A STUDY ON THE DEVELOPMENT OF THE URBAN WATERS FLOODING SIMULATION SYSTEM USING UNITY3D

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KEY WORDS: Risk Map, Disaster Information Providing, Dynamic Expression

ABSTRACT: Of urban natural disaster damage, the internal waters flooding brings on great damage on residential areas and big economic losses, so it should be promptly coped with. This study thus sought to develop the urban internal waters flooding simulation system using the open source-based Unity3D engine in order to promptly cope with the internal waters flooding thus minimizing damage. The target area was determined as Seoul where population is densely clustered with a huge number of facilities, and a virtual base map was constructed using the aerial images and DEM data. The internal waters flooding data consisted of coordinates and flooding depth. If the simulation function is implemented, a cube-shape 3D object will be created in each coordinate of data, and the material color value (RGBA) is applied according to the legend classified based on random criteria. And, the height value of the cube's Scale.z property is changed and visualized according to data flooding depth values. The urban internal waters flooding simulation system can identify the output in diverse angles and is intuitive, compared to the existing 2D output. The situation control tower, where the proposed system is applied, is expected to more accurately identify and cope with the internal waters flooding situation so as to provide support for efficient decision making.

1. INTRODUCTION

Although cities have developed rapidly and abruptly, flood control facilities have yet to be bolstered. Downtown areas are covered with asphalt and cement, forming an impervious huge area where water can hardly permeate. Of the total land of South Korea, about 8% is an impervious area, while cities have a 60% or more impervious area of the total area. In the case of rainfall, rainwater is drained in the direction of drains, or the earth has to absorb the rainwater. The impervious area does not gather the rainwater on its surface, but lets it pass by, thus causing flooding. Such flooding creates frequent flooding areas according to DEM and DSM, and makes it possible to forecast flooding according to rainfall. Thus, this study developed a system with various functions designed to identify the internal waters flooding according to the real-time rainfall in urban areas, to predict and visualize the flooding area according to the current rainfall, and to help decision making.

2. DESCRIPTION OF SYSTEM

The system was developed using Unity3D. The Unity3D was originally as a game engine which has nothing to do with GIS. The initial purpose of Unity3D was a tool designed to play games. So it could not import GIS coordinate systems and file formats(shp, tif, etc.) frequently used in GIS. However, it has been updated with various functions according to recent trends, and is strengthening its presence in the GIS area. The problems of coordinates and formats can be resolved through additional development of the engine, and the Unity3D has far better advantages for visualization compared to the existing GIS engines.

Table 1. Development environment

Category	Explanation
CPU	I7-6700 3.4Ghz
RAM	16GB
VGA	NVIDIA GTX 1060 6GB
Development Tool	Unity3D 2018.2.0f2, Visual Studio 2015
Program Language	C#

The development environment used for the development of the system is shown in Table 1. The main functions of the system are designed for visualization, so to facilitate the development and execution, graphic cards must be required.
In the urban internal waters flooding simulation system, Seoul, South Korea was selected the TestBed. Coordinates x, y and z of the relevant area DEM data were connected by mesh (Figure 1), upon which aerial images were mapped, so a 3-dimenstional base map was constructed (Figure 2). The coordinate system of GIS data was developed based on WGS 84. In Unity3D, WGS84 was used after being converted into a virtual coordinate which is used in the system according to certain ratios and rules.

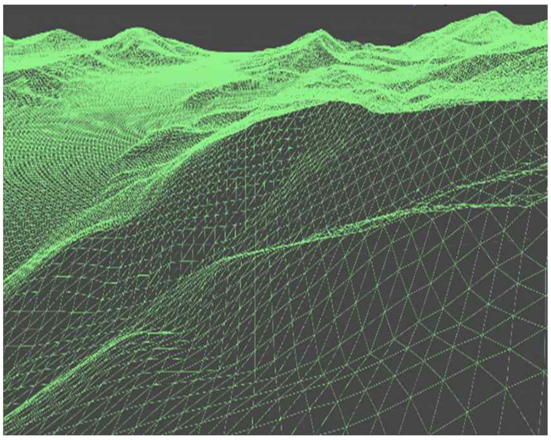

Figure 1. DEM connected by mesh

Figure 2. Aerial images were mapped on the mesh.

The data, which are used in the urban internal flooding simulation, is divided into the internal waters flooding data created according to real-time rainfall, and into the internal waters flooding prediction data calculated on the current rainfall, and the two types of data were provided from the outside and used.
The internal waters flooding data consist of txt-format coordinates and flooding depth values. The data quantity can become enormous according to the flooding scope, so coordinates without flooding depth value were treated as null, and they were excluded from the calculation data.
Cube-shape 3-dimensional figures are created according to flooding depth value, and the depth and color are designated.
A random legend was set up to study colors, and according to the criteria, each cube is determined compared to the flooding depth value. Figure 3 shows the portion set in the script and the relevant legend table.

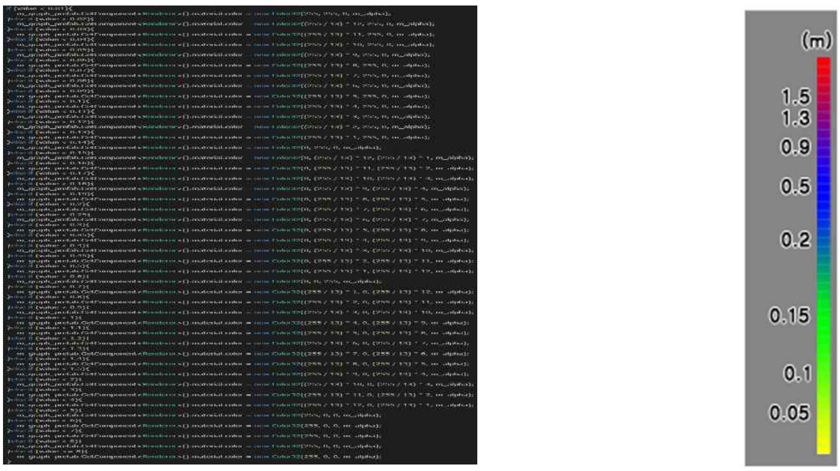

Figure 3. Color setting and legend table according to random criteria

If the data are expressed in Q-GIS based on the same data and legend which were used in the urban internal flooding simulation system, 2D symbols or icons are expressed as individual data(Figure 4).

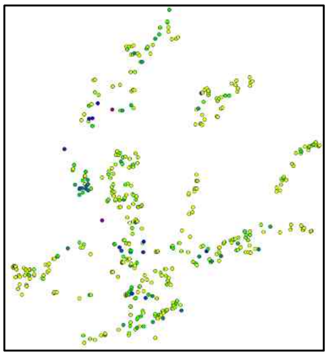

Figure 4. The screen created when opening the same data in Q-GIS

In the case of 2D visualized flooding depth data, the information of the initial flooding area and flooding progress direction cannot be known. The actual internal waters flooding spreads mostly from the great flooding depth to the surrounding areas. As such, if the data are rearranged according to the flooding depth value and are visualized, it will ensure a simulation with the effects of the internal waters flooding spreading in the system.

Simulation is conducted with the creation of one cube per line of the internal flooding data, and the cube position is set up based on x and y coordinates. The cube, deployed to the relevant position, sets up the height and color according to the flooding depth value as explained. If a great flooding depth is set up, it will read the DEM information of the relevant position and apply the flooding depth length based on DEM.

Transparent Shader was applied to the cube that is created to ensure a more effective expression of flooding depth value in the system. Transparent Shader applies transparency to objects. It can set up the most transparent 0 to opaque 255, and this study designated the transparency value as 130 in order to appropriately harmonize with the base map. Further, the directional light was designated so as to increase the visual immersion sense with the effects of shining light on the object. (Figure 5)

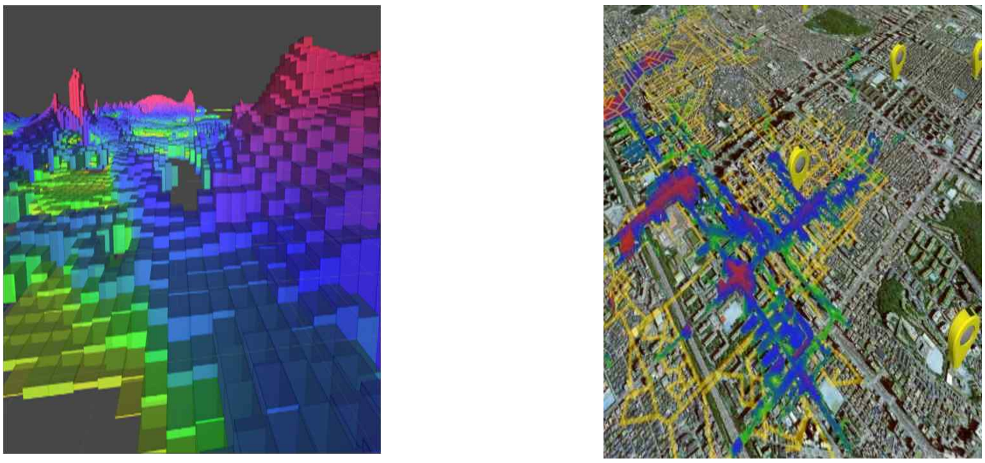

Figure 5. Internal waters flooding simulation function

Other functions developed in the system included the base-map mapping of administrative districts, road networks, the past flooding traces, and evacuation areas, etc. If the internal flooding simulation and the evacuation function are conducted simultaneously, the evacuation areas according to the residential areas are visualized simultaneously with the progress of simulation. This enables the quick identification of currently effective evacuation areas or provides the information of dangerous evacuation areas neighboring the flooding-damaged area.

3. CONCLUSION

This study developed the urban internal waters flooding simulation system which offers a 3D visualization of internal waters flooding data. The system thus has the advantage of offering an intuitive and diverse-angle view of the object compared to visualization using Q-GIS. It is expected that, in the case of internal waters flooding, the disaster situation control department can use the system to ensure a more efficient identification of the situation, and can use the evacuation area function of the system in reducing the human damage.

ACKNOWEDGEMENT: This work was supported by Korea Environment Industry & Technology Institute (KEITI) through Water Management Research Program, funded by Korea Ministry of Environment (MOE) (79627)

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