Texturing Techniques in 3D City Modeling

[1]İdris Kahraman, [2]İsmail Rakıp Karaş,
Faculty of Engineering, Department of Computer Engineering, Karabuk University, Turkey
[1]idriskahraman@karabuk.edu.tr, [2]ismail.karas@karabuk.edu.tr

Abstract

The usage of 3D city modeling within the three-dimensional geographic information system has increased considerably in recent years. One of the most important processes in modeling is texture mapping of 3D structures. This paper describes approaches to texturing methods for 3D city models obtained from different imagery systems. Comparison of the methods is done according to purpose of the usage of 3D models.

Key words: Texturing, pictometry, laser scanning, dynamic pulse function

1. Introduction

One of the common usage areas of Geographic Information System is 3D City Modeling for urban planning. 3D city modeling is increasingly used for the presentation, exploration, and evaluation of urban and architectural designs. 3D geo-information technologies empower architects, urban planners, and authorities to visualize and analyze urban and architectural designs in the context of the existing situation [1]. City modelling gives the complete imaginary view of any city area with its geometric model and some sort of semantic and topological information. There are some steps to carry out the city modeling such as data acquisition, digital terrain model, 3D model, façade textures of structures, semantic data. The data is the fundamental part of the modeling.

The important component of the 3D city modeling is texturing of the buildings. Textures obtained from structures increase the sense of reality. There are some ways to get textures according to the purpose of modeling. In this paper, texturing methods is described and compared.

2. Texturing in 3D City Modeling

3D city modeling allows to present partial or entire city virtually. 3D city model contains buildings, bridges, water bodies, road objects (traffic lights, electricity poles, the cultivated area) etc. in 3D structure form. It should consist of queries and spatial analysis rather than geometric appearances.

3D city modelling consists of mainly three components namely geometric modelling, thematic

modelling and semantic modelling. One of the important components of the 3D modeling is texturing within geometric modelling. It is very important to increase the quality of realistic image of the building in such applications like virtual tour, urban planning, disaster management and building inspection.

2.1. Photorealistic Texturing

The façade texture is required to give the realistic view in the city objects. Texture can be done with an image, solid color or shaded polygons. When dealing with picture image for texturing, each perpendicular picture that captured by digital camera has to be rectified (Figure 1.) and mapped on the related geometry. In the process of large and detailed buildings, more photos should be taken from each façade and rectified [2].

Figure 1. Four points must be selected on the photo (a) and each point provides 2 independent equations.

Due to the natural flow of life, some disturbing object can be seen on perspective view of building façades like shades, pedestrians, cars, trees. Because of the unnecessary details realistic images of buildings cannot be achieved. These problems should be avoided by image editing process. It is seen in Figure 2. that captured and improved image.

Figure 2. Optimization of the façade texture, before and after

2.2. Pictometry

Pictometry is a method to obtain the front and side elevation images and location of the building with aerial photographic techniques. Images are obtained by a low-flying airplane. Images get with pictometry is georeferenced. In this system, four in five cameras take five geo-referenced photos in north, east, south, west at a 40-degree oblique and vertical angle simultaneously from a low-flying airplane, the other camera looks straight down and captures high resolution vertical images. So four cameras show the side view of buildings and one provides terrain surface [5].

Figure 3. Illustration of the pictometry system

Pictometry technology is widely used in various applications such as emergency management, homeland security, disaster management, planning and development, insurance, real estate, construction, etc. areas. Due to the oblique angle to obtain photo in pictometry, it provides users practical and clear picture images and it shows the side looking of objects on the ground. In the same way, since every square foot is depicted in detail and high resolution obliquely and vertically, images produced that cannot be obtained with aerial images, satellites, and GPS. The images taken from pictometry, is georeferenced by its real place in the world and so there is possibility of conversion to the required file formats according to GIS. Because of more closure between buildings, some part of the structures may not be recognized by pictometry (Figure 4.). This method is more accurate for linear structures while it is more limited for the complex structures.

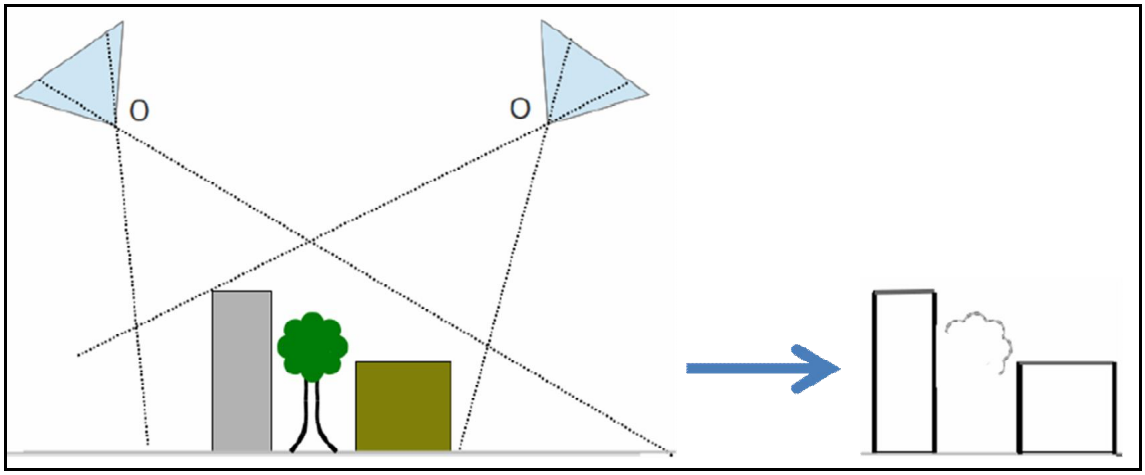


Figure 4. Point cloud segmentation [6]

2.3. Laser Scanning

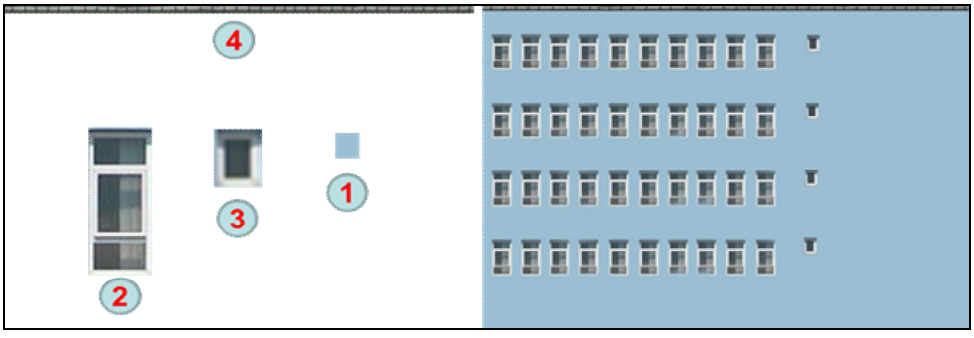
Laser scanning is used for texturing process as well as being used in 3D building modeling. This method proposes ways to texture-map a 3D city model that has structures not textured, with airborne images at oblique angles, capturing both façades and roofs. High-resolution aerial imagery is obtained from airplane. Texturing in this method is being superposed the images with the model by matching line segments. Aerial image registration consists of finding 3D line segments in the model and matching them to 2D line segments in the aerial images. Then, each triangle of the model, an optimal image is selected for texture. There are several steps for selecting optimal image for texture mapping. Firstly, defining the resolution as the number of pixels per area unit and determine the resolution for each 3D triangle, secondly, determining what percentage of a 3D triangle is visible in image z-buffer algorithm is used for detecting occlusions on a per-pixel basis in the images, thirdly the image used for texture should be taken from a direct view and the best direct view is calculated by comparing center points of the image and triangle, lastly, the coherence of texture with the texture of neighboring triangles is done to become smooth seam. [3]

Figure 5. Close-up view of an area texture-mapped with multiple images (a) Source images color-coded; (b) textures applied to the model.

Scan data derived from three-dimensional high accurate point cloud model, can be imported to AutoCAD/Autodesk, Revit Architecture, 3D-Studio Max Design, and Bentley Microstation software environment directly. Laser scanning is implemented in fixed position from air with assistant materials.

2.4. Dynamic Pulse Function

Dynamic pulse function is introduced by Alizadehashrafi and Rahman, 2011 for creating textures for the façade. This application is developed using Java Graphics. The concept of this method is applicable to façades that has repeating objects such as window, air-conditioner, etc. The output image file is generated in high quality and small data size. As shown on Figure 6.a, 4 texture parts (1-wall texture, 2-window texture, 3, small window texture, 4-rain gutter) load to the application and façade texture is generated as shown on the Figure 6.b.



(a) (b)

Figure 6. a) Texture parts b) Generated texture

Rectified photos could have some problems such as leaning geometries, shadows, disturbing objects and reflections. Because of that this images cannot be used for texturing of 3D models but they can be used for measuring or resizing in constrain proportion to real geometry. Size of the rectified image that is proportional to real geometry should be the output frame of the DPF. After

the measuring parameters of windows and doors to upper left corner

This method provides less data size images for textures for web-based applications and navigators. Hence, the speed of the system is advanced with this method.

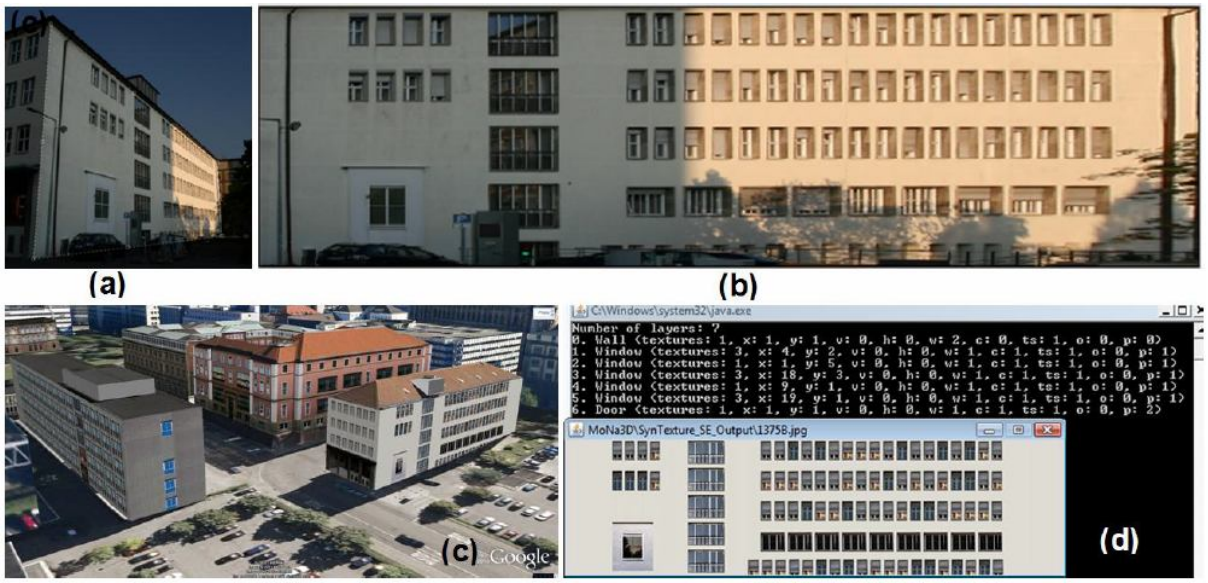


Figure 7. Original photo is 4MB (a) and the rectified photo is 7MB (b). Our created façade image is just 25KB in a very high quality (d). One pixel is used for the wall texture and three random textures are used for three different window layers, Upper left, upper right and downer right window layers are using these random textures to increase LoR. The database for the layers is in XML schema format which is a part of semantic modeling of the façade in Dynamic Pulse Function. (c) Is the approved 3D model via Google maps using Earth plug in [7].

The 3D model of Engineering Faculty of Karabuk University is modelled with SketchUp and textured by Dynamic Pulse Function (Figure 8.). Most of the façade of the building is textured by DPF basis of the repeating objects. Some façades that cannot be textured with DPF, is textured with photorealistic method by rectifying images and cleaning disturbing objects.

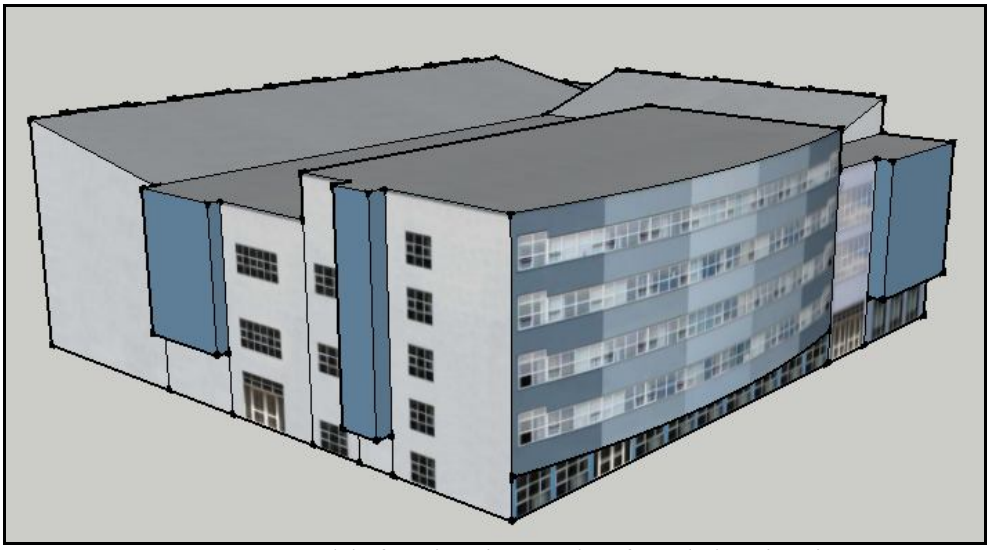


Figure 8. 3D model of Engineering Faculty of Karabuk University

3. Comparison of the Texturing Methods

The usage of photorealistic image texturing method gives more realistic view to buildings but it has some problems besides advantages. After rectifying the images captured with wide-angle camera, decreasing or changing the resolution of the image causes distortions and lower quality. Disturbing objects such as air-conditioners, pedestrians, parking cars and so on, can be removed by manually but it is time consuming if numerous structures will be modeled. Texture images obtained by capturing all of the façade of the buildings by camera. Capturing is done from ground level and the after rectifying the images, the problem of leaning windows especially for upper windows is occurred. This method is more useful for low number buildings for mapping details of the structure.

In usage of pictometry, polygon mapping is not used. The cost of pictometry is not usable in short term, but it is beneficial in long term. The footprints obtained from aerial images cannot be identifiable easily. This problem makes difficult the differentiating structures. In addition, the problem of detection underneath of the structures such as fuelling station. The recognition of non-buildings may happen. This method is more useful for big cities with numerous structures because of high cost.

The laser scanning method is more useful for big cities but there are some problems to overcome. If structure of the roof is changed, geometry errors may happen in terms of applying stereo vision technique. It would be more effective to select blending of several images rather than a single image for texturing to assure a realistic view. This method is decreasing the energy and time consuming.

The fundamental concept of dynamic pulse function is to repeat a pattern for creating textures

based on geometric information. Because of strange and abnormal background or geometry, some of the buildings cannot be textured by dynamic pulse function. Namely, this method can be used for uniform or symmetrically uniform façades. Besides the disadvantages, dynamic pulse function can produce high resolution and less data size textures.

4. Conclusion

In this paper, texturing methods for 3D city modeling is described and compares according to the purposes. Photorealistic method can be used for architectural projects that have not numerous structures. Dynamic Pulse Function is more accurate, fast and realistic than photorealistic method. This method is more useful for part of a city. When increases the number of buildings to be modeled, instead of these methods laser scanning and pictometry methods can be implemented. But quality of the buildings will be reduced owing to not being dealt one by one.

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