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Virtual Reality and Internet GIS for Highway Simulation Based on the ASE

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Abstract : This paper show that, without installation of expensive VR (Virtual Reality) program, the sharing information is possible through posting three-dimensional road structures on the web, and avoiding the conventional top-down decision making method, fast bottom-up communication is possible base on the Virtual GIS (Geographic Information System). In this paper, using Viewpoint Scene Builder, internet-based software, the transformation was conducted to give pertinent type for web posting. In order to use the completed route at the scene builder, the output with ASCIIExport is required, and ASE (ASCII Scene Export) contains the property information including the coordinate and frame of mesh vertex. Through in advance recognition of the problems regarding route design and petition due to environmental rights infringement, the time and cost due to design alteration can be reduced. It's difficult to provide VR based on the internet because file that embodied with internet GIS was complicated and its capacity comes to scores of mega-bites. But, this study provides VR with internet according to a basis by simplification of files.

Key Words : VR (Virtual Reality), internet GIS (Geographic Information System), property information, ASE (ASCII Scene Export).

1. Introduction

The advances of computer information and communication have provided an excellent data processing through internet. For that reason, the advances in the fields of three-dimensional graphic and geographic information system have become more visual through the establishment of Internet information infrastructure for last few years. In the area of design, the importance of three-dimensional drawing was not recognized because the previous design was focused on two-dimensional plane drawing. Therefore, using two-dimensional drawings, the visual effect for the design of structures could not be obtained, and in advance recognition of problems during the actual execution was difficult. Since the arisen problems during the actual occurrence are solved through the alteration of design at each situation, recently, the need of visible effect has been emphasized through the introduction of three-dimensional design from the beginning stage of design. Currently, in the advanced countries with well developed in machinery and aerospace industries, the three-dimensional design has been employed long

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time ago, and a consistent process, from design to production and fabrication, has achieved. However, in the field of highway design, the three-dimensional design was introduced recently, but the three-dimensional design was performed by computer graphic designer not actual coordinate design by civil engineer with only providing aesthetic function during bid or construction work.

Toshimitse Mukah (1999) investigated the virtual space (consisted of virtual city and roads) on the three dimensional computer graphics platform, using the vehicle model operated through a cockpit with a steering wheel, an accelerator and a brake pedal, and proposed the concept. Verbree E. *et al.* (1999) proposed a multi-view approach based on three types of visualization: plan view, model view and world view. The visualization in these views ranges from a topographic map, through a partly symbolic and simplified 3D representation to a full immersive and photo-realistic 3D display. The views can be used simultaneously or intermittently, and each provides a repertoire of interaction possibilities that are apt but not necessarily limited to that view. Verbree E. *et al.* are currently developing a 3D GIS (3 Dimension Geographic Information System) & VR (Virtual Reality) system (Karma VI) based on existing 3D GIS and VR technology that uses the three views to support the design, development and presentation of large infrastructure plans in The Netherlands.

Walter Di Carlo (1999) investigated the practical and fundamental data expression employing the three-dimensional expression method using remote sensing data. A.L. Belfore (2002) investigated an effective virtual reality system using the VRML (Virtual Reality Modeling Language) technology through real time update of the structures. Choi (2001) performed the research on the applicability of road driving simulation through the study of road design simulation using 3D GIS. Lee (2003) studied the establishment of cost model on optimum linearity satisfying the highway design criterion, and also developed the GIS modeling method for the highway linear optimization to find linearity for the maximum profit yield. National Computerization Agency in S. Korea researched on standardization for 3D GIS services for urban facility management.

The previous research was enough for the visual effect using geo-spatial information system for the road design and optimization, but the previous results only made possible for unidirectional route evaluation and static view evaluation through rendering time and selection of fixed camera orbit. Therefore, they contained several problems, e.g., offering various visual points like user at the scene, expressing some limitations regarding road design, the rendering time, etc. It's difficult to provide VR based on the internet because file that embodied with 3D GIS was complicated and its capacity comes to scores of mega-bites. But, this study provides VR with internet according to a basis by simplification of files.

In order to solve the above problems, in this paper, using virtual reality technology based on the web through the three-dimensional road design, the main objectives are to search the problems real-time basis on the web during design and construction work periods after establishing the user-based Virtual GIS, to find the problems during decision-making and design/construction work periods, and to provide an effective decision-making method between petitioner and user.

2. Virtual GIS & Web

In general, Virtual GIS is based on the application of techniques from the convergent fields of: computer graphics; image processing; computer vision; computer-aided design, signal processing, and user interface design studies. High-end virtual GIS require

Table 1. Properties of the Plan view, Model view and World view.

Model	Visualization	Navigation	Selection	Manipulation	Analysis
Plan view (2D)					
2D geometry Attribute values	cartographic	pan and zoom specify position	pointing query distance	create remove translate rotate	buffer overlay network proximity
Model view (2½D)					
2D geometry Extrusion by attribute values Multi-TIN surfaces	extruded 2D geometry cartographic (3D)	view-point center of interest zoom fly to	pointing query relation	translate rotate scale define relations	line-of- sight volumes proximity (3D)
World view (3D)					
3D CAD	realistic	walk-through virtual guide	pointing	scenarios	sound sight shadow

a significant investment in high performance graphics hardware and supporting virtual reality gear. Recent developments on the world wide web provide a less expensive alternative for Virtual GIS systems. Navigation is implemented through scrolling, panning and zooming or through browsing exploring hypertext links. In the 'model-view' relations, constraints, layers and other hierarchical and grouping structures will have to support manipulation and interaction. View point changes and navigation will be steered by real head movements of the user. In the web, navigation will be moving the virtual eye point through the 3D scene. Selection will be done by pointing. Table 1 summaries the properties for each of the views.

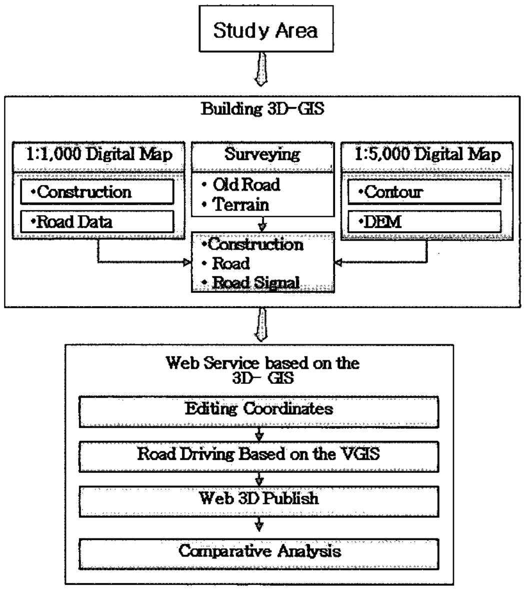


Fig. 1. This conceptual diagram identifies web service Based on 3D GIS.

3. How to Construct GIS Data

1) Study Area

Fig. 1 shows that conceptual diagram identifies web service Based on Virtual GIS in this paper. The studied area for this paper was a road route which is under construction located in South Kyungsang province, S. Korea, and the area was a combined section of road and bridge with the total area of 15.1 ㎢ and the route length of 2.9 km. The TM coordinates of starting and finish points in the route were N: 168,036.902, E: 172,811.690 and N: 168,775.082, E: 175,516.500, respectively. Fig. 2 presents the topographic map 1:1,000 of area for this study.

2) The DEM Generation

In order to establish Virtual GIS data with vectorizing of

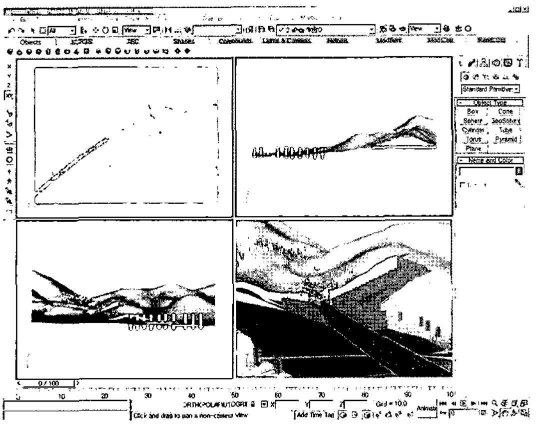


Fig. 2. Topographic map of S. Kyungsang province, Korea.

actual topography, a process producing TIN (Triangulated Irregular Network) by the altitude of the studied area for this study was required. In this study, the vertex coordinate was extracted through the contour line of topographic map, and the shape of topography was identified by shaded relief image. Although the TIN showed more precise presentation on linear configuration like valley, road, river, etc. as compared with DEM(Digital Elevation Model), the grid method was employed for the need of fast data processing since the main objective of this study is to embody Internet-based simulation.

Figures 3 and 4 show triangular irregular network and digital elevation model about two types of topography in the studied area respectively.

Fig. 3. Triangular irregular network of study area.

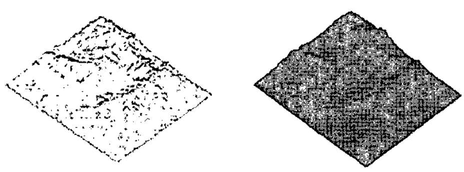


Fig. 4. Visualization of a digital elevation model of study area.

3) Three-Dimension Drawing Highways and Facilities

After selection of the route for offering the road simulation using Virtual GIS, the classification procedure for suitable section is needed. Then, the cross-sectional drawing was completed with each section, and the route was expressed three-dimensionally with determination of cut/fill section of the route. The three-dimensional drawing was shown on the topographic map with 1:1,000 scales. All facilities were installed based on the center line of route. When 20 m gap surveying station is used, which is installed on the conventional road, the solidity of road at the curve area is diminished. Therefore, for the polygon of route, the computer automatic extraction method was used for this study, not the interval by section with the consideration of ups and downs of curve. Also, based on route center, the shape of polygon was extracted according to the width of road, the number of polygon decreases, and the shape of curve section was shown ideally. In this case, the total numbers of polygon for the route topography representation was 81,096, which is a quite big value. However, for the optimal simulation effect, the duration time of the frame and rendering time were measured using the topography of 20 m grid.

Figure 5 shows the rendering image prior to providing texture of DEM for the studied area. For subsidiary facilities, road signs, street lights, protection facilities, etc. were set up according to 'Guideline for the installation and management of road safety facility in Korean criterion (2002)'.

Figure 6 shows the subsidiary facilities showing the installation location of all sorts of subsidiary facilities, and also shows a plane and three-dimensional drawings. The subsidiary facilities including safety sign was made using low polygon. The structures installed for the establishment of road

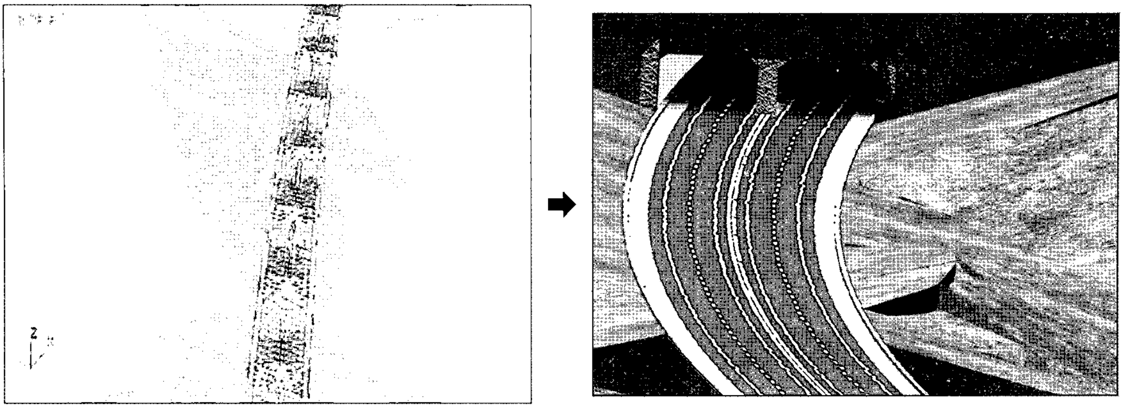


Fig. 5. A view of the simplified 3D model of study area.

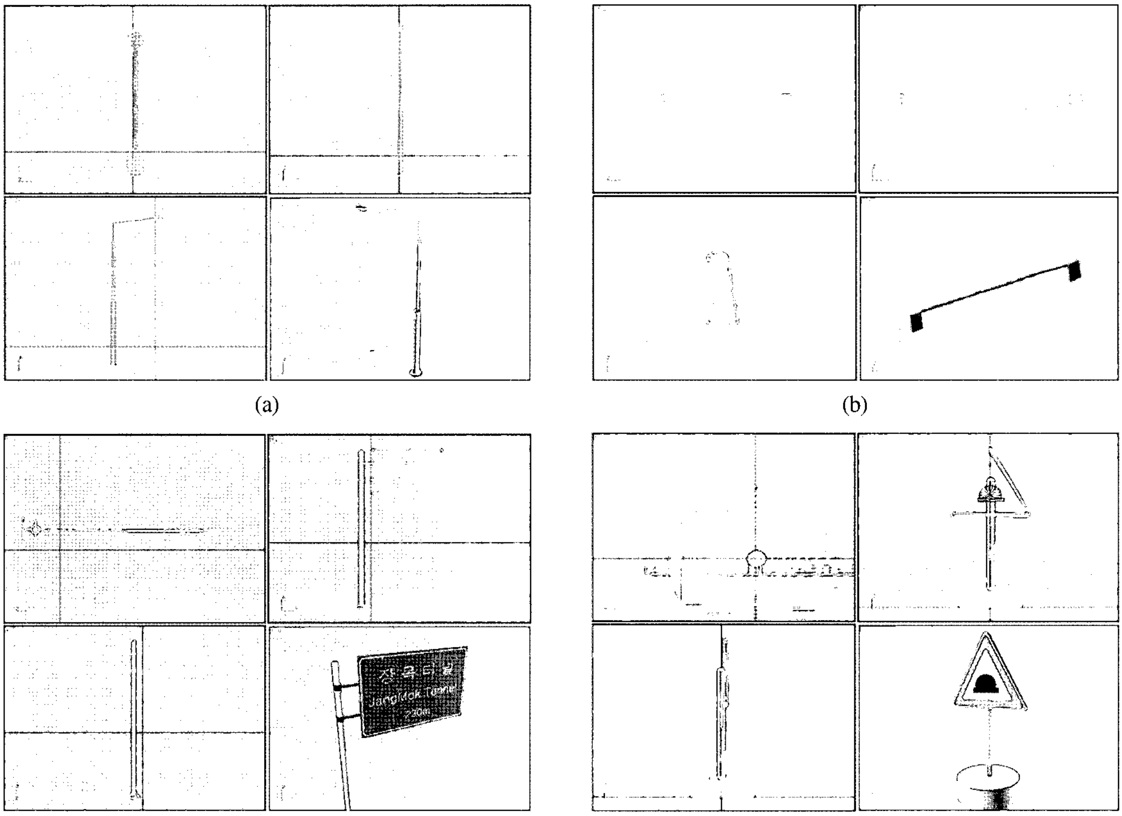


Fig. 6. Three-dimensional drawings of the subsidiary facilities showing the installation location of all sorts of subsidiary facilities, and also shows a plane: (a) road lamp, (b) guard rail, (c) sign board & (d) road sign.

design simulation of Virtual GIS were provided texture through the texture mapping. For the conventional three-dimensional design, since the road was expressed with only polyline, it was difficult to provide the visualization of evaluation or road driving. However, in this study, the visual effect was

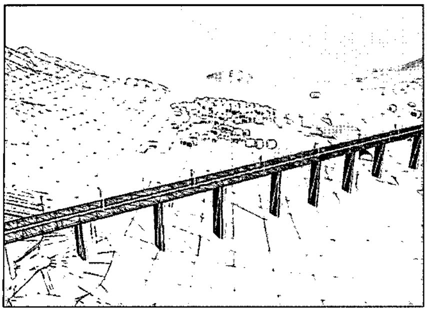
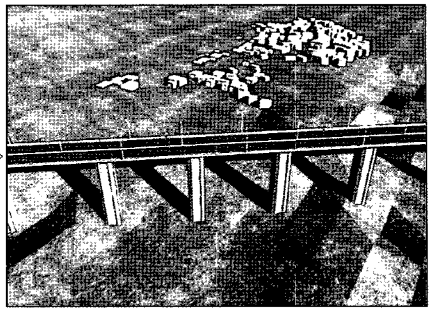



Fig. 7. The rendering scene after texture mapping.

induced through providing texture to the objects using the Autodesk VIZ. Especially, for VIZ, the ASCII Scene Export type file can be produced, and provides the interim stage of future Scene Builder structure file generation source, later on. Since the investigated area was consisted in the combination of roads and bridges between hills, grass and soil map was used for mountains, and the topographic map was used for road with concrete and asphalt materials. Figure 7 presents the rendering scene of three-dimensional road structures prior to providing pertinent materials and exhibits the rendering scene after texture mapping.

4) Transformation ASE

Over the past years, VRML has been the main standard for representing 3D content on the web (Huang, B 2003). It provides a versatile platform for a variety of applications that uses 3D as a central metaphor or interface. One of the strengths of VRML is its tight integration with a variety of other web technologies and its ease of incorporating the benefits of those technologies, from graphic, audio, and video formats to scripting languages and network protocols.

In this paper, using Viewpoint Scene Builder, Internet-based software, the transformation was conducted to give pertinent type for web posting. Viewpoint Scene Builder is an essential Viewpoint application for assembling a scene and publishing it in.html/.mtx/.mts format (www.viewpoint.com). In order to use the completed route at the scene builder, the output with ASCIIExport is required, and ASE (ASCII Scene Export) contains the property information including the coordinate and frame of mesh vertex. For example the following is the file transformed into ASE

```
* MATERIAL_LIST {
* MATERIAL_COUNT 5
* MATERIAL 0 {
* MATERIAL_NAME "02 - Default"
* MATERIAL_CLASS "Standard"
* MATERIAL_AMBIENT 0.5882
* MATERIAL_DIFFUSE 0.5882.5882
* MATERIAL_SPECULAR 0.9000
* MATERIAL_SHINE 0.1000
* MATERIAL_SHINESTRENGTH 0.0000
* MATERIAL_TRANSPARENCY 0.0000
* MATERIAL_WIRESIZE 1.0000
* MATERIAL_SHADING Blinn
* MATERIAL_XP_FALLOFF 0.0000
* MATERIAL_SELFILLUM 0.0000
* MATERIAL_FALLOFF In
* MATERIAL_XP_TYPE Filter}
```

The script command is controlled by the file transformed into ASE type through the Viewpoint Scene Builder. The file with VET is roughly classified into three types, such as mtx file for the

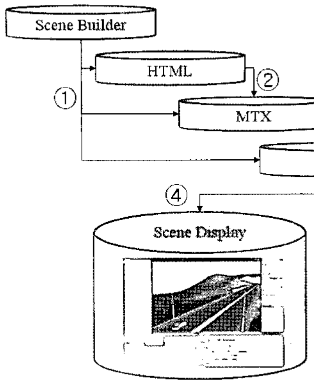


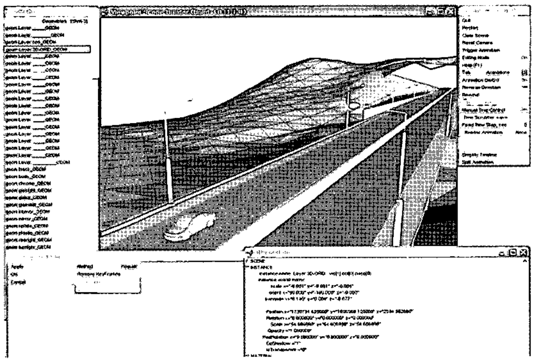
Fig. 8. The file structure of VET.

control of XML (Extensible Markup Language) type scene, mts file showing scene itself, and HTML (Hypertext Markup Language) document. Especially, the mts file plays a role as compiled document, and the coordinate of object and scene effect can be controlled through XML tag in mtx file without modification of data.

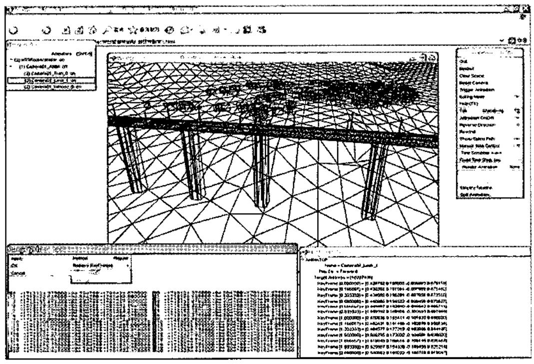
Figure 8 shows the file structure of VET, and first of all, after the formation of HTML, mtx, and mts structure files by the embodiment of VET, the simulation is embodied by the designation of mtx file type through HTML and the visualization of data by scene control through XML tag. Since the main objectives of this study were to make decision through visual analysis of structure with the embodiment of internet-based simulation, the research was mainly focused on the XML tag by the movement of a visual point of coordinate.

Figure 9 presents the data information of object using scene builder, and the process is a basic frame work for the use of XML tag. Figure 8(a) shows the object hierarchy scene, and presents the necessary information of coordinate, scale, etc. of selected object. Figure 8(b) shows the wire frame scene.

Figure 10 presents the coordinate control window for the control of scene movement by the key frame value. After input of shifting coordinate of a camera or object, it is possible for the animation of the object or the shift to selected visual point on the web. The input and modification of coordinate and key value are verified through the view, and it is an effective way to animate. It is possible to renew through the modification of mtx/xml files. Using final stage XML



(a)



(b)

Fig. 9. Control view of object using scene builder, and the process is a basic frame work for the use of XML tag : (a) Hierarchy view (b) Wire frame view.

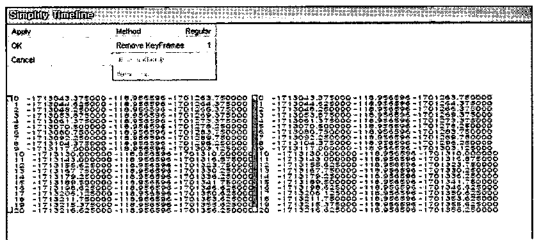


Fig. 10. Timeline keyframe.

tag command of web posting type, it is possible to provide the visual point by the posting type of drawn up structures and clear coordinate input. An example XML script about location information including the visual point movement method of user, texture, and scale is as follows:

```
<Scale x="0.02567"y="0.02567"z="0.02567" />
<Position x="-1731.77551"y="-0.09228"
        z="-1719.71838" />
</Transform>
</MTSSceneParms>
<MTSCamera Mode="Walk"OrbitDist="1.49">
<Rotate x="25.21015"y="87.0896"z="0" />
<Scale x="11"y="11"z="11" />
<ViewLocation x="0.60837"y="-0.0577"z="-0.20795" />
<LookAt x="25.21015"y="158.70927"z="0" />
</MTSCamera>
<MTSInstance Name="6" >
<Transform>
<Scale x="-1"y="-1"z="-1" />
<Rotate x="90.00001"y="-180"z="-0.00001" />
```

5) 3D Visualization Publishing by the Web Posting

Figure 11 illustrates a final scene using Scene Builder at the web posting step. The same composition like posting on the web can be verified at the completed scene. In this paper, the results only were posted on the web using the IIS (Internet Information Services) of Windows 2003 Standard Server, and posted through language incoding with Unicode Transformation Format-8. Since the results in this study was required 1.5 MB through the comfile of scene file, the speed problem due to initial activation was solved.

Figure 12 shows the scene of web posting result, and the camera coordinate fixed at mtx/xml or the animation of object can be controlled with the button on the web. Figure 12(a) is used for the animation by fixed coordinate or visual point shift, and Figure 12(b) the visual point can be shifted by simple mouse operation. Especially, for the case of VRML, approximately 30 to 40 MB is needed for the same effect, while the results in this study only need 1.5 MB through the comfier of scene file. Therefore, the speed problem due to initial activation can be solved by the results provided in this study.

Fig. 13 to 15 show the scenes offering the visual point change by each mode. Except the animation by fixed coordinate or the visual point shift, the visual point can be shifted through simple mouse operation on the scene. Furthermore, it can be used by the

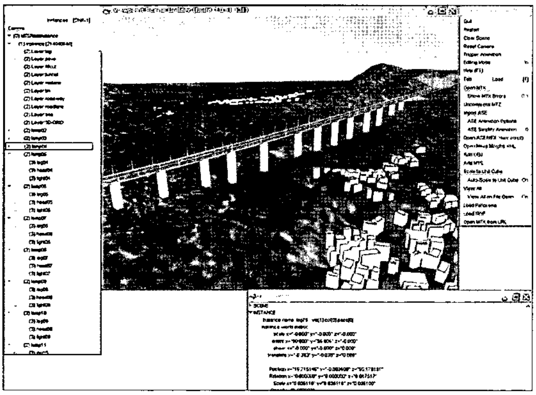


Fig. 11. Windows of the scene builder at the web posting step.

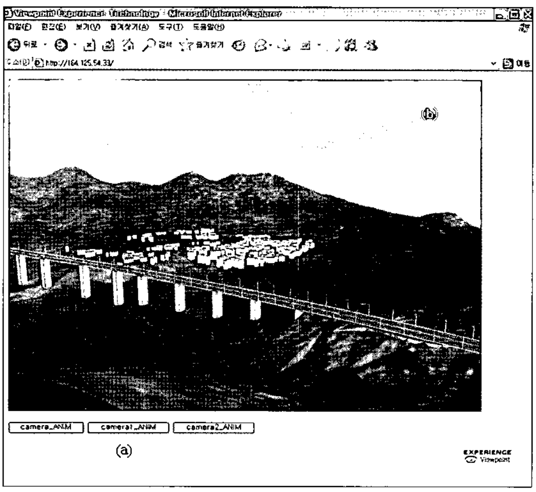


Fig. 12. The scene of web posting result.

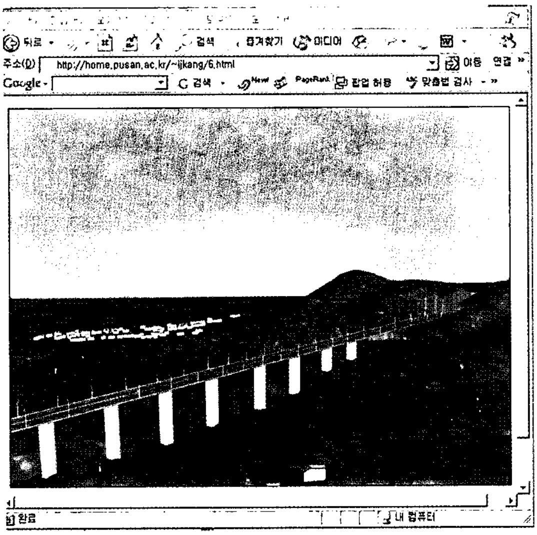


Fig. 13. The windows of the orbit mode.

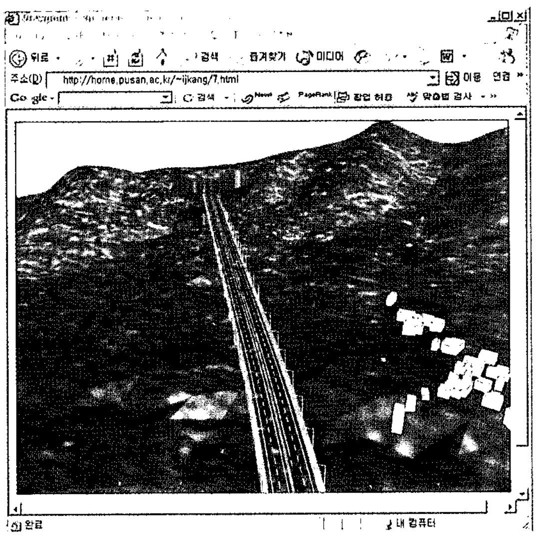


Fig. 14. The windows of the work mode.

allotment of information to each object.

4. Considerations

This paper show that, without installation of expensive VR program, the sharing information is possible through posting three-dimensional road

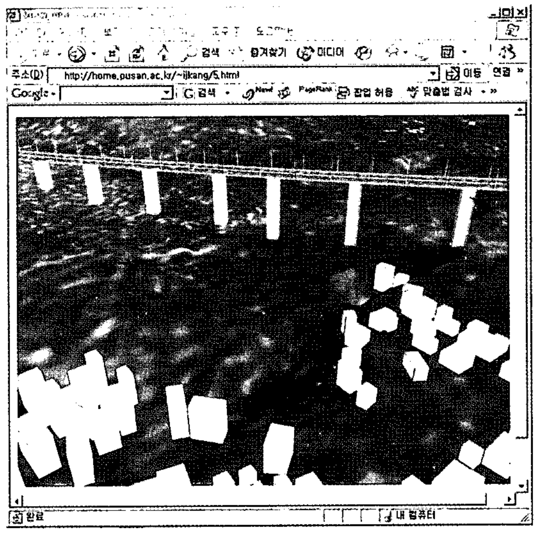


Fig. 15. The windows of the panorama mode.

structures on the web, and avoiding the conventional top-down decision making method, fast bottom-up communication is possible base on the Virtual GIS. Since through the results in this paper, the Internet-based preliminary installation of subsidiary facilities can be reviewed, many advantages can be provided for the review of effectiveness regarding the effective installation location by operator's visibility and the visual-spatial understanding of gaze inducement facility by vehicle approach location.

We measured the running example porting a rendering time of polygon by TIN and GRID type with the comparison between the results in this paper and three-dimensional illustration program in terms of the capacity with frame per second. Tests were performed on a PC cluster with dual PCs (2.8 GHz) connected through a Gigabit Ethernet network. Each machine was equipped with a Soft Quadro FX 3000 graphics card and 1,024Mb rams.

The total numbers of polygon for the route topography representation was 81,096, which is a quite big value. However, for the optimal simulation effect, the duration time of the frame and rendering time were measured using the topography of 20 m grid. The rendering time was measured based on the average of rendering time from 100 frames with different images, and the duration time of the frame was obtained by the determination of maximum and minimum frame during the rotation through visual point shift. The results were applied to three-dimensional simulation with the consideration of effective types. In general, large grid gap provides high effectiveness of data processing due to decreases in the number of polygon, but it presents different images as compared with the original topography. In this study, the grid of 20 m×20 m was used in the consideration of visual effect.

Table 2 presents the rendering time of polygon by TIN and GRID type. At the scene render time, The TIN is 7sec and the GRID is 5sec, but not much difference has been found between the taken rendering time per frame and the average duration time of the frame. Two types of the frame per second was not a difference.

Table 3 presents the comparison between the results in this paper and three-dimensional illustration program in terms of the capacity and frame per second. In these results, the file capacity used for the texture mapping was excluded, and only the size of pure scene file was considered. Since the capacity for web posting decreased by one sixth as compared with conventional VRML, the delay time due to loading decreased. In terms of frame, the duration time of the frame of more than over 10 frames was shown. The things need to be improved during the research on the development of road simulation system using Internet-based Virtual GIS are as follows. The real-time view or route evaluation, which can be generated before construction, is needed visually on the Internet, then, through the evaluation, the public opinions of user including local residents, the former designer, and evaluation expert group can be collected, and mutual agreement on decision can be drawn in a short time. Moreover, since XML command can be used, it is possible to provide user convenience through the convenient understanding of data structure and data connection. Also, for the active evaluation on the web, the precedence of three-dimensional structure system should be required from the early stage of design of road including structures.

Table 2. Rendering time of polygon by TIN and GRID type.

	TIN	GRID (20m)
Polygon coverage	81,096	19,728
Scene Render time	7sec	5sec
Frame per Second	15~60	15~60

Table 3. Results in this prepare three-dimensional illustration program in terms of the capacity and frame per second.

	Web	VRLM	3Ds Max
Capacity(Mb)	2.74	17	14.8
FPS	Over 10	Over 10	32

5. Conclusions

The current research on the Internet offering based on the establishment of three-dimensional road simulation using Virtual GIS leads the following conclusions.

Without installation of expensive VR program, the sharing information is possible through posting three-dimensional road structures on the web, and avoiding the conventional top-down decision making method, fast bottom-up communication is possible. Through in advance recognition of the problems regarding route design and petition due to environmental rights infringement, the time and cost due to design alteration can be reduced. The file capacity decreased eminently as compared with conventional three-dimensional web posting program, and it is easy to use through the easiness of modification and renewal of data. Moreover, since XML command can be used, it is possible to provide user convenience through the convenient understanding of data structure and data connection.

From the route plan and design to simulation evaluation, visual and three-dimensional plan is possible through the computerization of all processes, and the suitability of design alteration can be displayed. If the completed state, by three-dimensional road driving and view evaluation, could be established on the web-based, the objective review could be possible in terms of the suitability evaluation of environmental analysis on the basis of this paper. The novelty in this paper appear th be the use of ASE to control camera viewpoint and web posting to share data. When we makes efficient use of the remote sensing data for road design as well as estimation, virtual reality will be used to more its description.

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