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GIS를 이용한 가상모의 소방훈련
Fire Drill on Virtual Reality Using GIS Technology

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요 약

GIS를 이용하여 소방훈련을 위한 가상 모의기법에 대한 방안을 개발하였으며 실제 연구대상지역(일본 나가사키)의 항공 사진을 토대로 계측된 계단, 공간상의 건물 고도 등을 도식화하여 3차원으로 구현하였다. 또한 IPT 기법을 이용한 실제 다중 음향의 구현과 함께 대상지역을 디지털 지도화하였다. 그 결과 이용자는 다양한 각도에서 가상현실을 체험할 수 있으며 또한 소방활동에 이용될 것이다.

ABSTRACT

The vitual reality technology to assist fire activities has been developed using Geographic Information Systems (GIS). For this, the 3D-geographic information of Nagasaki city, Japan was constructed from tracing the aerial photograph and adding the height information of measured buildings including stairs. And also, with large multi-plane stereo presentation equipment called Immersible Projection Technology (IPT), and the 3D-digital map was presented in actual scale of town. As the result, the observer could obtain three-dimensional information in the various angles as if we can gain our experience at first hand, it will help to assist fire activities.

Keywords : GIS, Fire activities, Virtual reality

1. Introduction

There are many steps and slope way in the Nagasaki City. It is said that about 70% of the Nagasaki municipal area is the hillside district. The population on this hillside region decreases and the aging advances. For the reason of the superscription, Nagasaki City is planning for the activation in this hillside region as a regional development policy. The study area of this paper, Tateyama district of Nagasaki City, is the hillside zone with steep steps and slope way.[1] The Nagasaki City has been holding meetings of community planning to discuss how to improve their living circumstances in local area (Tateyama region) since 1998. The investigation of stair zone is included in this community planning. The GIS technology has been utilized for this community planning of Tateyama district. Because, the GIS database becomes basic material of the activation countermeasure of hillside zone.[2,3] Especially, GIS database of steps and hillside way offer the information to local residents, it is very important for the welfare policy or disaster countermeasures. But details are at an early stage due to insufficient GIS database and technique. This paper describes the application of virtual reality to support fire affairs adding 3D image reproduction technology in IPT, including 3-dimensional information extraction for Database of the GIS on hillside district with steps. Some results of simulation using GIS technique will be presented and discussed. Constructed database can be applied to various fields included fire affairs by adding the GIS technology.

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Table 1. The situation of fire accident and its human loss

Assortment	No. of cases	Component ratio (%)	Deaths (Persons)	Component ratio (%)
Building fires	33,332	55.2	1,410	70.7
Vehicles fires	7,076	11.7	242	12.1
Forest fires	2,590	4.3	12	0.6
Vessel fires	132	0.2	2	0.1
Aircraft fires	10	0.0	0	0.0
Others	17,254	28.6	327	16.4
Total	60,394	100	1,993	100

Table 2. The age-specific human loss

By age	Depths (Persons)	Component ratio (%)
Below 5	40	2.0
6~below 64	1,093	54.8
Over 65	847	42.5
Others	13	0.7
Total	1,993	100

2. Necessity of GIS for Fire Activities

2.1 Aging Society and GIS

In 2004, 60,394 fires were recorded with 1,993 deaths in Japan. Among them, building fires account for 55.2 percent of all fire accidents as shown in Table 1. As shown in Table 2 it is noteworthy that 42.5 percent of victims are over 65-year old.[4] Aging issue is at the top of both current and future agenda of the world. Things seem to be unusual in Korea. According to the Ministry of Health and Welfare and the National Statistical Office, Korea is expected to become the "Super-Aged Society" with the aged over 65 occupying 20% out of the total population in 2025. As a result, Korea becomes the one of the countries that experiences the acceleration of the population aging in the world. The aged have a large possibility of victimizing caused by fire accidents. If it makes rapid progress, the component ratio of the aged in fire accident will be on increase. The importance of GIS became clear in the course of discussion for aging society. GIS technology make possible to grasp obstacles like stairs and distribution of the aged, it will support to reach a destination quickly. And also various kinds of information like a crime-ridden district will be inputted, GIS can be applied in the field of prevention of crimes by integrated management system.

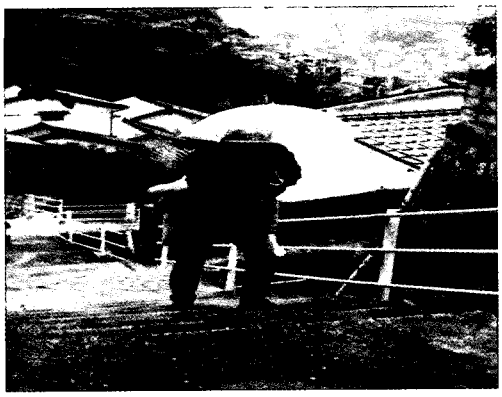

Fig. 1. View sight of stairs in study area.

Fig. 2. Fire drill on hillside of study area.

2.2 The Research Area and Present State of the Townscape Simulation in Japan

The Tateyama district of Isahaya City is chosen for this study, which is a typical hillside town as shown in Fig. 1-2. The Tateyama district is characterized by

small flat land and many steep stairs. The hillside district of the Isahaya City was formed in the high growth period after the 1960's. But the district was weeded out not only in industrial development, but also the movement of motorization in 1980's.

This resulted in a decrease of the young generation, hollowing of the population, and aging advanced on the hillside area. In the Isahaya city, virtual reality simulation using GIS technology was adopted to activate regional economy revival, and to improve social welfare system. In this study, for the superscription, Tateyama district of the Isahaya City was digitized on the map of the 1/2500 scale. 3-D image of the Tateyama district was made using the digital map, and the feature of the building reappeared in the 3D image. Finally, the townscape simulation was carried out on IPT for the Tateyama district. Until now, it is the mainstream that the simulation makes a landscape model of the object area in respect of the townscape. For a landscape simulation of good accuracy, the building feature is stuck in the model. The partial correction is difficult for this model, and it is easy to deteriorate, and permanent preservation is not possible. In such work, this model requires an extremely large cost and work period. It is also simple to correct the model, if this is realized on the computer, then permanent preservation is also possible. The simulation is always possible when necessary. For the Tateyama district in Isahaya, the computer simulation model (the GIS database) was made, and this model was carried out in virtual reality expression equipment (IPT).

3. The GIS Data Improvement

3.1 Fundamental Works for Stairs on Hillside

As mentioned above part, there are many stairs in study area. Fig. 3 presents real stairs in Tateyama district made by Macro language program as the first step for virtual reality. According to the experience, the matching work time of PhotoModeler Pro[5,6] occupies 80%. If the program of this study will be utilized, the workload can be reduced by about 80% with good accuracy. Future problem is to keep 100% hitting ratio without the target. Contrivance of the photographing is necessary in order to raise the hitting ratio. The contrivance of the target arrangement is also one of the future problems. GIS technique has been applied in broad field to obtain spatial information. Therefore, it has been neglected to extract information in limited area. Our experiments supported GIS have a characteristics to reappear real world in narrow area, our efforts would help the drill of fire activities and many kinds of welfare having many hillside areas.

3.2 The GIS Data for Virtual Reality

There are many kinds of GIS data in Japan. Presently, the Japan National Land Agency has released 8 types of digital information data such as; special district,

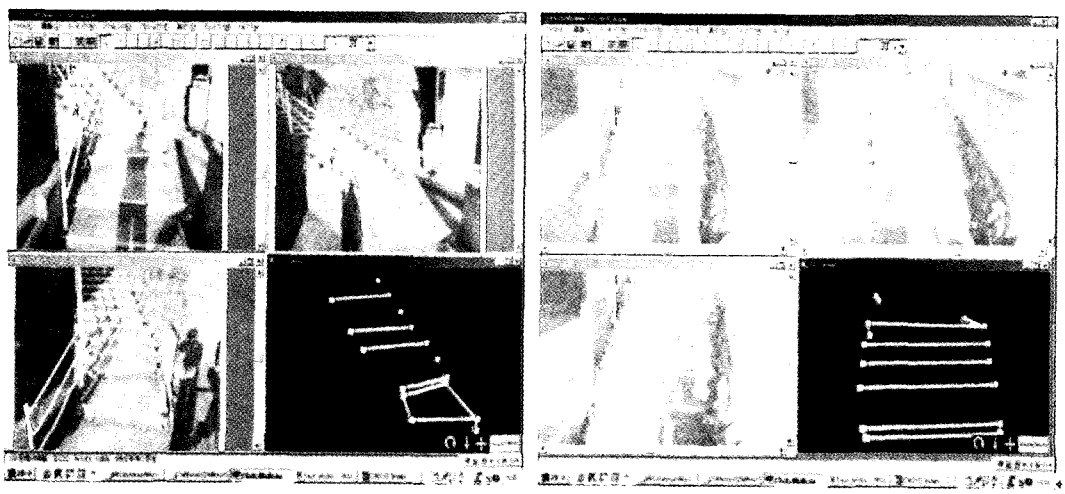

Fig. 3. Results of fieldwork for Tateyama district.

costal area, nature, land use, national land structure, facilities, industrial statistics, and hydraulics, etc. Also the Geographical Survey Institute has released 13 types of digital information data; including a 2500 scale digital map, a 50 meter elevation mesh map, and some kinds of CD-ROM for the state of the nation, etc. Among the supported digital data, numerical map of 2500 (spatial databases) has the sufficient utilization accuracy as a GIS data. As Isahaya city doesn't have this data at present, August 2004, we made it from the city-planning map of the Tateyama district 2 sheets of 2500 scale; No 62 and No72.

3.2.1 Graphical Data

On the basis of the 2 sheets of the city planning map, a digital elevation model (DEM) of topographic data (point information measured with the contour line) was made. Spatial data includes various properties such as; the information of building, administration field zone, road and stair, railway and train route, and coastal line as layered information. Fig. 4 shows tracing work photograph. And, Fig. 5 shows the ended sheet of tracing work, respectively. From the city-planning map of 2 sheets, a digital elevation model (DEM) of topographic data (point information measured with the contour line) was made.

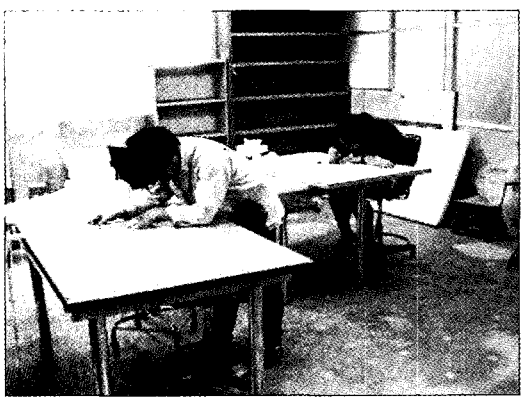

Fig. 4. Tracing work.

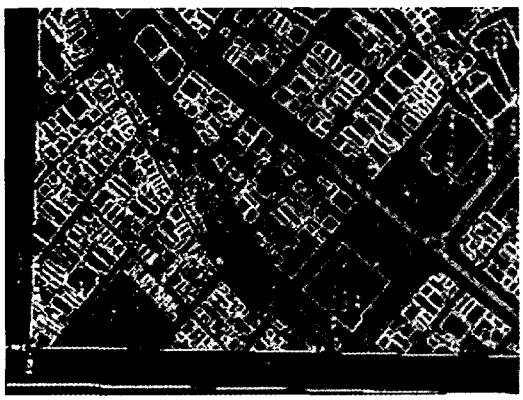

Fig. 5. Example of tracing work.

3.2.2 DEM Data

DEM Data of this study is the triangulation irregular network (TIN) model. TIN makes the triangle group arise from landform point placing in the random state, and it is a kind of DEM. The reason TIN was chosen for this study as a DEM model was that we want to use high accuracy DEM from the contour line and the measure points (total 760 points; 440 points for No. 62 and 320 points for No.72). The tracing work was carried out in this study at the 10 meters unit, even if the basic contour was a 2 meters unit. Vector data of the contour line was converted to line information and each line data contained the altitude information of the contour line as a property of information. The measured points arranged in the random state can be used to make TIN effectively. However, as there are insufficient surveyed data in the mountainous area, it is difficult to make detailed DEM. If we try to obtain TIN using contour, describing near the summit of a mountain is not so easy. In our study, the TIN of Tateyama district was made by two superimposed TIN, one is obtained from the contour lines of mountainous areas and the other is obtained from measurement point of the random state. Fig. 6 presents layered TIN made by point and contour. Fig. 7 shows extracted administration

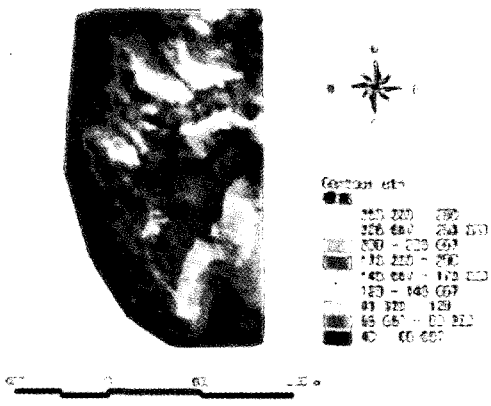

Fig. 6. TIN made by 10 m contours.

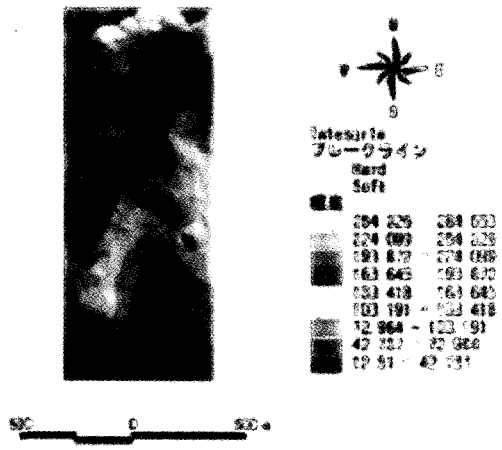

Fig. 7. Finished TIN in this study.

field zone from the Tateyama 1-chome to 5-chome.

3.2.3 Spatial data

In an administrative district, building and coastline information are inputted as polygon data. And also, road and stairs, railway and streetcar routes are inputted as line information. The completed special data including building and road for our study are shown in Fig. 8. As the property data of building, not only the information of stairs numbers and classification (for example; wooden structure, non-wooden structure, and concrete, etc.) were inputted, but also the information of nameplate and their use of building (classified into 22 types with a rank such as housing, store, public facilities) were inputted. Furthermore, idle land, agricultural area, parks, and planned roads, etc. are added as a layer information.

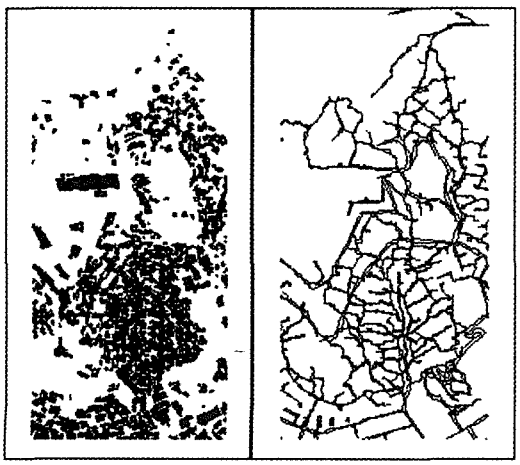

Fig. 8. Spatial data (building & road).

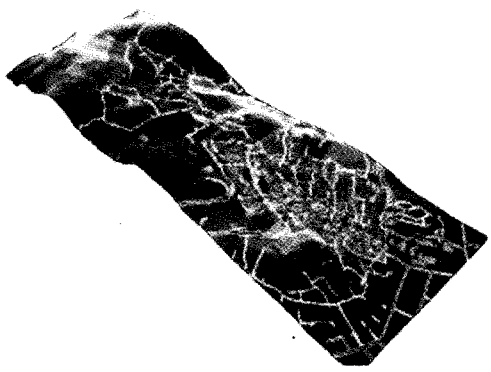

Fig. 9. VRML image of Tateyama region.

The 3D-preparation image was made to be Virtual Reality Modeling Language (VRML) format that could grasp the whole town. Fig. 9 shows 3D image that is converted as a VRML format. By adding the feature of "**town**" the image on IPT can be reproduced.

5. Simulation of Virtual Reality

Observers have a virtual world experience by Immersive Projection Technology, which is constituted of multi wide-screens and stereo system utilizing liquid-crystal-shutter or polarized plastic framed glasses. In this study to simulate urban views, we used IPT having front, both sides and floor screens. Graphics works were stored VRML files and projected them using performer library. Fig. 10 shows the simulation of the whole town. As original maps have cross-sections of buildings with height information only, all buildings seem like simple boxes. In order to make more reality, we will have to add roofs of Japanese houses and so on. Fig. 11(a-b)

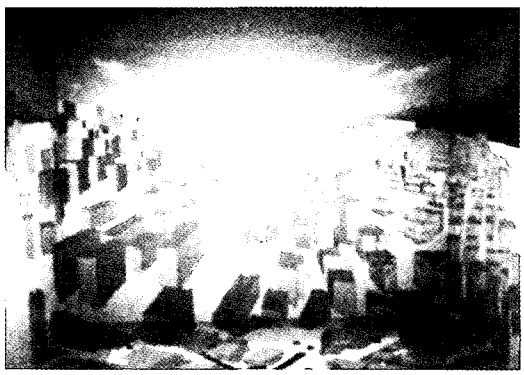

Fig. 10. Whole town in IPT.

(a)

Fig. 11. Various scale views from differenct angles (a).

(b)

Fig. 11. Various scale views from differenct angles (b).

Fig. 12. The aerial photograph of the Tateyama district.

shows different scale views. Observers can see the town from aerial view and enter the same scale town as a real world. Building's windows and entrances were obtained by texture mapping using digital photograph taken at the places. Moreover, the real feeling when seeing from the sky is directed by using an aerial photograph (see Fig. 12). The advantages of simulation using GIS in IPT are that observers can see the panoramic view through various angles and change scale size as if they are in the town. Furthermore, if we set a treadmill in the inside of IPT and the rotation speed of the belt synchronizes images, the observers experience a walking sensation in the town. In addition, our treadmill can change the slope of the belt, and then some sensation to ascend can be obtained too.

6. Concluding Remarks

A fire has broken out in anywhere. From the viewpoint of this, the simulation of urban views to support fire activities has been performed using computer technology step by step. Our experiments supported GIS in IPT have a characteristics to reappear real world, and the virtual experience will be useful for our welfare including fire activities. However, tracing work for digital map takes a lot of time and labor. If 3D information can be easily obtained from satellites in the future, unknown places will appear in IPT very soon. Recently, satellite (IKONOS) image with high resolution was released, and it may help for the application of these areas. The simulation of virtual reality would help the drill of fire works and many kinds of navigation having many hillside areas.

Acknowledgements

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Reference

1. B. Jun *et al.*, "Simulation of Virtual Reality to Improve Welfare Using GIS Technology with IPT", The Journal of GIS Association of Korea, Vol. 9, No. 4, pp.671-678(2001).
2. K. Sugiyama and B. Jun, "A Fundamental Proposal for Narrow Road Information System in Hillside Urban Districts by GIS Technology", the 2nd

International Symposium of Geo-spatial Information Science and Urban Planning in Japan, pp.10-14(2000).
3. K. Miyamoto *et al.*, "Study on Mayuyama Landslide in 1972, Hydraulic Engineering of Sustainable Water Resources Management at the Turn of Millennium", Proceedings of 28th IAHR Congress, CD-ROM(1999).
4. Fire and Disaster Management Agency of Japan, http://www.fdma.go.jp/
5. http://www.photomodeler.com
6. PhotoModeler Pro Online Manual of Version 4.0.