Building Three-Dimensional Model for Manama City Center Kingdom of Bahrain

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ABSTRACT

This research project explains how Three-Dimensional (3D) city models are important and developed all over the world, because it represent the Earth's surface and give the people the chance to enjoy a virtual visit in cities. It also presents some Techniques used for generating 3D cities, how we used it, and the difficulties we faced. It also shows that The Kingdom of Bahrain started to develop itself and to follow the world in its progress. A mosaic of high resolution aerial photographs was used to reconstruct 3D building models with accurate details. First, we used stereo graphics to determine the rooftops, roads and trees in the 3D window and also we determined the centroid of the roofs. Second, after finishing all roofs we used the tool extrude for extruding the buildings to ground and we used the tool 3D construct to extrude the buildings from the centroid of the roof. So the main goal of this paper was to build 3Dimensional buildings for Manama capital as a case study using available techniques and datasets. The results show that there is many ways to create 3D buildings if the dataset and the software are available, but not all the ways show real 3D city. In the present research we were able to extrude 3D solid buildings with high quality and high accuracy for Manama Center because this work was huge and needed many interpreters or operators with plenty of time.

بناء نموذج ثلاثي الأبعاد لمركز مدينة المنامة، مملكة البحرين

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المُستلخص

يوضح مشروع البحث هذا أهمية وتطور نماذج المدن ثلاثية الأبعاد في العالم أجمع، لأنها تمثل معالم سطح الأرض في المناطق الحضرية وتعطي الناس الفرصة للتمتع بزيارة افتراضية لتلك المدن. كما يعرض بعض التقنيات المستخدمة لإنشاء المدن ثلاثية الأبعاد، وطرق استخدامها، والصعوبات التي واجهتنا في إنجاز البحث. كما يبين أن مملكة البحرين بدأت بتطوير نفسها وبمواكبة العالم في تطوره. في هذا البحث تم استخدام مجموعة من الصور الجوية عالية الدقة المكانية (50 سم) من أجل بناء نموذج للمباني الحضرية ثلاثية الأبعاد بتفاصيل دقيقة. أولاً تم استخدام جهاز (Stereo Graphics) من أجل تحديد أسطح المباني والطرق والأشجار في صورة جوية على شاشة ثلاثية الأبعاد وأيضا تم تحديد مركز الأسطح. ثانياً بعد الإنتهاء من تحديد جميع أسطح المباني، تم استخدام أداة البناء (Extrude) من أجل سحب جميع المباني الى سطح الأرض وايضا تم أستخدام أداة البناء (Construct) من أجل سحب المباني من مركز سطح المبنى الى الأرض. كان الهدف الرئيسي لهذا البحث هو بناء نموذج ثلاثي الأبعاد لمدينة المنامة كدراسة حالة باستخدام التقنيات والوسائل المتوفرة. تظهر النتائج بأن هناك عدة طرق لبناء مباني ثلاثية الأبعاد إذا توفرت البيانات والبرامج الملائمة لكن هذه الطرق لا تعرض كلها نموذجا حقيقيا ثلاثي الأبعاد. في هذا البحث تم عمل نموذج ثلاثي الأبعاد صلب بجودة ودقة عاليتين لجزء صغير في مركز مدينة المنامة لأن هذا العمل ضخم ويحتاج إلى الكثير من المحللين مع الكثير من الوقت.

الكلمات الدالة

ثلاثي الأبعاد، رسومات ستيريو، زيارة افتراضية، نموذج، منامة، البحرين

Introduction

(1) Previous Studies

Three-dimensional city models are digital representations of the Earth's surface and related objects belonging to urban areas (like cities, factories, buildings, etc.). 3D city models allow citizens, decision makers, developers and tourists to explore and enjoy a virtual visit around the cities. You can walk on the streets or fly on the top of the towers and gain the impression of a city as an attractive area to visit and to do business (Isbister, 2000). The standard technique used to create city models is to apply stereo vision on aerial or satellite imagery. In recent years, advances in resolution and accuracy have also made airborne Laser scanners suitable for generating digital surface models (DSM) and 3D models. Automatic construction of 3D city models by merging Laser Scanners and images taken from the ground level and bird's eye perspective was applied to downtown Berkeley (Fruh and Zakhor, 2003).

A novel approach by integrating multi-view aerial imagery and Lidar data is used to reconstruct three dimensional models with accurate geometric position and fine details. In comparison to Lidar approach, the 3D buildings models derived by the used method have a higher correctness, completeness and geometric accuracy, which mean that the actual approach will lead to higher quality products. However, it is still difficult to automatically reconstruct 3D buildings models for complex structures (Cheng, *et al.,* 2011).

Berlin is the only city in Germany that has been mapped in a fully textured 3D format. The 3D model of Berlin opens up new dimensions for marketing the city. What does Berlin looks like today and what might it looks like tomorrow? The 3D model of Berlin allows viewers to look at the city as it is now, as it once was, and as it might turn into in the future. Using two- and three-dimensional geographic data, they can visualize recent historical changes as well as future urban development projects (BBLCl, 2011). Tehran, the capital of Iran, is bordered in the north by mountains and in the south by desert, and is a city undergoing rapid growth. Since the world around us undergoes gradual changes, maps and 3D models need regular updating. The use of 3D city models reduces cost and effort spent on preparing high-quality representations, map prints and physical models (Parmehr, *et al.,* 2011).

(2) Research Project Objectives

This research project aimed to create 3D solid building for the center of Manama city in the Kingdom of Bahrain by using the construction and extruding tool, which is available in Stereo Graphics and Micro-station software and illustrate the difficulties and obstacles which face the experts while conducting this study. This main goal will be achieved through the following sub-goals:

a) Overview of the software and tools used to create the 3D building.
b) Describe the methodology adopted in the present study.

(3) Characteristics of the Study Area

(3.1) General Context

In the past, geospatial data was mostly 2D, but interest in 3D maps has increased dramatically. Today, it's widely recognized that 3D city models for visual simulation help to support urban planning, tourism, *etc.* Tree-Dimensional city models present and animate all urban features such as buildings, highways, parking areas and bridges on computer platform. 3D city reconstruction helps to set up a base for reorganizing current city structures and it is an important requirement to help future decision-making process. Many cities in the world experience currently strong urbanization and are expanding very fast. Due to the improvement of transportation infrastructures, rural migration as well as high natural birth rates, expanding economies and the effects of globalization in general, these cities increase quickly in the size and get a regional extend. The Kingdom of Bahrain is one of the countries that are interesting to follow in its progress and development.

COWI is one of the largest private mapping and surveying companies in the world which had an important international experience in providing services within surveying, mapping, geographical information, 3D city modeling, IT solutions and land registry. COWI operates three large-format Digital aerial cameras of the type Vexcel Ultra cam, Airborne Laser Scanning and Digital Terrain Models, Oblique aerial photographs, Thermal mapping and Mobile mapping in capturing and

processing large data volumes (COWI, 2011). We used this company as an example to show how big is the work to create 3D Model, which needs big companies and big data to do the Job.

(3.2) Geographic Characteristics

The Kingdom of Bahrain is an archipelago in the middle of Western coast of the Arabian Gulf composed of 40 islands between the Qatar peninsula and Saudi Arabia. It covers the total land area of (717.5 sq. km) and the total sea area of (7552 sq. km) marine borders length of (442 km), and coastlines length of (673 km). The capital, Manama, is on the main island of Bahrain, which contains most of the population (1.8 million) and is linked to Saudi Arabia by a (25 km) causeway (SLRB, 2011). Three main factors have shaped the urban landscape in the Gulf region in general and in Bahrain particularly: the 1970 oil boom, the large-scale movement resulted from the gulf wars, and globalization. Rapid economic growth, which occurred in the region over the past three decades, was accompanied by population growth and increased urbanization. Currently, almost the entire population of Bahrain (92.2%) is living in urban areas. Urbanization and land reclamation projects extend the shorelines into the sea, and resulted in an increase of the total area by (47.3 km2) in 23 years (Ait Belaid, 2006).

(3.3) Study Area: Manama Capital

Manama governorate is the capital and the largest city of Bahrain with total area is about (38.03Sq. Km) and the total Population of Manama is (329.510 inhabitants) in 2010. The geographic location is 50°36' Longitude East and 26°12' Latitude North as shown in figure 1.

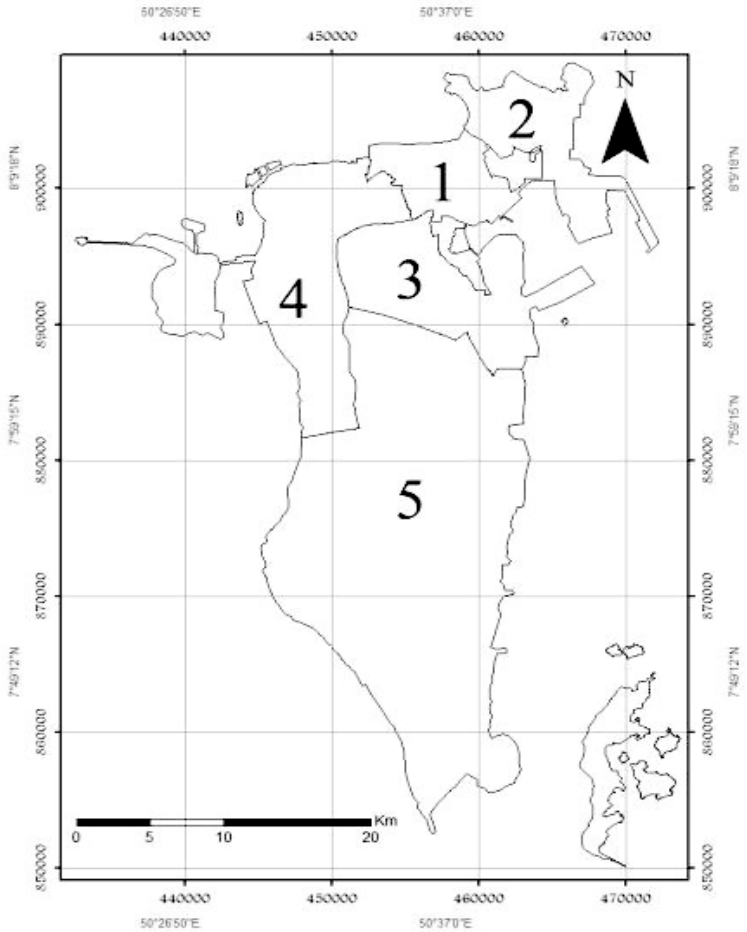

Figure 1: Subdivision of the Kingdom of Bahrain into (1 to 5) Governorates Including Manama Governorate (# 1), Source: SLRB, 2012

Methodology and Materials

(1) Methodology

The methodology adopted is composed of four main successive steps, which are shown in figures 2.

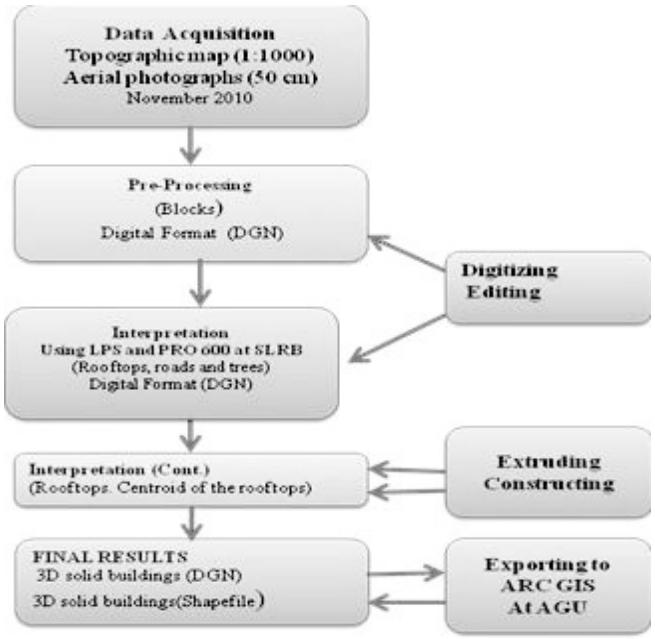

Figure 2: The Adopted Methodology Flowchart Along with Data Input, Processing and Output

(1.1) Data Acquisition

Aerial photographs of November 2010 with very high resolution (50 cm) were provided by the Survey and Land Registration Bureau, Topographic map of Manama capital, Scale of Mapping is (1:1000) in digital format (SLRB, 2010).

(1.2) Pre-Processing

We started by choosing 13 Blocks (301, 302, 303, 304, 305, 306, 307, 308, 309, 313, 314, 315, 316) for creating 3D buildings. This map has been edited using Pro600 to capture the rooftops Buildings from stereo models viewed within LPS by using the collection tool. (See, table 1).

(1.3) Analysis and Interpretation

we digitised the roof outline as it appears. However the digitised shape needs to be moved to the correct planimetric position. At least one corner of the building at base level should be visible. The shape should be moved so that the relevant vertex is correctly positioned at this location. Most features will therefore need to be captured with an accurate height by choosing the centre of the building by the other tools for collection. After capturing all the rooftops buildings, it was possible to extrude the roof to the ground to create solid three dimension buildings. In this step we use two tools for the extruding:

Table 1: Urban Blocks and the Corresponding Areas in Manama City, Source: CIO, 2010

Areas	Blocks	Areas	Blocks
Al- Burhama	353; 354; 357	Salihiya	356
Al-Bilad Al-Qadeem	361; 362; 363; 364	Zinj	358; 359; 360
Al-Guful	312	Al-Seef	428; 436
Al-Naim	303; 314	Karbabad	430; 432; 434
Al-Salmaniya	309; 310; 311; 329	Al-Suwayfiyah	313; 351
Sanabis	402; 404; 406; 408; 410	Sea Front	344; 346
Al-Adliyah	327; 336	Dipl	317
Al-Mahuz	334	Al-Fateh	324
Al-Suqayyah	328	Al-Juffair	340; 341
Buashirah	332	Al-Qudaibiya	308; 321; 325; 326; 338
Bughazal	330; 331; 373	Manama Center	301; 302; 304; 305; 306; 307; 315; 316
Al-Corniche	322	Al-Ghurayfah	342
Al-Hoora	318; 319; 320	Mina Salman Ind. Area	343
Sea Front	344; 346	Umm Al-Hassam	333; 335; 337; 339
Dipl	317	Nabih Saleh	380; 381; 382

(1.3.1) The extrude tool which is used for extruding the rooftops directly.

(1.3.2) The construct tool which is used for constructing the centroid of the rooftops because some roofs do not extrude directly, it needs to click on the centroid of its roof, in addition to the roof outline to construct. These processes required effort and time, because we need to do it one building by one.

(1.4) Results Output

After finishing the whole Blocks, the DGN files were exported to shape files to present the layers in Arc Map. Furthermore, the layers were displayed in ARC Scene (e.g. Buildings, Roads, and Delimiters) because it allowed visualizing the layers in 3D without names of places as shown in figure 3.

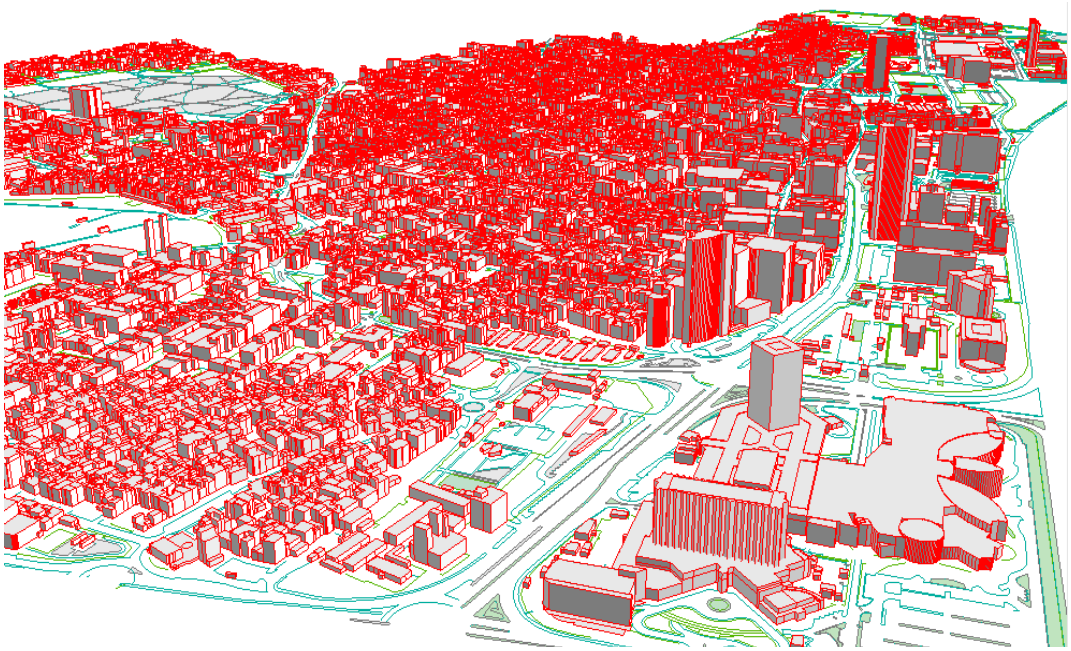

Figure 3: 3D Building for Manama City in Arc Scene (Perspective View)

(2) Materials

Data and Softwares

The study used the following datasets and softwares:

(i) Data and statistical reports gathered from various Ministries and organisations in the Kingdom of Bahrain (SLRB, 2011; CIO, 2010).

(ii) Topographic map of Manama capital, Scale of Mapping is (1:1000) in Digital format.

(iii) Aerial photographs taken on November 2010 with very high resolution (50 cm) as shown in figure 4 (SLRB, 2011)

(iv) LPS Leica Photogrammetry Suite: the Leica Geosystems Photogrammetry Software within ERDAS Imagine.

(v) Pro600 the extension of Bentley Microstation to enable direct capture of vector data into a DGN file from stereo models viewed within LPS.

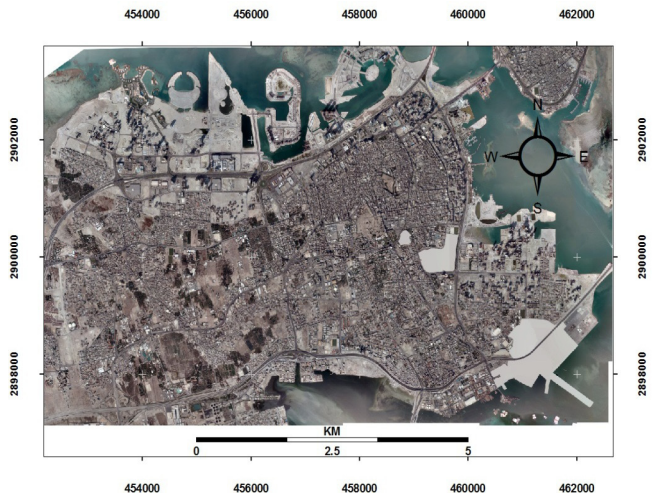

Figure 4: Mosaic of Aerial photographs of Manama City (Resolution of 50 cm),
Source Ref. (SLRB, 2010)

Results and Discussion

To obtain 3D building models with precise geometric position and fine details, very high resolution (50 cm) aerial photographs was required in this study which means it was proposed a higher correctness and accuracy. The main objective in this study is to find out a method to create 3D buildings just by pressing the extruding tool. However, it is still difficult to extrude 3D building models with very complex structures, because it needs different ways in capturing the data and different software for data processing. If the cadastral 2D data and façade measurements are available, it is possible to make real three-dimensional model. In addition, this research still needs more improvement in order to accomplish more efficient generation of 3D building models.

Conclusion and Recommendations

The findings of the study are the followings:

(1) We were able to extrude 3D solid buildings for small parts of Manama centre because this work is huge and needs many operators with plenty of time.

(2) There are many ways to create 3D buildings, if the datasets and software's are available, but not all of them could create real 3D City.

The study recommendations are:

(a) Generalization of the methodology developed to the entire City of Manama or governorate.

(b) Considering the extruding tool as an important method in creating 3D building.

(c) Development of new methods and techniques for the creation of 3D City.

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