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Online 3D Terrain Visualization: A Comparison of Three Different GIS Software

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***Abstract* - In recent times, the online 3D terrain visualization has created much interest in many applications such as land information system, military, environmental, tourism and mapping science. Many systems such as CityGML, Terraserver, Google Earth and Spaceye3D have successfully adopted this technology in their system for different applications. The aim of this paper is to compare the effectiveness of developing online 3D terrain visualization by using three popular GIS Software; R2V, Arc View 3.2 and Arc GIS 9.2. In this paper, we implement the system based on the Digital Elevation Model (DEM) and Triangulated Irregular Network (TIN) for the terrain data and then overlay with satellite image. Finally, the effectiveness of online 3D terrain rendering in terms of terrain visualization quality, file size, and loading time are made to compare the quality of the systems. The results help the developers on finding the right software to be used for their online 3D terrain visualization.**

Keywords-component; online system; 3D terrain visualization; GIS software; effectiveness; R2V; Arc GIS; Arc View;

I. INTRODUCTION

The new era of viewing the terrain information is changing from offline systems to web based systems which have interactive and collaborative capabilities among the users. Now the expectations of users are increased and they are demand access to more information which has greater accuracy and realism. This is due to the emergence of new generation of geo-browsers such as Google Earth, Microsoft Virtual Earth and NASA's WorldWind [1]. This new era of geo-browser is supported by continued research and development projects by IBM which want to introduce "a 3D Internet" of virtual world. IBM's new technology call Second Life already subsisted, which is the popular online 3D community right now. The company first began hosting meetings in Second Life in 2006, and IBM currently holds public and private events in this 3D world [2]. This IBM project help motivate this study on online 3D terrain visualization using different GIS software. The study area for this project is the Universiti Putra Malaysia (UPM). The scope of this study is limited to the online 3D terrain visualization of UPM. According to the UPM website (http://www.upm.edu.my), UPM has two main campuses, the main campus in Serdang, Selangor and the branch campus in Bintulu, Sabah. The size of main campus is 1200 hectares and the branch size is 715 hectares. It has about 1,955 academic staff not including inbound and outbound visiting academics. Recently UPM has been recognized as one of Malaysia's leading Research University. UPM is chosen for this study because of its beautiful landscape which consist of many rolling hills and flat areas [3].

The aim of this paper is to compare the effectiveness of the online 3D terrain visualization developed by three different GIS software. The implementation of this project is started by collecting the Quick bird satellite data. Then the contour (elevation) data is collected from the Department of Survey and Mapping Malaysia (JUPEM). In order to compare the online 3D terrain visualization, three GIS software has been used; 1) R2V from Able Software [4], 2) Arc View 3.2 with 3D analyst, and 3) Arc GIS 9.2 from ESRI (http://www.esri.com) [5]. Firstly by using R2V software, the terrain was generated into 3D Digital Elevation Model (DEM) and satellite image is draped over the DEM data. After that, the data is converted to the Virtual Reality Markup Language (VRML) file for generating online 3D terrain visualization. Secondly, by using Arc View 3.2, the contour data is first converted into GRID file, then converted into TIN file and lastly, the satellite image is draped over the TIN layer. To generate online 3D terrain visualization, this data is converted into VRML as well. Thirdly by using Arc GIS 9.2 (Arc Scene), the contour data (SHP file) is first converted into TIN file. Then the satellite image is draped over this layer. The same type of VRML conversion is also done for this data. The fully online 3D terrain visualization is developed by using Macromedia Dream weaver. It can then be accessed online. The conclusion is made after comparing the output from all the above mentioned GIS software.

II. RELATED WORK

In recent times, the number of internet users and its technology has increased tremendously. Due to this impact, the 3D terrain visualization has also moved forward into online system. That has attracted many researchers to do

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research on this topic, to help solve the problems that arise in implementing this system especially on how to visualize the large storage of terrain data in an online environment. The VRML technology has been used by many researchers for developing online visualizing for large 3D terrain data. They are using many different technique such as Level of Details (LOD), tiles technique, progressive technique, and selective visualization [6, 7, 8, 9, 10]

Shiau, Shiau, & Liang [11] has proposed a new system for creating the 3D environment by combining the Digital Terrain Model and SPOT images of GIS with the weather simulation of the particular system in a networking environment. In order to make the system run in real time several accelerating schemes have been used. These are Real-time Optimally Adapting Meshes (ROAM), view frustum culling, and level-of-detail. The dead reckoning technique is used to reduce the flow rate of network to make the distributed real-time 3D environment feasible.

Guth, Oertel, Bénard, & Thibaud [12] introduced a technique for visualizing the terrain data on a mobile device by using the wireless technology. Their technique involved using GIS and GPS running on a Pocket PC. These technologies are individually powerful but when combined together, they can be more efficiently utilized. The pocket PC acts as a client-server, which contains all data and performs all display manipulation. In order to visualize the terrain, the pocket PC transmits its position to the server and then http protocol is used for communicating between the client and server. The pocket PC can then automatically display high resolution maps around its position with a single click on the stylus from the Terraserver. The main problem of this system is that the network handheld devices can access only limited imagery from the server.

III. THE IMPLEMENTATION OF ONLINE 3D TERRAIN VISUALIZATION

In this paper, the process of comparison of the three software for the implementation of online 3D terrain visualization is carried over six stages, which were: Data Preparation, R2V implementation, Arc View 3.2 with 3D Analyst implementation, Arc GIS 9.2, VRML Data Compression and Web Based Development. The details of each process are explained in detail in the next six sub-sections.

A. Data Preparation

The data used in this study consisted of the contour data and satellite data of Universiti Putra Malaysia (UPM). In order to prepare the contour data, the data on the Sri Kembangan digital map, where UPM is located, is edited and filtered by using the AutoCAD software to fit with the Universiti Putra Malaysia area. The interval between each contour line is 5 m. The projection used in this data is the Rectified Skew Orthomophic (RSO) Peninsular Malaysia. Figure 1.0 shows the contour line of Universiti Putra Malaysia. The data was in a DXF file. The R2V software can easily read this data and convert it directly into DEM or grid. But for Arc View 3.2 and Arc GIS 9.2, this data needs to be converted into SHP files first before it can be read. R2V software is used to convert the DXF data into SHP files for further processing. Figure 3.0 shows how R2V is being used to convert data from DXF into SHP files.

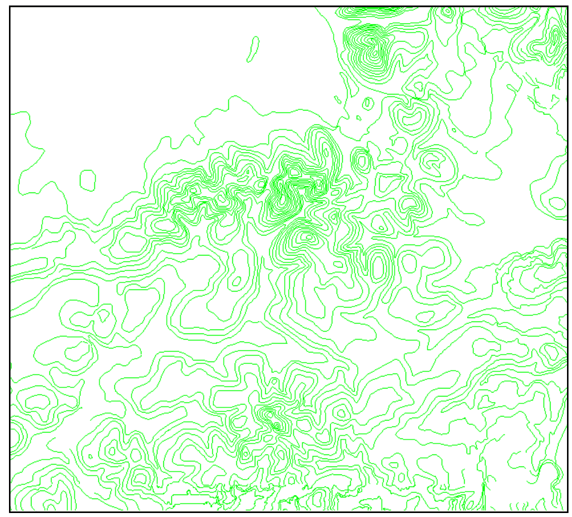

Figure 1 The contour map of Universiti Putra Malaysia.

The satellite imagery over UPM was obtained from Taman Pertanian Universiti, which had bought the Quick bird format imagery in 2004. The data was separated into ten tiles of different resolutions. Seven tiles had coverage of 8192 X 8192 pixels and the other three tiles had coverage of 4415 X 8192 pixels. The projection used for this data is same as contour line data which is RSO format.

In order to be fit with the contour line data, the satellite image data need to be clipped so that it covers the same area as the contour line data. This is where the accuracy of the data is important. If the clipping is not carried out correctly or in the wrong sequence, the accuracy of the resulting data will be lower. But if it is done correctly, the data will maintain its high quality. Before it can be clipped, this data needs to be converted into GeoTIFF format. The Global Mapper software was used for this purpose. Then PCI Geomatica V 9.1 is used to clip the data into the same area as the contour line data. The coordinates for UPM are measured first from the contour line data, and then this information was used in PCI Geomatica software for clipping the data. The area is 411821.765 East, 333381.626 North for upper left and 416571.840 East, 328770.814 North for lower right. The data was saved in TIFF format.

Figure 2.0 shows the satellite data of UPM after the clipping process.

Figure 2 Universiti Putra Malaysia satellite image after editing.

B. R2V Implementation

The data is in 3D DEM grid format after completion of the data preparation stage. Subsequently, we need to drape the image over the DEM and export is as a VRML file. This is done by opening the 3D file in DEM format by using the pull down menu. Then open the image data in TIFF format. This procedure continues with draping the image by using the File -> 3D data -> Image Drape. The satellite image will drape over the 3D DEM data for exactly the same area and size as the area setting done during the data preparation stage. Figure 3.0 shows the flow chart of this procedure.

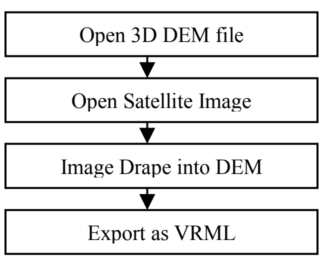

Figure 3 Flow chart of R2V Implementation.

The data is then converted into a VRML file using the export functions tools. This VRML data is now ready for use in the online 3D terrain visualization.

C. Arc View 3.2 with 3D Analyst Implementation

The data is in SHP files format after completion of the data preparation stage. To create the VRML file, we started by adding the SHP files into a new project. Then, we converted the SHP files into GRID format. The same data is then converted from GRID format into the TIN. Now the data can be viewed in 3D by using 3D scene menu. The next step is by adding the satellite image (TIFF format) to the project. Make sure that the 3D scene is open, and then go to Theme menu and select 3D properties. We then choose the TIFF image to overlay with TIN data. The data is then converted into VRML file using the export functions tools. This VRML data is now ready for use for online 3D terrain visualization. Figure 4.0 shows the flow chart of this procedure.

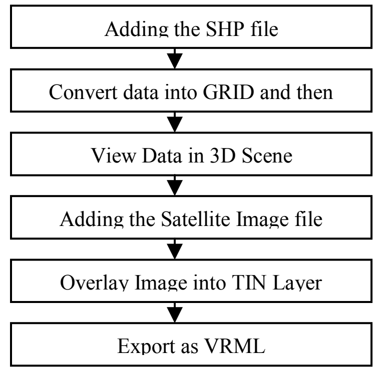

Figure 4 Flow chart of Arc View 3.2 Implementation.

D. Arc GIS 9.2 Implementation

The data is in SHP files format after completion of the data preparation stage. We the created the VRML file by adding the SHP files into new project. The SHP files are then converted into TIN format. Now the data is in 3D and can be viewed in 3D. Some of the 3D analyst functions can be done, such as shading the different heights with different colors. The next step is by adding the satellite image (TIFF format) to the project. Open the TIFF layer properties and obtain the base heights from the TIN surface as created before. Now the user can view the 3D satellite image in their screen. The data is then converted into VRML file using the Export Scene functions tools. This VRML data is now ready for use in the online system. Figure 5.0 shows the flow chart for this procedure.

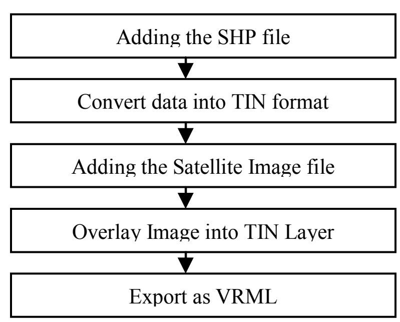

Figure 5 Flow chart of Arc GIS 9.2 Implementation.

E. VRML Data Compression

All of the outputs in section B, C and D are then in the VRML format. The size of the file can be very large depending on the area of the study. If the file is streaming online, it will take a longer time to visualize. So, the Chisel software developed by Trapezium development and additions by Michael N. Louka was used to compress the VRML files. First, the files need to be opened before being compressed. If the file cannot be opened, it is probably because the file is too big to be handled by Chisel Software. The user needs to make sure that the file is not larger than 100 MB in order to be compressed by Chisel Software. When the file is opened, the software will automatically suggest what parameters need to be cleaned for reducing the file size. The parameter can be cleaned by Remove default Value, Remove Repeat Value, and Removed Unused Value. The user needs to click on the CLEAN button to activate this process. After removal, the content of the file was found to be messy and it needed to be reformatted for easy reading. This was done by clicking the FORMAT button to reformat the file. Lastly, the file was saved as a GZIP format file. This software has a capability of reducing the VRML files to about 80% from the actual file size.

F. Web Based Development

The Macromedia Dreamweaver was used to develop the complete website for the online 3D Terrain Visualization. The development was done by drafting a design for the website based on the developer's creativity. Then, the VRML compress data was arranged according to the design. For the purpose of making a user friendly interface, the website was designed based on three frames; it was separated by banner (top), contents (left) and main frame (display). When the user clicks on the link for VRML data, it will display in the main frame area. The user needs to install the VRML viewer for viewing the VRML data. This can be done by clicking on the link inside the USER MANUAL. There are only two types of VRML viewers that can be used for viewing data which are BS Contact Management and Cortona Player. The best viewer for using this online system is BS Contact Management. Then the system was launched into the proper place as chosen by the developers. The example of the online 3D Terrain Visualization is shows in Figure 6.0. The complete system of online 3D terrain visualization was launched into the address:"http://spatial.upm.edu.my/webupm/3dterrain.html"

IV. RESULTS AND DISCUSSION

The experiment in this project was done by comparing the quality of terrain visualization produced by three different GIS software in terms of the VRML files. Three VRML file has been launched into the Internet server. The first experiment done for output of online 3D terrain visualization was generated from the R2V software which can be accessed from the address: "http://spatial.upm.edu.my/webupm/r2v3d.wrl". Figure 7.0 shows the image of this experiment. It shows that the results of the experiment give a low visualization quality where most of the area in UPM cannot be viewed clearly. The image has many distortions but the height of the data is shown almost perfectly. The advantage about this output is that it is actually in 3D solid block (see Figure 6.0). Compare to the output of other GIS software which produces output in 3D view or 2.5 D only.

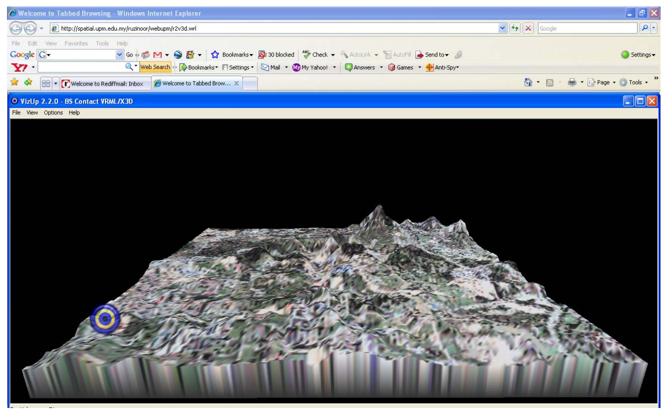

Figure 6 Image of online 3D terrain visualization generated from R2V Software

The second experiment was done for online 3D terrain visualization generated from Arc GIS 3.2 software which can be accessed from the address: "http://spatial.upm.edu.my/webupm/arcview3d.wrl". Figure 7.0 shows the results of the experiment. The quality of terrain visualization is better than the first experiment where most of the area in UPM can be seen. However, it is still difficult to identify the objects because the viewpoint is very far from the place. When we zoom closely, the image will be blurred.

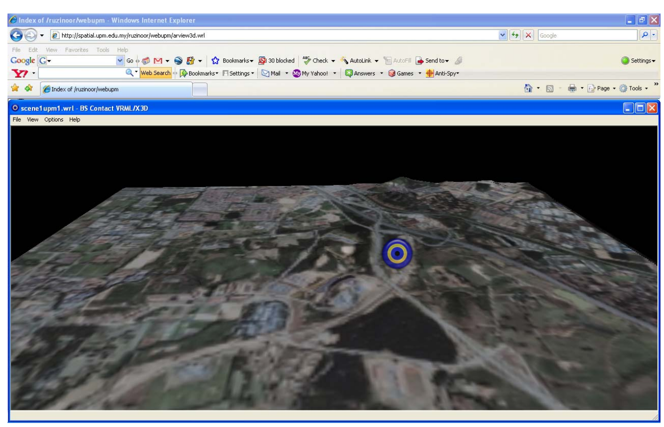

Figure 7 Image of online 3D terrain visualization generated from ArcView 3.2

The third experiment was done for online 3D terrain visualization generated from Arc GIS 3.2 software which can be accessed from the address: “http://spatial.upm.edu.my/webupm/arcgis3d.wrl”. Figure 8.0 shows the results of the experiment. The quality of terrain visualization is better than the second experiment. Most of the area in UPM can be seen and the object still can be identified when the camera is zoomed closely. But it still has a little blurring effect.

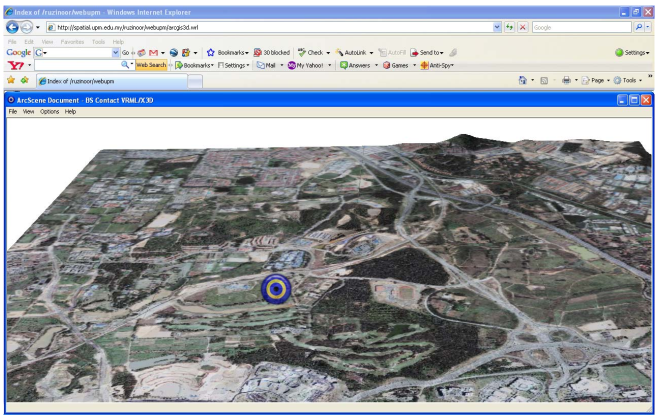

Figure 8 Image of online 3D terrain visualization generated from Arc GIS 9.2

Table I shows the comparison of different output produced from three GIS Software. There are five chosen criteria for the comparison which is in terms of original file size, VRML file size after compression, image file size, terrain visualization quality and loading time. The output of Arc GSI 9.2 has the slowest speed for loading time although it has a better quality of terrain visualization. The output of R2V software has the biggest size of the original VRML file. The output of Arc View 3.2 has the lowest file size for original VRML file and also the highest speed of loading time. The quality of terrain visualization is acceptable.

TABLE I. COMPARISON OF DIFFERENT GIS SOFTWARE FOR ONLINE 3D TERRAIN VISUALIZATION

Criteria	GIS SOFTWARE		
	R2V	***Arc View 3.2***	***Arc GIS 9.2***
Original VRML file size	11,588 kb	170 kb	10,325 kb
VRML file size after compress	536 kb	26 kb	648 kb
Image file size	none	88 kb	488 kb
Terrain Visualization quality	Bad	Acceptable	Better
Loading time	9.51 sec	8.55 sec	12.55 sec

V. CONCLUSION

In conclusion, in order to design the online 3D terrain visualization overlaid with satellite image data by using GIS software, there are some considerations that we need to be aware about. The quality of the visualization depends on the GIS software used. In this project, the Arc GIS 9.2 has given promising results, with the best quality of visualization. Most of the objects in the 3D surface can be recognized by the user but it is still difficult to identify clearly which object belongs to which image. The R2V produce low quality visualization but is good in the representations of heights of the surface. It can be concluded that the development of online terrain visualization need to have appropriate GIS software for higher quality of visualization.

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