

3D Building Models and an Example for Use of Photorealistic Models in Geomatics

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Key words: key word 1, key word 2

SUMMARY

3D models are widely used in many different applications, such as medical industry, movie making, video games and scientific researches. Also architectures and engineers use them to design new devices, vehicles and structures. In the Geomatics Engineering, 3D modelers can be used to create landscape models, process digital elevation models and modeling cities in 3D for GIS. In this study, 3D models of Civil Engineering Faculty Building of Istanbul Technical University was realized and obtained model was textured with the photographs in order to generate a photorealistic model of the building. Due to different height level of the building, they have been conducted as separate blocks and they have been merged to produce only one block. After obtaining the 3D model, photos of facades were taken to texture the blocks. The photos are processed to correct perspective of textures. The model is then uploaded to Google Earth for further evaluation. The model is currently accepted and visible in Google Earth as 3D layer. This study was conducted in limited time and tools. In this study Google SketchUp and Adobe PhotoShop were used as main software.

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1. BRIEF INTRODUCTION AND HISTORY OF 3D MODELING

Nowadays 3d modeling is being used even more widely from medicine to engineering applications. The involvement of Geomatics engineering with use of spatial data and the improving use of geographic information systems, both in our country and around the world, and the need to be relieved from the restrictions analog maps revived the subject of intense use of digital maps and spatial modeling.

3D modeling and visualization has made a rapid development parallel to the technology, especially altogether with animations, the use of these models are more frequent than it was before. Early computer graphics were Vector graphics, composed of thin lines whereas modern day graphics are Raster based using pixels. The first triangulated irregular network program for GIS was written by Randolph Franklin at Simon Fraser University in 1973. A major breakthrough in simulating realism began in 1975 when the French mathematician, Dr. Benoit Mandelbrot published a paper called "A Theory of Fractal Sets." After some 20 years of research he published his findings and named them Fractal Geometry. At the 1980 SIGGRAPH conference a film entitled "Vol Libre" was shown. It was a computer generated high-speed flight through rugged fractal mountains. A programmer by the name of Loren Carpenter from The Boeing Company in Seattle, Washington had studied the research of Mandelbrot and then modified it to simulate realistic fractal mountains. (http://hem.passagen.se/des/hocg/hocg_2000.htm, visited: 28.04.2008)

2. NECESSITY OF 3D MODELS IN GEOMATICS AND MOTIVES OF THIS WORK

The advancements in both acquisition and representation of spatial data together with computer technologies took the Geomatics engineering to a new level, both engineers and users who want to be freed from the restrictions of analog maps followed a trend to create and use maps in a "digital world". This way the maps become more interactive and more "visual" so that the users can form a mental map far more easily than they do with an analog map. This lead the result of creating more and more interactive maps so that users can orient themselves on location. This brings up the need of 3D models to produce more realistic environments for the users and even more realistic ones by using photorealistic 3D models. The 3D models on a geographic information system have many areas of use from architecture to urban planning, from military to hazard management. (Lancelle, Fellner, *Current issues on 3D city models*, Computer Graphics 2003/2004)

The maps and GIS systems supported with 3D models are becoming irreplaceable elements of decision making systems, because of their ability to simulate volumetric effects more visually and easy to understand 3D models are becoming key elements of urban GIS in disaster management situations with its abilities to allow the users to simulate and obtain statistical

results for predefined situations, (Batty *Urban Modeling* 2007) for example in a flood scenario, where time and effective use of resources is essential, decision makers can easily analyze the situation on a 3D modeled GIS system and distribute the resources according to need which is far more cost effective than to send standard rescue teams to the places that may not be needed. The 3D models combined with GIS can also be used in military areas to train or to brief combatants in a more realistic environment with simulation and scenarios. For the historical monuments protection and recreation 3D models (especially photorealistic models) are also important, the 3D models can be important guides to both tourists and governmental agencies (Parish, Yoav I.H., Müller, P. *Procedural Modeling of Cities*)

The distribution and accessibility of these models are also an important topic and motive of this work. Therefore the photorealistic model of Istanbul Technical University produced on a web based virtual globe service macro, and published by using the service. The details of production steps and details of web service and macro of this web service will be mentioned below.

3. GOOGLE EARTH

There are many virtual globe programs present online such as NASA World Wind Google Earth Microsoft Virtual Earth 3D ArcGIS Explorer Software MacKiev's 3D Weather Globe & Atlas. Google earth is one of the many virtual globe programs that are present today and created by Keyhole Inc. the company is acquired by Google in 2004. The Google earth displays satellite images on a digital elevation model data which are obtained from NASA's Shuttle Radar Topography Mission (SRTM). The Google earth also able to show 3D buildings and allows the user to browse the landscape via address, latitude, longitude or just by mouse cursor. The average image resolution of satellite images provided by Google earth is around 15 m, however it differs from subject to subject for example while the Googleplex (see figure 7) can be displayed in 0.15 resolution, the isles of Scilly are about a resolution approximates to 500 m. the fact that determines the resolution of a place is proportional with its degree of being whether a place of interest or not.

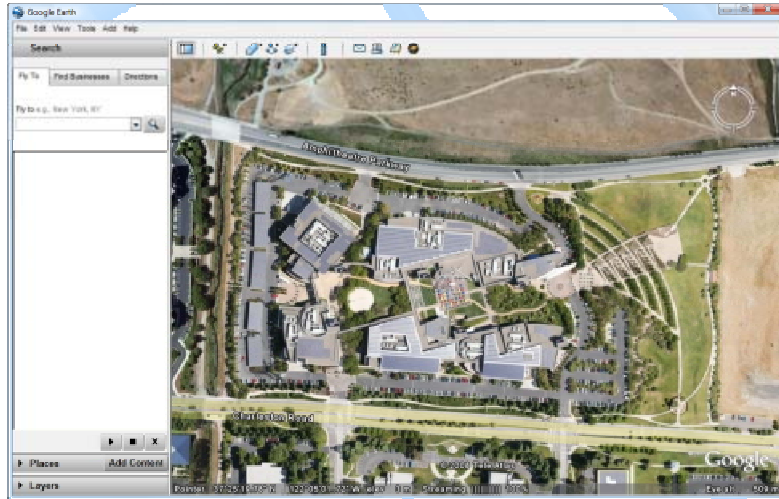


Figure 4.1.1: Screenshot of Google Earth showing Google campus in Mountain View, California, USA

(http://en.wikipedia.org/wiki/Google_Earth, visited may 2, 2008)

Specifications of Google Earth are:

- Coordinate System and Projection
- Baseline resolutions of 15 meters
- Typical height resolution of 0,3m
- Altitude resolution varies
- Age: Images dates vary. The image data can be seen from squares made when DigitalGlobe Coverage is enabled.

SketchUp is a 3D modeler or a 3D modeling program integrated with Google Earth. The program is created by “@Last Software Company” in august 2000 as a general 3D content creation tool. Today it is currently in version 6. There are two types of version 6 as “free” and “pro”.

As mentioned before there are many 3D modelers but SketchUp is especially designed for architects and civil engineers and is more prone to create detailed building models. SketchUp is also the 3D modeling program for Google Earth 3D warehouse which means users can upload their 3D building models to Google Earth. Compared with other 3D modelers it is more practical, user friendly, easier to learn and use. There are some distinct differences between SketchUp and other 3D modelers the main distinctions are; a “smart” drawing cursor (inference) system (which allows user to find the intersections, parallel directions, perpendicular lines, and so on) and a patented push/pull system which allows users to create masses just by pulling pushing the surface.

4. APPLICATION

In this study Istanbul Technical University Civil Engineering Faculty Building is modeled for design project, the reason to choose the Faculty is that the amount of knowledge about the building and the ease to obtain and compare the model results more accurately. The first step of the project was to get the view of the Faculty of Civil Engineering into the SketchUp. Sketch up's 'Get Current View' tool helps users to obtain any view they are observing from any altitude at Google Earth to their SketchUp workspace. In other words, that tool provides the users a snapshot of the current view they have in the Google Earth. In addition to the snapshot it provides, it also gives the topographic features of the snapshot called terrain. Terrain helps the users to have an idea about the actual topography of the site they are working at. It is important when the users try to geolocate the model properly to their workspace so that the actual models are not floating. **Figures 6.1 and 6.2** below shows a geolocated and non – geolocated examples of a model created.



Figure 6.1: Non - Geolocated



Figure 6.2: Geolocated

In most of the 3D models created, SketchUp and Google Earth users tend to use the snapshots and terrains to have measurements and to create the actual model according to those measurements. In other words, once the snapshots and terrains are obtained as different layers in SketchUp, usually all of time geometric features (edges, faces, heights) of the 3D model are measured, calculated and drawn according to the measurement that are taken from the snapshots and terrains. The examples of Google Earth Terrain and Snapshot can be seen in the **figures 6.3 and 6.4** below.

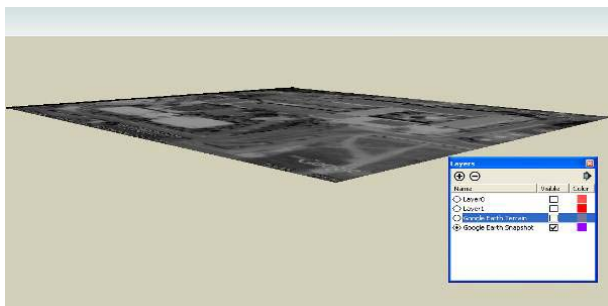


Figure 6.3: Google Earth Snapshot

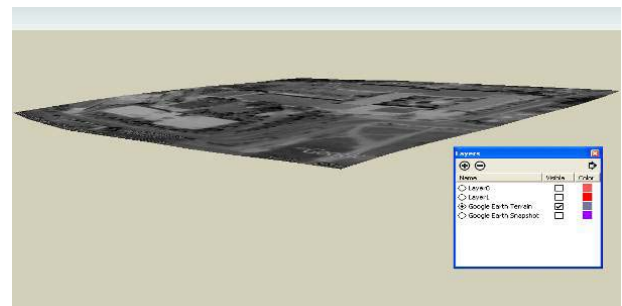


Figure 6.4: Google Earth Terrain

In this project, even though snapshot and terrain was obtained as the first step, they were only used to accurately and correctly geolocate the model. Rather than having edge and height measurements from the snapshot and terrain of Faculty of Civil Engineering area, the 1:2000

scaled plan of ITU Ayazağa Campus for 2008 was obtained in DWG format for any 2D measurements of the model using AutoCAD. In addition, conventional techniques (30 m. steel tapes) were used to find the relative height differences between roofs of the different blocks of the Faculty of Civil Engineering Faculty.

Sketch up's Import function provides users to import several different file types directly into the Sketch up's work space. In this project, DWG file of 1:2000 scaled plan for ITU Ayazağa Campus is used. Since SketchUp provides accurate angle, area or distance value entrance to its user by Value Control Box (VCB), 2D model from DWG file was easily redrawn in Sketchup rather than only importing it through import function.

Actual drawing of 2D model of Faculty of Civil Engineering Faculty was done using tools like line, protractor, rectangle or tape measure. Once the 3D axes of the Sketchup were set parallel to the axes of DWG of 2D model any edges with accurate values were drawn to create the 2D base model for Faculty of Civil Engineering.

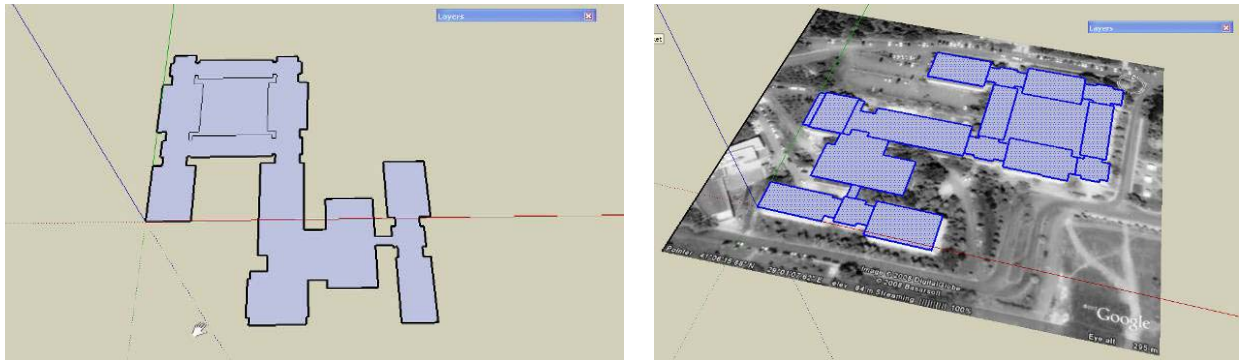


Figure 6.7: 2D Base Model for Faculty of Engineering in SketchUp (One – Block and Multi – Block Design)

Since the actual topography of the work area for the project had different slope values in different parts, the 2D model had to be divided into different blocks rather than having it one piece model like in DWG format. As the whole model was divided into small blocks in 2D, they were precisely geolocated into the terrain they belong to using the move tool of SketchUp. While geolocating each block separately, it was important to specify the points of terrain where height values were minimum. This method caused the loss of some parts (especially lower floors of the buildings) of the final 3D model where there were significant slope differences on the terrain of the model. However, this method was required in order to accurately geolocate the model and prevents the model to float over the terrain.

Once the geolocating of the individual blocks on the terrain was complete, the design of the 3rd dimension – which is the heights of the buildings – was the next step in the design of the model. The Push/Pull tool with the help of Value Control Box was the main action used for setting the heights of the building accurately. Since the individual and relative heights of building from their roofs were measured, it was easily modeled in SketchUp. SketchUp'

Push/Pull tool was used to decrease or increase heights of any surfaces in any direction (axes) which greatly helped our design. During the design of the 3rd dimension Sketch up's view styles for faces such as wireframe or monochrome, created opportunities to see any missing or mistaken parts. Examples Wire framed and monochrome images of the model are in the **figures 6.8** below.

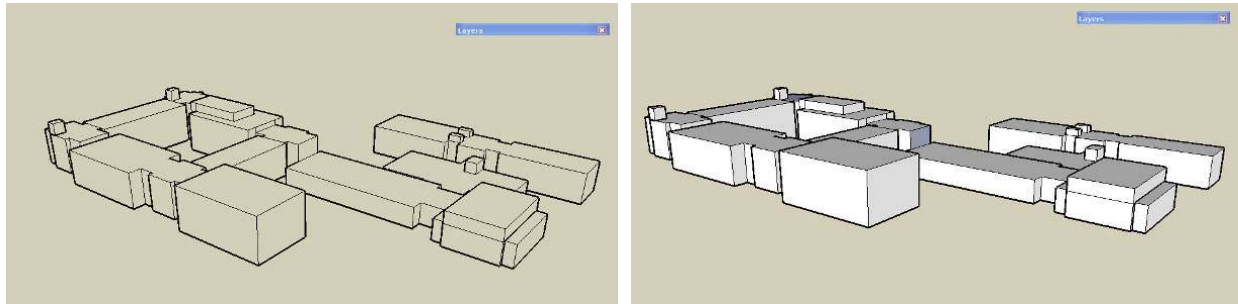


Figure 6.8: Wire framed and Monochrome version of the Model

After the design of 3rd dimension of all individual blocks, the design of elevator at the back entrance of Faculty of Civil Engineering was the next step. During the design of the elevator, the complexity used for creating the cylindrical shape of the elevator was also taken into account. Since one of the aims of the project is to upload the design into Google Earth and share it with 3D Warehouse, it was wiser to use less detail on both the geometry and surfaces especially on the textures of the model.

After completing the 3D monochrome design of the Faculty of Civil Engineering with all blocks, the next step of the project was obtaining images of the faculty and texturing the outer faces of buildings that are visible to any person viewing outside of the whole faculty through Google Earth. In order to obtain the images of the Faculty of Civil Engineering building, 7.0 mega pixels Olympus Digital Camera was used. Since there were many obstacles in front of buildings like trees, street lamps, cars and even humans while taking the shots, pre - editing of the images before actually using them in the model was crucial. Capturing the largest view possible for the surfaces of building helped create the most realistic representations for the images that will be applied to the model. For the faces with almost no obstacles (tress, street lamps, cars, etc.) the largest view photos were sufficient and efficient to represent the realistic texture for the model. Other critical feature of the images for surface of buildings was the angle of sight for each image. For this reason, while capturing the images for surfaces, the line of sight of the camera was positioned perpendicular to the building surfaces. Once sufficient images were captured, the next step was pre editing of the images using Adobe Photoshop before actually applying them to the model.

First part of the editing was about the angle of view for the images. Since some images had to be taken in angular view with respect to the line of sight because of obstacles in front of them, their perspective had to be corrected in order to apply them into the surfaces realistically. Photoshop's crop tool was used when doing perspective correction (transformation) of the images. Below **2 images(fig. 6.9a and 6.9b)** are the examples of perspective editing.



Figure 6.9a: Edited / Corrected Perspective **Figure 6.9b:** Original Image

Second part of the editing mainly focused on removing any obstacles in between the camera and the surfaces of the buildings. Using a window to make series of windows or using the column(s) of a building surface to create entire surface were examples of editing.

Final part of the editing for the images was to adjust the optimum image resolution for the images that are going to be used in the model. Since there were nearly 500 surfaces in the model, using a high resolution image for each surface would result in a high file size. Therefore the images used in the model were saved as low resolution images like 5 to 10 kilobytes even though they were actually in 3.5 megabytes resolution while capturing. **Figure 6.10a** **Figure 6.10b** are examples of images (original & edited), where perspective transformation, cropping, cloning, copying & pasting or other techniques are applied.



Figure 6.10a: Original Image

Figure 6.10b: Edited Image

After editing was done on the images for the model, the next and final step to finish the model before uploading to Google Earth and 3D Warehouse was to accurately position the images on the surfaces of buildings. SketchUp's import function was used to import any edited images as textures on each face (surface of the building) in the model. With the import function, users can edit the size of the image they are importing. If the image is not stretched to fill the whole surface, it automatically duplicates itself to fill any remaining spaces of the surface. It is important to apply the images as textures since Google Earth only visualizes the images that are applied as textures. **Below is the image of the model with textures applied.**

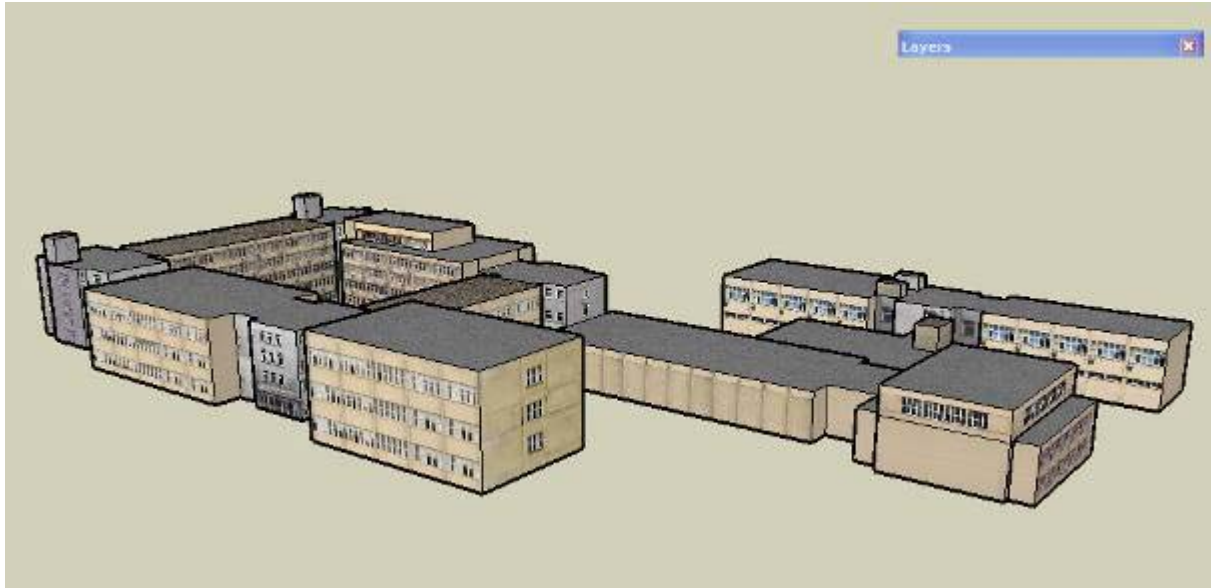


Figure 6.13: Textured Image of Model

Once the correct images were applied to correct faces on the model of Faculty of Civil Engineering, there were few optimization steps to increase the performance of model before it was actually uploaded to Google Earth. Optimization was mainly about removing or hiding any objects that won't be visible in the model when viewed in Google Earth. The edges, extra faces or some reference layers that had no importance in the final version of the model were either hidden or deleted. This optimization technique also decreased the file size of the final model which improved the upload time for the model in Google Earth.

The final step of the project was to upload the model of Faculty of Civil Engineering into 3D Warehouse and Google Earth. This step enabled the sharing of the model with the entire Google Earth, 3D Warehouse and SketchUp users in the whole world. There were 3 main steps followed while uploading and sharing the model.

First, the final version of the model was placed on the Google Earth using the 'Place Model' tool of SketchUp. This tool is useful for users since it actually shows how a single 3D model is located and viewed in Google Earth before uploading and sharing it. Using this tool, the model of Faculty of Civil Engineering was also checked on Google Earth several times. The precision of geolocation the model and the actual visualization of the model was checked

before uploading it. **Figure 6.14** is the image of the model in Google Earth along with other 3D models:



Figure 6.14

The second step of the uploading was to create a Google account. Using Google Web Page, a Google account was created. With any Google account created, users can access to 3D Warehouse to upload any geolocated or non geolocated models they have created. Once the users sign in, uploading or editing their existing model or viewing, downloading other models for Google Earth or SketchUp is accessible.

Finally using the ‘Share Model’ tool, the final version of the model was shared and uploaded through the account created. If users use ‘Share Model’ tool, it provides them the web page where users do final steps before actually uploading the model. In the Uploading page, users can edit the name, website, logo, description, and tags for the model they create. All these information are supplied to any user in the world when they view the model in Google Earth or 3D Warehouse. In the project, once all sufficient information was supplied for Faculty of Civil Engineering, the model was successfully uploaded to Google Earth and 3D Warehouse. Any user that has the 3D warehouse link installed in Google Earth or any 3D Warehouse visitor or user can view the model of Faculty of Civil Engineering. The model can be downloaded to Google Earth or Sketchup directly using the link below as well:

<http://sketchup.google.com/3dwarehouse/details?mid=9ea2ed9f1a895c6de00e8369118b0809>

5. PROBLEMS ENCOUNTERED, RESULTS AND RECOMMENDATIONS

The optimization process of the model was the crucial part of the work. There is a complicating fact that the model is a photorealistic model, this brings up the issue of optimizing the texture files and the polygon (surface) count. The reason for making such an

optimization is that the model is meant to be published via a web service, thus via a web browser. Since the connection speed is the key element for viewing such an item and users visit an average of 43 pages and spend about 45 seconds on each page, suggesting that users are interested in skimming over the contents of a page, rather than spending time going in depth. (Source: Nielsen/NetRatings, visited 10.12.2008), this optimization affecting the load speed of the model is not mandatory but necessary.

The acquisitions from this work are the experience of photo realistically modeling a building, optimization processes of a 3D model and the data acquisition and surveying techniques for creating a 3D surface model, Computer Aided Design program knowledge and photographic texture processing and geometric registration knowledge.

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BIOGRAPHICAL NOTES

Adil Enis Arslan Born in 1985 in Istanbul finished his undergraduate education in Istanbul Technical University, Civil Engineering Faculty, Department of Geodesy and Photogrammetry Engineering in 2008, currently continues the graduate program in Istanbul Technical University Geomatics Graduate program. Currently works as a research assistant in Ankara Hacettepe University Engineering Faculty, Geodesy and Photogrammetry Engineering Department.

Dr. **D. Zafer Seker** is graduated from ITU, Civil Engineering Faculty, Department of Geodesy and Photogrammetry in 1985. He graduated MSc Program in 1988 and PhD in 1993 from the same department. He was started to work as Research Assistant in 1986 and still working as full professor in the same department.

Firat Ergun was born in Adana in 1984. He was graduated from Robert College of Istanbul in 1999. He graduated from Geodesy & Photogrammetry Engineering Department of Istanbul Technical University (ITU). In fall 2008, he started his Master of Science Degree in Geodesy & Geoinformatics Engineering at Kungliga Tekniska Högskolan (KTH), Stockholm. He still continues his graduate studies in Sweden.

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