

Online 3D Terrain Visualization of GIS Data: A Comparison between Three Different Web Servers

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ABSTRACT

Geographical Information Systems (GIS) and three dimensional (3D) World Wide Web (WWW) applications usage are on the rise. The demand for online 3D terrain visualization for GIS data has increased. Current users demand for more complex data which have higher accuracy and realism. This is aided by the emergence of geo-browsers in the market which provide free service and also cater for the commercialized market. Other new technology driving the market is the use of software such as CityGML, Virtual Reality Markup Language (VRML)/ Extensive 3D (X3D), geoVRML, and Keyhole Markup Language (KML). These technologies also play an important role for this new era of online 3D terrain visualization. The aim of this paper is to implement the online 3D terrain visualization for GIS data by using VRML technology and launching the system into three different web servers. The data used for this system are contour data and high resolution satellite image (QUICKBIRD) for Universiti Putra Malaysia (UPM) area. Testing was done only for satellite image overlaid to 3D terrain data. The web servers used in this experiment were the Spatial Research Group Server in UPM, Universiti Utara Malaysia (UUM) web server, and ruzinoor.my web server. The comparison was based on the performance of web servers in terms of accessibility, uploading time, CPU usage, frame rate per second (fps), and number of users. The results from this experiment will be of help and guidance to the developers in finding the right web servers for the best performance on implementing online 3D terrain visualization for GIS data.

Keywords: Web map server, 3D terrain visualization, satellite image, web server, GIS

INTRODUCTION

In this new era of modern technology, the demand for accessing information is increasing tremendously due to the availability of Internet technology. The backbone of Internet technology involved different kinds of technology such as networking (LAN, MAN, WAN), World Wide Web (WWW), and Groupware. The WWW latest version is Web 3.0. Due to this, the WWW is now in the era of 3 dimensions (3D). Geo-browser such Google Earth, NASA World Win, and Virtual Earth emerged from this new era. The important part in all of these browsers is the 3D terrain data. That is why the demand for online 3D terrain visualization has increased and is a popular area of study. The success of these browsers is based on the web servers behind it. For example Google Earth and NASA World Win have their own powerful web servers. Most of the modern web servers have to process million of client requests on a daily basis. That is why it should be equipped with the capability to process multiple request concurrently (Praphamontripong *et al.*, 2006). The aim of this study is to experiment the implementation of online 3D terrain visualization by using locally

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available web servers and test their performance. The Virtual Reality Markup Language (VRML) was used as backbone for developing online 3D terrain online draped with high resolution satellite imageries. The three web servers chosen for this experiment were Spatial Research Group (SRG) web server in UPM, Universiti Utara Malaysia (UUM) web server and ruzinoor.my web server. The criteria used to compare these three web servers were accessibility, loading time during office hours and out of office hours, CPU usage, frame rate per second (fps), and number of users at one time.

RELATED WORK

Research in 3D terrain visualization has emerged more than 10 years ago. Many researchers have shown an interest in this area. Praphamontriping *et al.* (2006) examined the performance analysis of asynchronous web server by using Proactor pattern. There presented the model based approach for the design time performance analysis of a web server which implement by using concurrent processing. Otherwise, Lu & Gokhale (2006) use a M/G/m queuing model to model the performance of web server which consider the response time of a client request. Furthermore, Mohd Syazwan & Nor Farzana (2008) have done the study on finding the factors that influencing the use of wecube web server from groupware and also acceptance issues from the users. They found that the lacks of wecube users in Universiti Utara Malaysia (UUM) were due to the service provided by the system which is not suitable to the users. In terms of 3D terrain visualization, Zhu *et al.* (2003) have proposed the hybrid 2D-3D interface for solving the problem of low bandwidth for implementing 3D terrain visualization. They also introducing tile based selective visualization for improving this system to increase the performance. Other than that, Ruzinoor *et al.* (2008) introduced the method of developing 3D web based terrain visualized by combining several software such as R2V, Arc View, Auto CAD, VRML, Chisel, and Dream weaver. This development has been successfully launched into the web server (Ruzinoor *et al.*, 2009).

METHODOLOGY

The method used in this study consists of three steps which were data preparation, implementation, and testing. The detailed discussion on this matter will be explained in the following three sections.

Data Preparation

The data used in this study involved contour and high resolution satellite image data of UPM area. The contour data was provided by Department of Survey and Mapping Malaysia and satellite data by Taman Pertanian Universiti UPM. Both data need to be of the same extent in order make the overlaying of image over the terrain data successful. AutoCAD and R2V software were used for editing the contour data and this was then exported into SHP files for the next process. PCI Geomatica software was used for cropping the satellite image to be the same extent as contour data. The file was saved in TIFF format. The last process is draping the satellite image over the 3D terrain data. These overlaying method is based on Ruzinoor [6] which used Arc GIS 9.2 software. This software was found to be the best on performing this task compared to other GIS software. The end product of this process is the VRML file of 3D terrain draped with satellite imageries which can be used online. For the purpose of testing the performance of online 3D terrain visualization of GIS data in three different web servers, only one file was used.

Implementation

Three web servers were chosen in this study; the Spatial Research Group web server in UPM, ruzinoor.my web server in Petaling Jaya and UUM Webcube web server. As mentioned by Praphamontripong *et al.* (2006) each modern web server employs the request/reply paradigm by using the HTTP protocol to communicate between itself and the clients. Normally web server provides only two types of request which is read request and write request. When both of requests were performed successfully the operation will be run in the client computer. But this is depends on the queuing process whether it is faster or slower. The location of Spatial Research Group Web Server was in the testing environment. The second web server ruzinoor.my was located 20 km from the location of testing and then the third web servers UUM webcube web server located 496 km from the testing location. The specifications and locations of these three servers are shown Table 1 – Table 3.

TABLE 1
Specifications of spatial research group web server

Spatial Research Group web server	
Domain	http://spatial.upm.edu.my
Location	Spatial Lab UPM
Provider	UPM
Type	Windows Server (XAMP)

TABLE 2
Specifications of ruzinoor.my web server

Ruzinoor.my web server	
Domain	http://www.ruzinoor.my
Location	Bandar Sunway, Petaling Jaya
Provider	Backbone Technologies (M) Sdn. Bhd.
Type	MYNIC Web Server

TABLE 3
Specifications of UUM web server

UUM web server	
Domain	http://staf.uum.edu.my
Location	Universiti Utara Malaysia Sintok
Provider	Universiti Utara Malaysia
Type	Webcube Groupweb

Data for the first web server was launched into address “http://spatial.upm.edu.my/ruzin-oor/-webupm/arcgis3d.wrl”. The data for the second web server was launched into address http://www.ruzinoor.my/webupm/arcgis3d.wrl, and data for the third web server into address “http://staf.uum.edu.my/ruzinoor/webupm/arcgis3d.wrl”. *Fig. 1* shows the online data for Spatial Research Group web server.

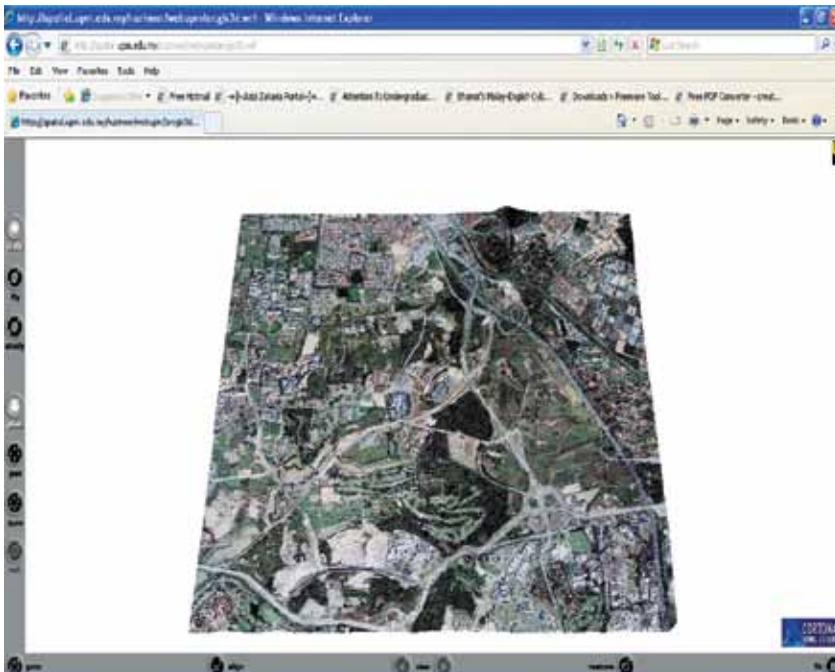


Fig. 1: Image of online data for Spatial Research Group web server

Testing

In order to test the three different web servers, the following criteria were used: accessibility, loading time, CPU usage, frame rate per second (fps), and number of users. The accessibility was tested based on how easy the web servers could be accessed in a certain time during the experiment. This is not the major criteria of testing because this test result could be determined based on other criteria. The major criteria tested were the loading time during office hours and out of office hours. This test was performed on a laptop with specifications as shown on Table 4.

TABLE 4
Specifications of laptop used for testing

Laptop	
Processor	Intel Core Duo Processor
Speed	1.66GHz, 667MHz FSB, 2MB L2 cache
Memory	2Gb DDR2
HDD	60Gb
Graphics	Intel Graphics Media Accelerator 950

The loading time was also tested with a different number of users accessing each web server at one time. The other two criteria tested were frame per second and the CPU usage. All of these tests were performed in one type of desktop computer with one type of actions which is walkthrough. The specifications for all of these computers were similar. Table 5 shows the specifications of this computer.

TABLE 5
Specifications of desktop computer used for testing

Desktop computer	
Processor	Intel Core 2 Duo Processor
Speed	2.40GHz, 800MHz FSB, 2MB L2 cache
Memory	2Gb DDR2 SDRAM
HDD	150Gb
Graphics	Onboard Graphic Cards

Based on the observations during the testing, different actions shown to have different value of frame per second and CPU usage. That is why the last criteria were tested based on different actions perform in one desktop computer (same specification as Table 4). The actions consist of four different types of interactions with online 3D terrain visualization which was fly, walk, rotate and pan. All of these tests were performed on three web servers.

RESULTS AND DISCUSSION

The first experiment measured the loading time in three different web servers running on one desktop computer. The measurement was performed by using stop watch and the result is produced in two decimal points. The result of this experiment is shown in Table 6. The graph for this result is shown in Fig. 2.

TABLE 6
Loading time during office hours and out of office hours

Criteria	SRG web server	Ruzinoor.my web server	UUM web server
Load time (office hours)	4.42 sec	7.96 sec	4.84 sec
Load time (Out of office hours)	1.25 sec	7.95 sec	1.69 sec

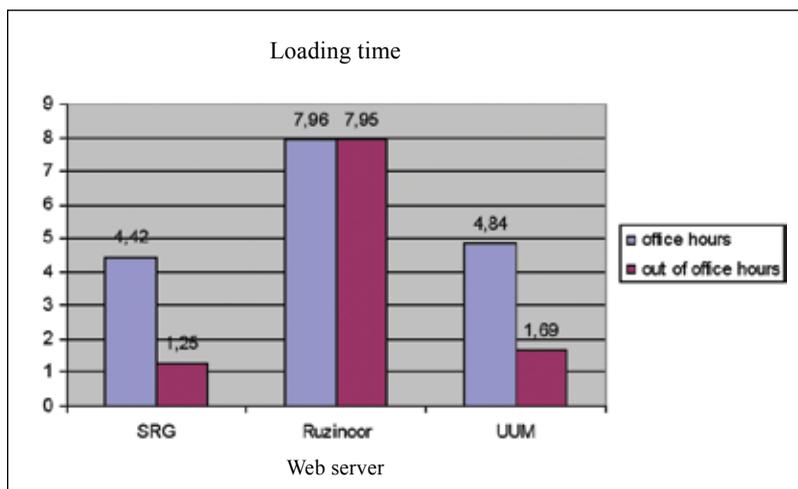


Fig. 2: Loading time in different web servers

The result shows that the best web server was Spatial Research Group Web Server which has the fastest loading time during office hours (4.42 sec) and out of office hours (1.25 sec). The worst web servers was ruzinoor.my which took more than 7 sec to load the file during office hours and also out of office hours. But overall the three web servers had taken less than 8 sec for loading the file which is not bad for accessing the system.

The second experiment was testing the loading time, frame per second (fps), and CPU usage by different number of users. All the users accessed the online system at the same time. The number of users started with 2 users, then, increased to 4, 6, and 8 users respectively. The result of this experiment is shown in Fig. 3 – Fig 5.

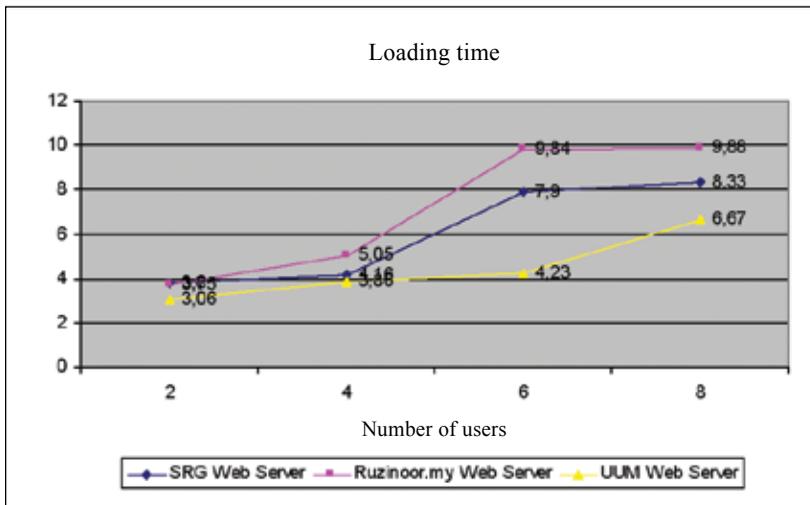


Fig. 3: Loading time in for different number of users

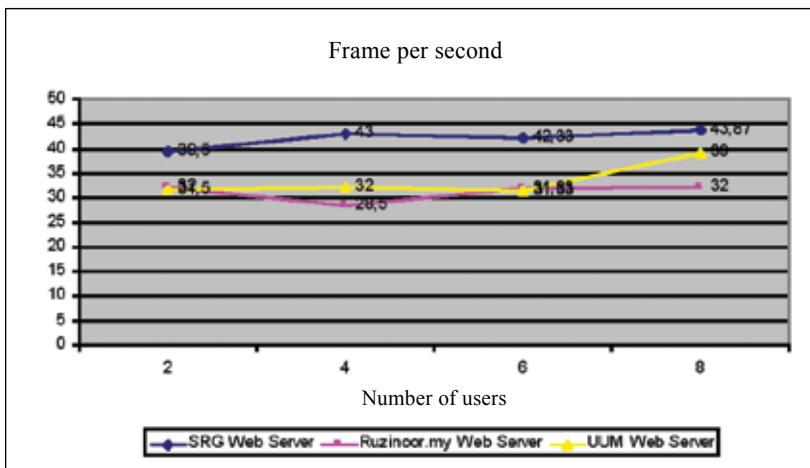


Fig. 4: Frame per second in for different number of users

The result for loading time in *Fig. 3* shows that when the number of users increased, the loading time becomes much slower. This may due to the time for loading the same file by many users at the same time slows the file accessibility from the same web server. Overall the UUM web server had the best loading time for the whole number of users compared to other web servers. This should not have occurred if we compare based on the location of the web server. The closer the web server is to the users, the faster should be the file loading time, and the further the distance, the slower time for loading. On average, the UUM web server had the fastest loading time for accessing the file online for the whole number of users. This may due to the network bandwidth and queuing process (read and write) for this web server at the best situation during the time was tested. That is why this web server stated the fastest loading time compared to others.

The results for frame per second in *Fig. 4* shows inconsistency of fps for three different web servers. In normal situations, when the number of users increased, the fps value should be lower but the results produced the opposite value of fps where when the number of users becoming eight, the fps value was the highest in most web servers. This may due to the network bandwidth and queuing process (read and write) for all web servers during the time of testing eight users is in the best situation which allowing the fps value to be the highest. As an average, the Spatial Research Group web server showed the lowest frame per second for accessing the file online for the whole number of users.

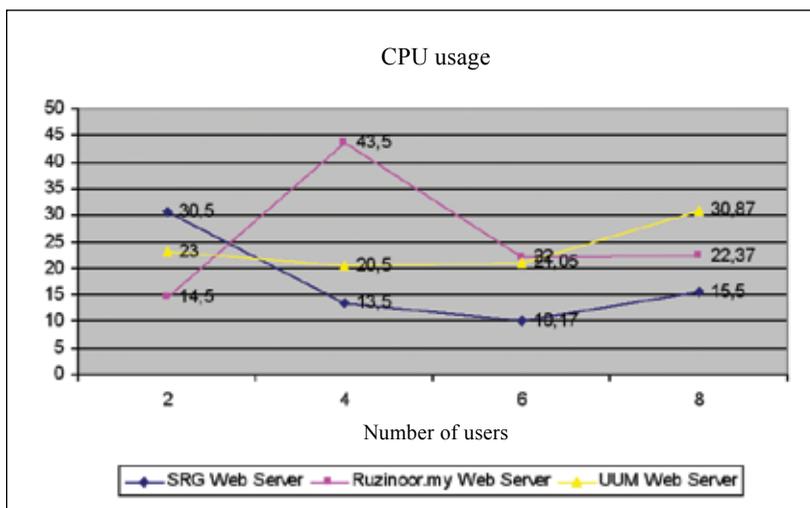


Fig. 5: CPU usage in for different number of users

The results for CPU usage in *Fig. 5* produced inconsistent values for the three web servers. In normal situations, when the number of users increases, the CPU usage should increase. However, in this situation most of the web servers produced the opposite results. The most inconsistent value for CPU usage was ruzinoor.my web server whereas the two users illustrated the highest value. As an average, the Spatial Research Group web server demonstrated the lowest CPU usage for accessing the file online for the whole number of users. This may due to the value of network bandwidth and queuing process (read and write) during the time for accessing the file was also inconsistent which sometime is lowest and sometime is highest. That is why most of the web servers giving the inconsistent value for the CPU usage.

The third experiment was testing the frame per second (fps) and CPU usage for different type of actions (refer *Fig. 6* and *Fig. 7*). This proved that different actions performed will produce different value of fps and CPU usage. In term of fps the pan actions produced the highest fps in all three web servers except for actions in Spatial Research Group web server which has a little bit fastest than pan actions. The actions which have the slowest value were rotate. This is may be due to the fact that actions involved much more movement of the object in online environment.

The second part was testing the CPU usage for different types of actions. The walk actions produced the best value which has the lowest CPU usage value for all of the actions tested. The rotate action was the weakest whereas CPU usage showed the highest value compared to the other actions. This is true where this action was the lowest in term of fps. These actions need more space for the actions which consume more CPU usage. Overall the best web server for performing different actions in term of fps was UUM web server and in term of CPU usage was ruzinoor.my.

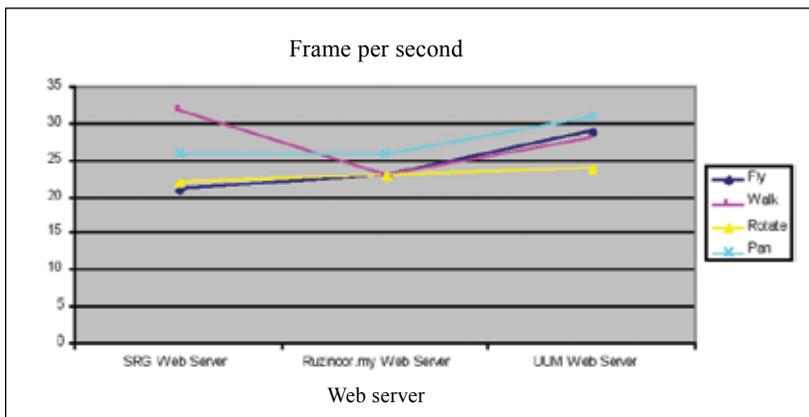


Fig. 6: Frame per second in for different actions

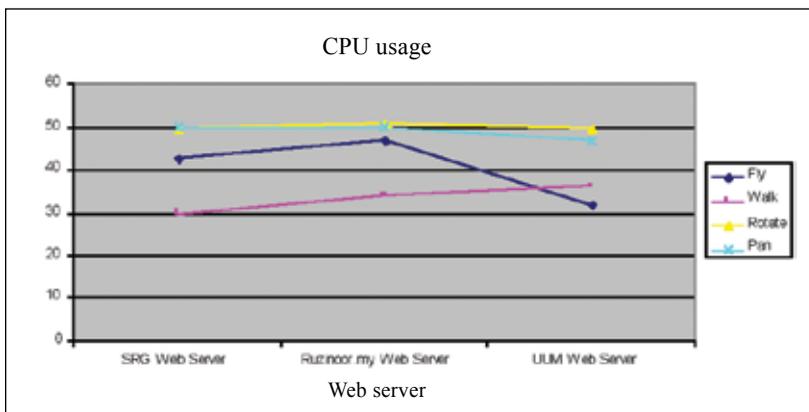


Fig. 7: CPU usage in for different actions

CONCLUSION

In conclusion, the best web servers to be used for implementation of online 3D terrain visualization was the Spatial Research Group Server. This is because it has the best value and is fastest for most of the test performed except for loading time involving different number of users and performance on different actions. In term of loading time in the second experiment, the location of the web server did not affect the file loading time. But in term of network bandwidth and queuing process (read and write) most of the web servers have inconsistent value where sometime is slower and sometime is faster. That is why in certain operation such as CPU usage the inconsistent value for web server is stated. The last experiment of this study produced opposite results where the Spatial Research Group Web server should be the best in term of fps and CPU usage because its location is the closest compared to other web server. But the Spatial Research Group web server stated the worst value on fps and CPU usage. It means that each web server has its own advantages in certain situation.

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