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## Constructing Real-Time Terrain Model for Flight Simulation

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### ABSTRACT

A flight simulator has different points to be considered compared to a driving simulator, because the operator can be located at any position of the virtual world. Especially, a helicopter moves more freely than a plane. We need more considerations and it is more difficult to visualize the terrain and scene of the virtual world for a helicopter VR simulator. This paper introduces a method for constructing real-time terrain models for the VR simulator of a light helicopter, and introduces the problems and research issues that are found in this process.

**Key Words : Virtual Reality, VR Simulator, Terrain modeling, Real-time rendering**

1. 가,  
1.1 가, [2].  
3 가 가 가 가 가 가 가 [3].  
law) 가 가 (Moore's [1]. 가 가 /  
가 가 3 가 가 가 가 70% 가 [4].  
1990 가 가 가 가 가 가 가 가 [5].  
가 가 , , , Level of Detail,

[5][6].  
 global view local view  
 가 , 가  
 가 , 가  
 가  
 1.2 가 가  
 ( KAIST) 가 KAIST  
 가 가  
 2. 가  
 가 가  
 (I) (Base Terrain) , (II)  
 가 (III)  
 가  
 가 [3][5].  
 가 (1)  
 가 , (2)  
 가 , (2)  
 가 , (3)  
 가 , (4) 3  
 (5) 가  
 가

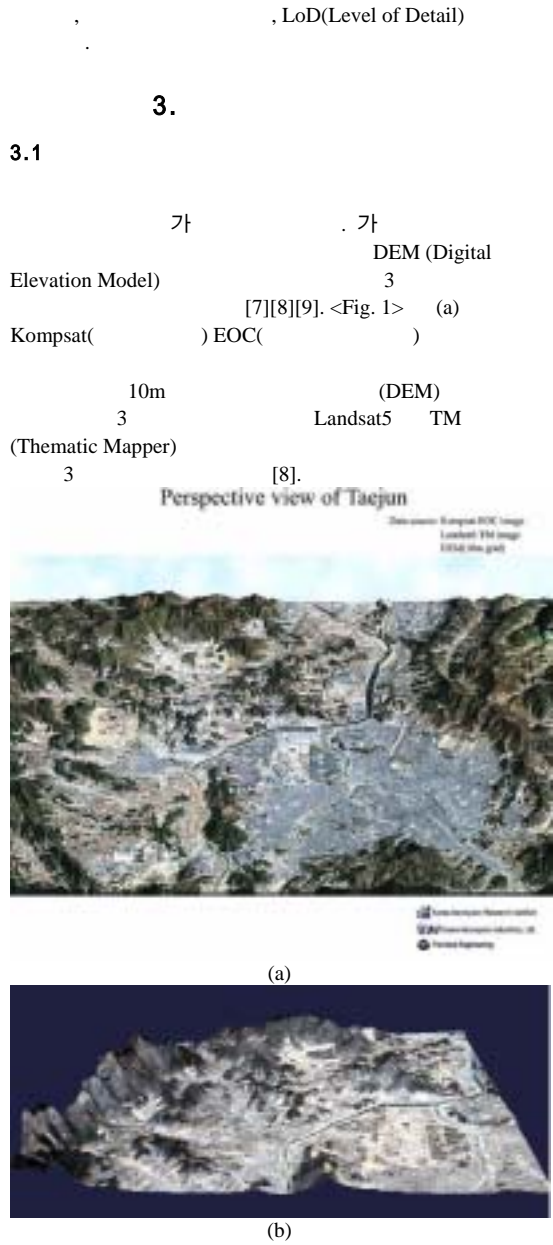


Fig. 1 (a) (b) 3 VRML [9].

3

DEM  
 가  
 DEM  
 GIS(Geographic Information System) 3

3.2 : NGIS

(digital) [10],  
 DEM 가  
 m  
 (1:5000 ) [11] 5m  
 1m  
 DEM  
 3  
 NGIS( 가 ) [10]  
 NGIS 가  
 1:1000 1:5000  
 1:5000 .<Fig. 2>



Fig. 2 NGIS 1:5000

2.2km 가  
 2.7km  
 DXF  
 9 <Fig. 3>



Fig. 3 KAIST

3.3 Preprocessing

NGIS <Table 1> [12]. 3  
 7  
 가 7 <Table 2>  
 DXF  
 AutoCAD 2002 7110 7124

|   |  |
|---|--|
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |

Table 1 NGIS

|      |  |
|------|--|
| 7    |  |
| 71   |  |
| 711  |  |
| 7110 |  |
| 7111 |  |
| 7112 |  |
| 7113 |  |
| 7114 |  |
| 712  |  |
| 7120 |  |
| 7121 |  |
| 7122 |  |
| 7123 |  |
| 7124 |  |

Table 2 NGIS

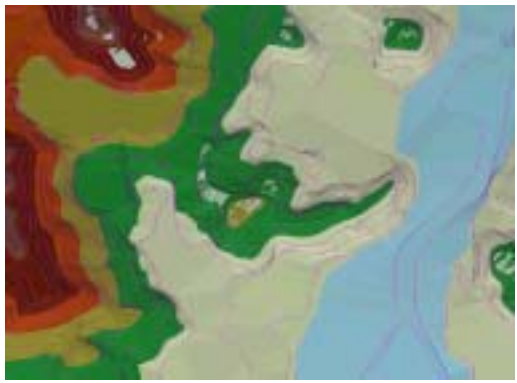
### 3.4 TIN

DXF 3 Polyline  
 가 3  
 3 가 3  
 DEM X Y Z Grid 2 Z  
 ENVI[13], DXF2DEM  
 TIN(Triangulated Irregular Networks)  
 DEM  
 가  
 Polyline TIN  
 TIN [14]  
 ESRI ArcGIS[15] DXF  
 Polyline TIN

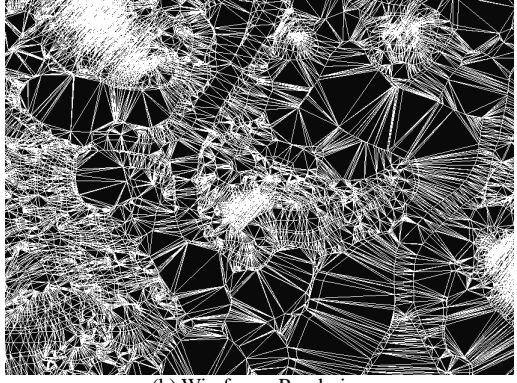
### 3.5 Optimization

### 2002 CAD/CAM

TIN  
 가 1:5000 1m  
 1 (2.2km x 2.7km) 10 가  
 TIN 가



(a) Surface Rendering



(b) Wireframe Rendering

Fig. 4 TIN VRML

<Fig. 4> (a) TIN 3  
 VRML 가  
 <Fig. 4> (b)  
 가  
 2.2km x 2.7km x 130m(1 )  
 VRML 130k  
 triangles, 88k vertices  
 (18.9k faces, 22.4k  
 vertices) (3.5k faces)

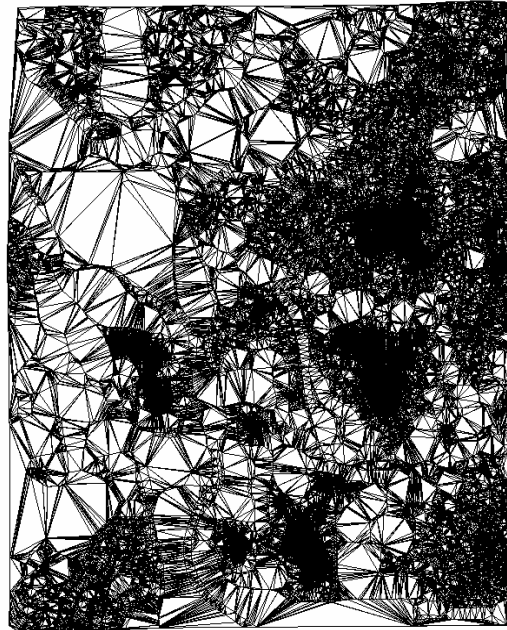
VRML 1 가  
 25MB, 9 가 125MB  
 VRML Parallel Graphics Internet  
 model optimizer, Vertex concatenation  
 radius Preprocessing Crease angle  
 Optimization Crease angle  
 가 <Table 3>  
 <Fig. 5> (a)  
 VRML, <Fig. 5> (b) 1/10  
 VRML

|                    |        |       |       |       |
|--------------------|--------|-------|-------|-------|
| Optimization Ratio | 0      | 0.5   | 0.7   | 0.9   |
| Shape              | 10     | 10    | 10    | 10    |
| Triangles          | 130194 | 65097 | 39058 | 13019 |
| Vertices           | 88670  | 39743 | 23501 | 8137  |

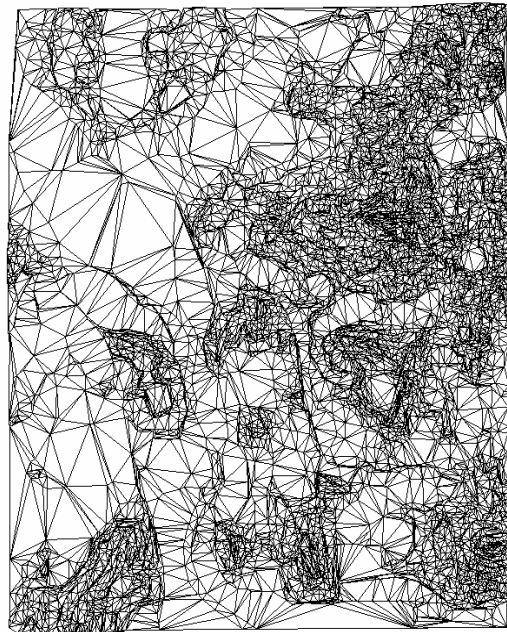
Table 3 VRML Optimization

3.6 Postprocessing

MultiGen[16] 가  
 OpenFlight 가  
 MultiGen 3 [7].  
 MultiGen LoD  
 4. :  
 가 가  
 Vega Vega API  
 가  
 <Fig. 6>



(a)



(b)

Fig. 5 VRML Optimization



Fig. 6 가

5.

5.1 가

3  
 TIN  
 Polyline Vertices  
 5m (1:5000 ) [11]  
 1m  
 TIN  
 Strip Triangular strip  
 가 1:5 TIN 가 가  
 가 가 가  
 가 가

5.2 (LoD)

가  
 LoD  
 LoD 가  
 가 가  
 LoD  
 가 가 LoD 가  
 가 가 가  
 LoD 가 LoD 가  
 가 가 LoD 가

5.3

◇ GIS - VR : GIS  
 (AutoCAD, ENVI, ArcGIS ) 3  
 가  
 (AutoCAD, 3DS, Multigen )  
 가 가  
 가 가 GIS - VR  
 ◇ :

2002 CAD/CAM

- ◇ GIS VR : 가
- 가 , 가 .
- 가
- 가 .
- 6.
- ◇ KAIST 1:5000 1
- 10km x 10km
- ◇ LoD
- ◇ HMD Augmented Reality
- ◇ 가
- \* 가

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