	Supports Web publishing via Open API; supports IE and Chrome	Supports Web service in connection with various APIs in the open information platform	Supports the basic analysis function; external DB linkage	Can easily develop new services based on the V-World function (national open source data); government-wide utilization tools (Ministry of Land, Transport, and Maritime Affairs)
Unity 3D	Provides 3D web map publishing plug-in	Supports web services through Unity Web Player; supports IE, Chrome, and Firefox	Supports the development of various Unity 3D libraries and user experiences	Customizable system with high developer induction	Supports the building of new modules with high customer satisfaction based on a high degree of development freedom

When producing original high-resolution aerial images with the Unity 3D engine, the system's speed ratio to the capacity ratio may not be high because all the terrains and maps are called forth when moving the map and viewpoint. Therefore, the level of detail (LOD) technique, which changes the LOD of each image according to the zooming level or the number of revolutions of the wheel, has been introduced to solve this problem. This technique uses low-quality full images when the viewpoint is far above the ground, and then shifts to high-quality detailed images as it gets closer to the surface. In the GIS program, the rrd extension of the GeoTIFF and IMG formats can automatically generate the LOD of images and mount high-resolution images. As the Unity 3D engine cannot use an rrd extension, low- and high-quality images are separately stored in the DB server, and then images with varying details are called forth depending on the zooming level (Figure 2).

2.2 Construction of a responsive web system

To realize a 3D terrain information system via the HTML5-based web system, various web languages were surveyed and analyzed before the WebGL language was selected (Table 2). WebGL is Unity 3D's web-enabled language. Through the integration of these technologies, a system that satisfies the demands of stream information managers and of the general users by containing and displaying comprehensive 3D information on rivers on the web environment of various devices was constructed.

Table 2. Overview of web languages for web-based multi-dimensional presentation

Web language	Overview
WebGL	The OpenGL ES shading language can be used to access OpenGL 2.0 to display 3D graphics drawn on the web with a variety of platform APIs. It also works in harmony with other web contents in HTML documents, and allows one to write graphics in the Javascript language to enable the development of dynamic 3D web applications.
Java 3D	An object-oriented programming language, the Java compiler converts a program written in the Java language into a binary form called "byte code." It is not possible to call forth OpenGL API in the C language directly from Java. To use the OpenGL function, it is necessary to process the Java wrapper through a Java native interface (JNI) call. To take advantage of the object-oriented programming language, Java 3D enhances the characteristics of object-oriented programming and renders the use of OpenGL by representing 3D scenes as a collection of objects, and placing application logic and interaction inside the Java code.
JOGL Java (OpenGL)	JOGL is OpenGL-bound to Java and can access OpenGL and OpenGL ES, allowing applications written in Java to implement hardware-supported 3D graphics.

3. Conclusions

In this paper, ways of representing the information on city river facilities and various facilities around rivers on Unity 3D and the reactive HTML5-based system are described. The Unity 3D engine, which is customizable in relation to the construction of a three-dimensional (3D) terrain information system, was selected, and a system architecture for developing a hydrophilic information demonstration service was designed considering the users' demands to enable efficient disaster response through monitoring using the WebGL language, for the introduction of an HTML5-based responsive web portal for the 3D terrain information system. It is expected that the developed system can be used in the future as a quick decision-making tool applicable to river facility management by constructing a 3D geographic information system (GIS)-based system that is capable of analyzing various data on rivers from various angles.

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