بسم الله الرحمن الرحيم

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF GRADUATE STUDIES

Computer Science and Information Technology

Three-Dimensional modeling with Texture Maps for Alfaiha Commercial Center

نمزجه ثلاثية الابعاد مع خرائط الملمس لمركز الفيحاء التجاري

A Thesis Submitted in Partial Fulfillment of the Requirements of Master Degree in Computer science
(GIS Geographical Information Systems)

Prepared by:
Hussein Ahmed Hussein Abosham

Supervised by:
Prof. Dr.-Ing. Dieter Fritsch

August 2017

بسم الله الرحمن الرحيم

وَأَمَّا مَنْ خَافَ مَقَامَ رَبِّهِۦ وَنَهَى ٱلنَّفْسَ عَنِ ٱلْهَوَىٰ ﴿٤٠﴾ فَإِنَّ ٱلْجَنَّةَ هِىَ ٱلْمَأْوَىٰ ﴿٤١﴾

صدق الله العظيم

Dedication

This thesis dedicated to my parents, brothers, sisters, classmate's and my supervisor

For their endless love, support and encouragement

Abstract

The use of geographic information systems (GIS) on public facilities has become widespread in recent times as the need for the application of maps and 3D models has become a real simulation of reality

The purpose of this research is using geographic information systems **GIS** to providing a flexible interactive environment and the best conceptual model for the **Alfaiha Commercial Center** to use it in inquiries, planning and participation in decision-making. The use of **GIS** has added many benefits to visitors and managers by building an integrated model of the building, which shows a lot of information about the building, which helps to easy access and saves a lot of time and effort. The model was built using AgiSoft software. It works on the collection of points to create 3D physical form of the building by collecting photographs of the building from all sides. In addition, converted output to a 3D geometric form using SketchUp software. Where we can add some modifications if some points lost or not completed during image capture or processed in AgiSoft. Then the model was moved to the ArcGIS to add a spatial information and use it on the maps where customers and managers of the Center and all interested can use the form to inquire about any information about the commercial Center

المستخلص

انتشر استخدام نظم المعلومات الجغرافية على المنشئات العامة انتشار كبير في الآونة الأخيرة حيث ظهرت الحاجة لتطبيق الخرائط والنماذج ثلاثية الابعاد وهي محاكاة حقيقية للواقع

يهدف البحث للاستفادة من نظم المعلومات الجغرافية (GIS) في توفير بيئة تفاعلية مرنة لتقديم أفضل نموذج تصوري لمركز الفيحاء التجاري للاستفسارات والتخطيط والمساهمة في اتخاذ القرارات. أصبح استخدام **GIS** يضيف الكثير من الفوائد لمستخدمي المرافق العامة وذلك ببناء نموذج متكامل للمنشئة يبين الكثير من المعلومات عنها مما يساعد على سهولة الوصول ويوفر الكثير من الوقت والجهد. في هذا البحث قمنا ببناء نموذج ثلاثي الابعاد لمركز الفيحاء التجاري يبين معلومات عن المركز حيث يمكن ان يستفيد منها الزوار وإدارة المركز. وقد تم بناء النموذج باستخدام برنامج **AgiSoft** الذي يعمل على تجميع النقاط لإنشاء شكل فيزيائي ثلاثي الابعاد للمبني وذلك بتجميع صور فوتوغرافية للمبني من كل الجهات حيث يقوم بإخراج نموذج في شكل ثلاثي الابعاد ثم تم تحويل النموذج الي شكل هندسي باستخدام برنامج **SketchUp** حيث يمكن إضافة بعد التعديلات واكمال بعد النقاط التي يمكن ان تكون قد فقدت او لم تكتمل اثناء التقاط الصور او معالجتها في **AgiSoft**. ومن ثم قمنا بتحويل النموذج الي **ArcGIS** حيث يمكن اضافة الكثير من المعلومات المكانية واستخدامه على الخرائط بحيث يستطيع عملاء المركز وكل المهتمين الاستفادة من النموذج في الاستفسار عن أي معلومات عن المركز التجاري.

Content

List of Abbreviations

B (BIM) ……………………..……..….Building Information Management

C (CAD) ……………………...………... Computer Aided Drafting
(CIM) ……………………….……………City Information Model
(CRP) ………………..............…...Close Range Photogrammetry

D (DEM) ……………………………………… Digital Elevation Model
(DTM) ……………………………...…. Digital Terrain Model

G (GIS) ………………………………Geographic Information System

L (LOD) …………………………….…………………...Level Of Detail

T (2D) ………………………………………………...Tow Dimension
(3D) ………………………………………………...Tree Dimension

W (WGS) ………………..…………………… World Geodetic System

Chapter 1

Introduction

- Introduction
- Models
- Representation
- Modeling process
- Texture mapping
- Research problem
- Research objective
- Research significance

Chapter 1

Introduction

One of the primary objectives for geospatial data collection and processing is to generate realistic visualization products of sufficient resolution. Because of the complexity of geographic features, realistic visualization becomes a major challenge for geospatial research, development and practice. To achieve this objective, geospatial features need to model effectively at the required levels of resolution and detail [1].

In order to be in line with the great urban progress in the country and permanent renewal of buildings and to go along with the progress of the society and building requirements of existing infrastructures such as universities, hospitals and commercial centers, there is a continuous challenge to plan and add new buildings for public services [2].

One example is Elfaiha commercial center, for which visitors are suffering from difficulties of knowing places of companies and Shops and how to reach it, especially the new visitors. They are wasting their time in asking a way to reach a particular place inside the commercial center - this could have a negative effect on time. Therefore, any plan and project to assist the commercial center administration to develop the commercial center and the provision of visitor's comfort is welcome.

Starting from that point, different ideas and techniques grew up to make it easier for visitors and guiding them to reach a particular place. In this dissertation, three-dimensional visualization with texture mapping is applied to make the true simulation of reality. On the other hand, GIS environments offer a flexible interactive system for providing the best visual interpretation, planning and decision making process [3].

One of the most important concepts to be knowledgeable of when planning the development of 3D urban maps is that very different types of maps can be designed and created, often dependent on the intended application requirements and how they will be utilized. Some 3D maps and the associated building models are no more than photorealistic images of buildings within a geographic area and are, therefore, limited to providing users with the ability to picture how a specific section of a city looks. This can be great for a handful of simple visualization applications but is inadequate for performing many types of 3D spatial analysis. Another possibility is the creation of robust 3D building models, which may not be as visually attractive as the photo-realistic variety but have the ability to be strongly attributed, enabling a variety of GIS analytics to be performed [3].

The 3D urban map and associated building models are enabling the convergence of several established disciplines, including engineering computer-aided drafting (CAD), architectural building information management (BIM), and GIS. A single 3D urban map can now contain detailed building specifications, representations of the physical and functional characteristics of a facility, all tied to a 3D geographic location [4].

This collective urban map, if fully built and attributed, enables a high degree of understanding of the complete urban environment and facilitates an enhanced ability to plan and manage events while providing solid decision-making. However, even if partially complete, 3D maps with key attributes enable significant advances over traditional 2D applications. This research will provide some background on various types of 3D urban mapping, explore several different approaches to creating a 3D urban map, and examine a number of potential applications [5].

Models

Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created by hand,algorithmically (procedural modeling), or scanned. Their surfaces may be further defined with texture mapping.

3D models are widely used anywhere in 3D graphics and CAD. Actually, their use predates the widespread use of 3D graphics on personal computers. Many computer games used pre-rendered images of 3D models as sprites before computers could render them in real-time.

Today, 3D models are used in a wide variety of fields. The medical industry uses detailed models of organs; these may be created with multiple 2-D image slices from an MRI or CT scan. The movie industry uses them as characters and objects for animated and real-lifemotion pictures. The video game industry uses them as assets for computer and video games. The science sector uses them as highly detailed models of chemical compounds.[2] The architecture industry uses them to demonstrate proposed buildings and landscapes in lieu of traditional, physical architectural models. The engineering community uses them as designs of new devices, vehicles and structures as well as a host of other uses. In recent decades the earth science community has started to construct 3D geological models as a standard practice. 3D models can also be the basis for physical devices that are built with 3D printers or CNC machines [6].

Representation

Almost all 3D models can be divided into two categories.

- Solid - These models define the volume of the object they represent (like a rock). Solid models are mostly used for engineering and medical simulations, and are usually built with constructive solid geometry
- Shell/boundary - these models represent the surface, e.g. the boundary of the object, not its volume (like an infinitesicommercial centery thin eggshell). Almost all visual models used in games and film are shell models.

Solid and shell modeling can create functionally identical objects. Differences between them are mostly variations in the way they are created and edited and conventions of use in various fields and differences in types of approximations between the model and reality.

Shell models must be manifold (having no holes or cracks in the shell) to be meaningful as a real object. Polygonal meshes (and to a lesser extent subdivision surfaces) are by far the most common representation. Level sets are a useful representation for deforming surfaces which undergo many topological changes such as fluids.

The process of transforming representations of objects, such as the middle point coordinate of a sphere and a point on its circumference into a polygon representation of a sphere, is called tessellation. This step is used in polygon-based rendering, where objects are broken down from abstract representations ("primitives") such as spheres, cones etc., to so-called meshes, which are nets of interconnected triangles. Meshes of triangles (instead of e.g. squares) are popular as they have proven to be easy to rasterize (the surface described by each triangle is planar, so the projection is always convex) Polygon representations are not used in all rendering techniques, and in these cases the tessellation step is not included in the transition from abstract representation to rendered scene [7].

Modeling process

There are three popular ways to represent a model:

1. Polygonal modeling - Points in 3D space, called vertices, are connected by line segments to form a polygon mesh. The vast majority of 3D models today are built as textured polygonal models, because they are flexible and because computers can render them so quickly. However, polygons are planar and can only approximate curved surfaces using many polygons.
2. Curve modeling - Surfaces are defined by curves, which are influenced by weighted control points. The curve follows (but does not necessarily interpolate) the points. Increasing the weight for a point will pull the curve closer to that point. Curve types includenonuniform rational B-spline (NURBS), splines, patches, and geometric primitives
3. Digital sculpting - Still a fairly new method of modeling, 3D sculpting has become very popular in the few years it has been around.[citation needed] There are currently three types of digital sculpting: Displacement, which is the most widely used among applications at this moment, uses a dense model (often generated by subdivision surfaces of a polygon control mesh) and stores new locations for the vertex positions through use of a 32bit image map that stores the adjusted locations. Volumetric, loosely based on voxels, has similar capabilities as displacement but does not suffer from polygon stretching when there are not enough polygons in a region to achieve a deformation. Dynamic tessellation is similar to voxel but divides the surface using triangulation to

maintain a smooth surface and allow finer details. These methods allow for very artistic exploration as the model will have a new topology created over it once the models form and possibly details have been sculpted. The new mesh will usually have the original high-resolution mesh information transferred into displacement data or normal map data if for a game engine [8].

Texture mapping

Texture mapping is a method for defining high frequency detail, surface texture, or color information on a computer-generated graphic or 3D model. Edwin Catmull pioneered its application to 3D graphics in 1974.

Texture mapping originally referred to a method (now more accurately called diffuse mapping) that simply wrapped and mapped pixels from a texture to a 3D surface. In recent decades the advent of multi-pass rendering and complex mapping such as height mapping, bump mapping, normal mapping, displacement mapping, reflection mapping, specular mapping, mipmaps, occlusion mapping, and many other variations on the technique (controlled by a materials system) have made it possible to simulate near-photorealism in real time by vastly reducing the number of polygons and lighting calculations needed to construct a realistic and functional 3D scene [9].

The Research problem

This project provides an answer to the following questions showing the research problem:

- What is effect of designing system or application representing the geographical locations in a three-dimensional representation for Elfaiha commercial center?
- What are the goals and the importance of designing system or applications represents the geographical areas in three-dimensional modeling?
- What is influence degree and contribution of applying the system on the visitors in Elfaiha commercial center?
- What are the techniques which use in designing three-dimensional systems?
- What is importance of using selected technology in the proposed system?
- The scope of applying the system?
- The obstacles and difficulties that hinder the system works?

Research Objectives

- The main purpose of this research is to understand the benefits of utilizing interactive, three- dimensional (3D) visualization by designing a 3D model for Elfaiha commercial center to assist visitors and commercial center administration when they need to reach palace inside the commercial center.
- Restructuring of the commercial center
- Provides information about all resources inside the commercial center.

Research Significance

Represented in Research Objectives

Methodology and Project Planning

Data Modeling.

Data Measurements, Processing and Preparation
Build 3D model.
Build a 3D GIS model with all relational spatial database.
Texture Mapping.

Chapter 2

Related work and literature

- Related work and literature

Chaper2

Related Work and Literature Review

Title of study:

3D Building Visualization – Outdoor and Indoor Applications

Name of researcher:

DIETER FRITSCH, Institute for Photogrammetry (ifp), University of Stuttgart

Study objectives:

The paper started with general remarks on scientific visualization, computer game engines and Photogrammetric computer environments.

Texture mapping becomes an issue when photorealistic visualizations are desired - no matter which mode is desired - still or streaming. In between of still and interactive (human controlled) streaming modes are movie-like virtual walk-throughs – rendered image sequences resulting from a fixed path set beforehand by the user.

The methods introduced in this paper aimed at visualization methods in PC environments (PoMaViEn) for daily use in simulation, animation and visualization of textured 3D building models. VRML 2.0 can play an important role because of its easy-to-use capability and real-time navigation option.

Title of Study:

Texture Mapping and Implementation Aspects for 3D GIS Applications

Name of researcher:

Nedal Al-Hanbali

Study objectives:

3D modeling of Al Hussein Public Parks

The main objective of 3d modeling and texture mapping is to build suitable procedure for documentation of cultural heritage objects and thus to serve as a tool to make information accessible for documentary and research tourism. Applications for any interested persons, who can investigate the object without going to the site. The result of the documentation has to include not only the graphical knowledge, but also some no graphical information such as objects' history, conservation status and owners

Title of Study:

Hawaiian Islands in 3D

Name of researcher:

An Esri® White Paper

Study objectives:

The State of Hawaii, Office of Information Management and Technology, is now offering 3D GIS building models covering more than 25 square kilometers and consisting of 19,500 measured buildings of Honolulu as part of its Open Data Program. These highly accurate building models were created from stereo aerial imagery by Cyber City 3D (www.cybercity3d.com/) as part of the Hawaii Office of Planning's efforts to gather, analyze, and provide information to the governor to assist in the overall analysis and formulation of state policies and strategies. To help the state plan for its future sustainability, the 3D building models have been used to show the potential for solar renewable energy for buildings, with solar exposure values calculated on actual roof areas and orientation of the roofs to the north.

Title of Study:

3D Modeling Using Multi-View Images

Name of researcher:

Jinjin Li, ARIZONA STATE UNIVERSITY, December 2010

Study objectives:

This thesis presents a MATLAB-based 2D to 3D conversion system from multiple views based on the computation of a sparse depth map. The 2D to 3D conversion system is able to deal with the multiple views obtained from uncalibra ted hand-held cameras without knowledge of the prior camera parameters or scene geometry. The implemented system consists of techniques for image feature detection and registration, two-view geometry estimation, projective 3D scene reconstruction and metric upgrade to reconstruct the 3D structures by means of a metric transformation. The implemented 2D to 3D conversion system is tested using different multi-view image sets. The obtained experimental results of reconstructed sparse depth maps of feature points in 3D scenes provide relative depth information of the objects. Sample ground-truth depth data points are used to calculate a scale factor in order to estimate the true depth by scaling the obtained relative depth information using the estimated scale factor. It was found out that the obtained reconstructed depth map is consistent with the ground-truth depth data.

Title of Study:

Texture Mapping 3D Models of Indoor Environments with Noisy Camera Poses

Name of researcher:

Peter Cheng, University of California, Berkeley

Study objectives:

Texture mapping procedure is shown in Figure 1, they propose a tile-based approach for sampling high-resolution portions of images and compositing them into a texture. Section 2 provides background on the data acquisition system and describes a region segmentation procedure. Section 3 covers existing approaches to image stitching, and their performance on our datasets. Section 4 explains how to down sample the set of available images by selecting those with the best orientation and distance from surfaces under consideration. Section 5 contains the proposed approach towards 2D image alignment, followed by Section 6, which describes two methods of selecting and compositing images to create the final texture. Sections 7 and 8 contain results and conclusions.

Own comments on previous studies

The previous studies contributed to an examination to use current off-the-shelf software technology to build geometry and texture for 3D GIS models using several techniques for various applications. This research aims to take advantage of the proposed recommendations, including the possibility of applying the regulations on the 3D mapping systems using photogrammetry and viewing real world models over PC's desktop environment.

System description

Current System

Alfaiha Commercial Center is property of **Faisal Islamic Bank** (Sudan) and consists a lot of companies, commercial shops, and offices of particular interests. The current system relies on labeling and signs with names of companies, offices and faculties. For customers and visitors during visiting time Elfaiha commercial center offers some brochures and banners greeting for each building and some information about the offices with pictures. Placed signs indicate the offices address. For customers and visitors there is a guarding company in each building appointed to help them as a guide.

Current System Problems

- The customers and visitors have no idea about the commercial center and sections, unless coming to the commercial center.
- Labels or Signs of buildings are not obvious small.

- Some privacy places for males/females unknown as well as prayers places.
- Visitors, especially first time visitors have to ask every time when they want to reach a particular place during the visiting.
- Delaying and loosing time and efforts asking about locations and Procedures.

Proposed System Description

The main objective of 3D modeling and texture mapping is to build suitable procedures for Elfaiha commercial center buildings and thus to serve as tools to make information accessible for visitors and visitors who can investigate the commercial center without going to the site. The importance of commercial center planning focuses on offering 3D real world visualization for Elfaiha commercial center main buildings with its semantic information. In addition, the proposed system will be accessible from desktops and smartphones to take advantage of the virtual visualization anytime.

Scope of system

The proposed system offers a 3D model for the Elfaiha commercial center and includes the three main towers. The system offers 3D visualization for building as well and provides information by using desktop and tablet computers.

Chapter 3

Methodology and research planning

- Research community
- Methodology and planning
- Data molding
- Build 3d model
- Select methodology and technique

Chapter 3

Methodology and Research Planning

Overview

This chapter contains three main headlines, the first about the community of research; the second is methodology and research planning, and the third one is selected methodology and techniques.

Research community

The commercial center represents a complex infrastructure. Especially visitors who are came for the first time and employs because they have a hard time to orientate themselves and finding places. Elfaiha commercial center has three buildings. Visitors do not have continuous help to get to their destination. They can try to figure out a way to get to their target on these static maps, but as soon as they start walking in the target direction, they are without help anymore. So, how is it possible to help freshmen and inexperienced people to orientate them on the commercial center and how can they be supported using modern tools.

The commercial center contains so many companies, offices etc.

Methodology and Project Planning

The objective of this research was to support decisions for the development of virtual Commercial center models by presenting a structured overview of 3D GIS analyses that are likely to be applied in 3D modelling.

The research methodology and project planning will be done in the following steps, by using ARCGIS applications: data acquisition, generation of a 3D model, visualization of the 3D model. In the following the implementation steps required to build a true reality 3D GIS model of Elfaiha Commercial center with texture mapping are given.

- Data Modeling.
- Data Measurements, Processing and Preparation -Building of 3D models.

- Build a 3D GIS model with all relational spatial databases. - Texture Mapping [9].

Data Modeling:

- **Data collection** of all available geospatial databases and attribute data no matter it is

• Images captured by scanning buildings for dense image matching.
• Point cloud files (Las data format).
• Files available from point clouds for the 3D model construction.
• Attribute database and documentations related to the commercial center information.

- **GIS Data Modeling:**

This is an important step to define all required geospatial databases including vector and raster classes and their relationships based on the defined objectives of the project. This will draft what is required and also missing to build the desired GIS data model.

Data Measurements

- **Processing and Preparation:**

To build the required 3D GIS information system.

- **Data measurements and capturing:**

In this process some important data measurements are given:

- Dense images of the area of interest using a high precision camera.
- Stereo images of objects to build 3D models,
- Photos of required texture to be used as filters, later on to put texture to 3D models.

- **Data Processing and Preparations:**

In this process, the important processing steps are as follows:

- Build point clouds for the area of interest (using AgiSoft PhotoScan).
- Build 3D view of the point clouds (Autodesk 3DMAX and Trimble SketchUp are used).

- Edit captured photos and add texture (MS Paint is used).
- According to the GIS data-model, build 2D layers. also add their attribute data (Esri ArcMap is used).
- Build relational databases within the GIS data model layers (Esri ArcMap and Esri ArcEditor are used).

Build 3D Model:

Based on required details and available spatial data and also according to the GIS data model design all the needed features are selected. In the following are the important implemented cases: [7]

Case I Simple 3D shape geometry:

In this case the 2D layer was built and the height dimension was determined either by direct survey measurements or taken from CAD drawings. The 3D model can be built directly in the 3D GIS software environment. The shape appears like 3D block shapes (Esri ArcScene software is used).

Case II 3D CAD Model is available:

In this case, the dimensions have to be verified by scaling it with the built 2D layer and also via survey measurements. The final 3D model is then verified and georeferenced to its exact position on a map (Autodesk AutoCAD and Trimble SketchUp software's are used).

Case III Only 2D layer is available:

In this case close range photogrammetry is used to build a 3D wire mesh of the required object(s) using the captured stereo imagery during the data capturing step (AgiSoftPhotoScan and Photomodeler software's are used).

Case IV some parts are available in 2D and others in 3D: Combination of case II and III is used, but it is very important to use a consistent reference system to merge all 3D objects into one object (Trimble SketchUp software works well in this case) [3].

BUILD A 3D GIS MODEL with all relational spatial database:

that corresponds to the 3D model. There are several techniques to insert the built-up 3D models from step 3 within the 3D GIS environment as follows:

- The 3D GIS environment in our case is the ArcScene environment of the ArcGIS software. The datum for providing a reference base-height for any inserted point, 2D or 3D objects is chosen.

• **Case I Simple 3D shape geometry**: In this case ArcScene build the 3D model directly using the 2D vector layer with the added height information as part of the layer attribute for each feature in the layer, or added directly as a constant height for all features in the layer. A DTM is also specified as the base-height for all layers.

• **Case II 3D CAD Model is available:** In this case, if the CAD software has the capability to export the 3D model file into 3D shape file, it then can be inserted directly into the ArcScene environment. Quite often the file can be imported into SketchUp software, where it will be exported into the proper format for ArcScene. It is important to note that complex 3D models should be split as much as possible to smaller objects in order to be able to export it easily into the environment using the geodatabase format. Our practice found that the best scenario is to use SketchUp software. You can better control your splitted objects since the export formats are geodatabase standards. Also, it is important to georeference the model to its exact position in ArcScene before exporting it.

• **Case III Only 2D layer is available:** In this case close range photogrammetry such as PhotoModeler or other photogrammetry software such as SOCET SET or Z/I can export the 3D model to 3D CAD model or shape file. Our recommendation is to convert the models to CAD format and
then exporting them to SketchUp software and repeat the same as described above.

• **Case IV some parts are available in 2D and others in 3D:** A Combination of case II and III is used, but it is very important to use a consistent reference system to merge all 3D into one object (SketchUp software works well in this case) [3].

Texture Mapping:

Appending to all facets of the 3D features the true texture is very essential to simulate reality and thus provide the user/planner with a true scene, that can help in making better decisions. The following are the options and scenarios one can follow:

Use the Orthophoto with added DTM as a base-height to provide true texture of the earth and ground surface for the area of interest.

Append/stitch texture to build up 3D models using the following options:

- **Orthophoto Accurate Texture Mapping:** One needs to build Orthophotos of all the faces of the objects. Use these images as filters to append/stitch these to the 3D CAD model surfaces using Sketch up or 3D MAX software's.

- **Direct photo Texture Mapping**: It is important when capturing the photos for the model surfaces to make the line of site of the camera axis as perpendicular as possible to the surface of interest. Then use these photos as filters to append/stitch these to the 3D CAD model surfaces using SketchUp or 3D MAX software.

  In both cases, the best way to export the 3D model with texture is through exporting all models to SketchUp software and then exporting it in a geodatabase format to ArcScene software.

Export the built up 3D model object with texture as point-symbols. SketchUp software is designed to work perfectly in case of:

- The object is designed to provide general attributes of the whole building for example, if he object is very complex and cannot be exported as true 3D model with texture.
- The objects are standard and are very similar in shape such as villa compounds, To be built using other software's such as SketchUp or 3D Max.

  The resultant 3D reality model offers a flexible and interactive visual decision support system for data management. The following sections are the direct implementation results of the above discussed methodology for various applications, that are related to the conducted system [3].

Selected methodology and techniques

The suggested methodology is very flexible and can be utilized and implemented for various types of projects and applications, that are becoming essential in the near future. Photogrammetry and Texture mapping is now becoming feasible with low cost and less time consuming using the new capabilities of the below mentioned software's. In this proposed system, several software's will be employed and used in order to complete the required production, which are the following:

- **AgiSoft'sPhotoScan:**

AgiSoft PhotoScan is an advanced image-based 3D modeling solution aimed at creating professional quality 3D content from still images. [9]

It will used to extract the point clouds by dense image matching of the areas of interest.

- **TrimblesSketchUp Pro (version 2016):**

The platform enables users to create collections of models, including 3D buildings, and share them with fellow modelers around the world. SketchUp, which was a tiny startup when Google bought it in 2006, now, boasts of millions of active users.

It will be used to import point clouds in *.las format and exporting 3D models from and to ArcGIS depending to build/complete 3D building

Models. Finally, was use for adding the true texture to these models

The Undet extension package works well with SketchUp for importing point clouds and exporting 3D models in various file's formats.

- **Esri's ArcGIS 10.1:**

ArcGIS Desktop is comprised of a set of integrated applications, which are accessible from the Start menu of your computer: ArcMap, ArcScene and ArcCatalog. **ArcMap** is the main mapping application, which allows you to create maps, query attributes, analyze spatial relationships, and layout final projects. **ArcCatalog** organizes spatial data contained on your computer and various other locations and allows for searching, previewing, and adding data to ArcMap as well as manage metadata and set up address locator services (geocoding). **ArcToolbox** is the third application of ArcGIS Desktop. Although it is not accessible from the Start menu, it is easily accessed and used within ArcMap and ArcCatalog. ArcToolbox contains tools for geoprocessing, data conversion, coordinate systems, projections, and more.

ArcMap will be used to build 2D GIS layers and data-model, in addition to ArcScene that provides suitable 3D environment [2].

- **Sketchfab:**

Is the leading Internet platform to publish and find 3D and VR content, anywhere online. Moreover, it is a good environment to upload files in almost any 3D format.

Sketchfap will be used to visualize the 3D model in VR mode by uploading the model to be accessible online

Chapter 4

System analysis and design

- System requirement
- Analysis and design

Chapter 4

System Analysis and Design

Overview

This chapter contains system requirements, subdivided in functional and non-functional requirements and system analysis with design.

System Requirements

Functional Requirements:

- The system provides 3D design for Elfaiha commercial center.
- The system aims to provide information about all the Commercial center towers.
- Also its aims to represent all resources within the Commercial center in a hologram.
- The system offers real world visualization, helps visitors and administrators viewing the resources inside the Commercial.
- It also supports virtual visualization over desktop platforms to be accessible anytime.
- The system illustrates locations of the؟؟؟؟؟.
- It also illustrates locations of landmarks, gates and textured towers.
- It even identifies locations of mosques and other places of prayer in the Commercial center and private sections for male and female.
- It illustrates locations of cafeterias.
- For now, trees are not yet involved in the model.

Technical Requirements:

The tower geometry (dense point cloud and mesh generation) usually has the largest memory footprint, especially if the model is constructed in medium or high quality. This fact should be carefully taken into account. The processing of the photographs and the 3D model construction comprises the following main system requirements:

Minimal configuration

Windows XP or later (32 or 64 bit), Mac OS X Snow Leopard or later, Debian/Ubuntu (64 bit).

Intel Core 2 Duo processor or equivalent.

2GB of RAM

Recommended configuration

- Windows XP or later (64 bit), Mac OS X Snow Leopard or later, Debian/Ubuntu (64 bit).
- Intel Core i5 processor.
- 4 GB of RAM.

- The number of photos, which can be processed by PhotoScan depends on the available RAM and reconstruction parameters used. Assuming that a single photo resolution is of the order of 10 MPixel, 2GB RAM is sufficient to create a model based on 20 to 30 photos.12GB RAM will allow to process up to 200-300 photographs.
- In addition, capturing photos for objects must be taken panoramically and it is better to use a high precision camera as well as an Xcopter with a camera on board. The resulting 3D model must be available over desktops and various smartphone platforms (Windows, Android, and iOS)

Nonfunctional Requirements

In order to obtain better model visualizations, the system has to achieve the following specified requirements:

- Performance: The most important requirement is the performance of the system, which includes the following:
  - Query and Reporting time: the response time between the mouse action and retrieving object information.
  - Response time: also the time of loading the model, which is subject to the screen refresh times or orientations.
- Availability: the system needs to be available all the time, for every visitors / visitor over desktop and smartphone platforms.
- Maintainability: the model also has to be updated due to the ongoing renewal of Commercial center towers.

Analysis and Design

Database Design

As well known, GIS layers are groups of features organized object-wise and are stored in a Shapefile format. In this Research, 2D and 3D layers have been created using Esri's ArcGIS software. The model comprises 2D GIS layers, which contain the geospatial data of the objects. In particular these layers are the tower layers.

Database Transactions

Information retrieval is essentially required, when the users inquire about a particular object by getting a popup message. Thus, the data must well organized.

The 3D model of the Elfaiha commercial center will be visible for each visitors and visitor online for better view and access over desktops (Web browser) and smartphones allowing them to orient the model or retrieve geodata in response of a mouse click.

Chapter 5

Simulation and result

- Photogrammetry
- AgiSoft
- Model reconstruction
- ArcGIS

Chapter 5

Introduction

This chapter contains a full documentation of the main interfaces of the system, which has been ordered according to the implementation using 3D modelling software sequentially. For the photo shooting, a Canon camera and a smart phone are used (see figure 5.1)

Photogrammetry

- A 3D model of the main campus was created. An excerpt of an aerial photo from Google Maps has been taken illustrating the region and location of Elfaiha commercial center (Figure 5.2).
- The first step of the study was getting the point clouds of the buildings from a collection of overlapping images using Dense Image Matching. To build the required 2D and 3D GIS information system, some data measurements and processing were applied.
- Furthermore, we have to take more images in this research.
- A set of overlapping images have been captured panoramically using CANON camera and a mobile phone camera as illustrated in (figure 5.1).

Figure 5.1 Canon camera and phone

Figure 5.2 An image patch from Google Earth excerpt illustrating the Geographical Location of Alfaiha Commercial Center

Figure 5.3: Several Photos “scanning” of building (the front)

Figure 5.4 Several Photos “scanning” of building (from behind)

AgiSoft

- PhotoScanis a software of AgiSoftfor the pose estimation and dense image matching.
- AgiSoftPhotoScan is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data [11]. (Figure 5.5)

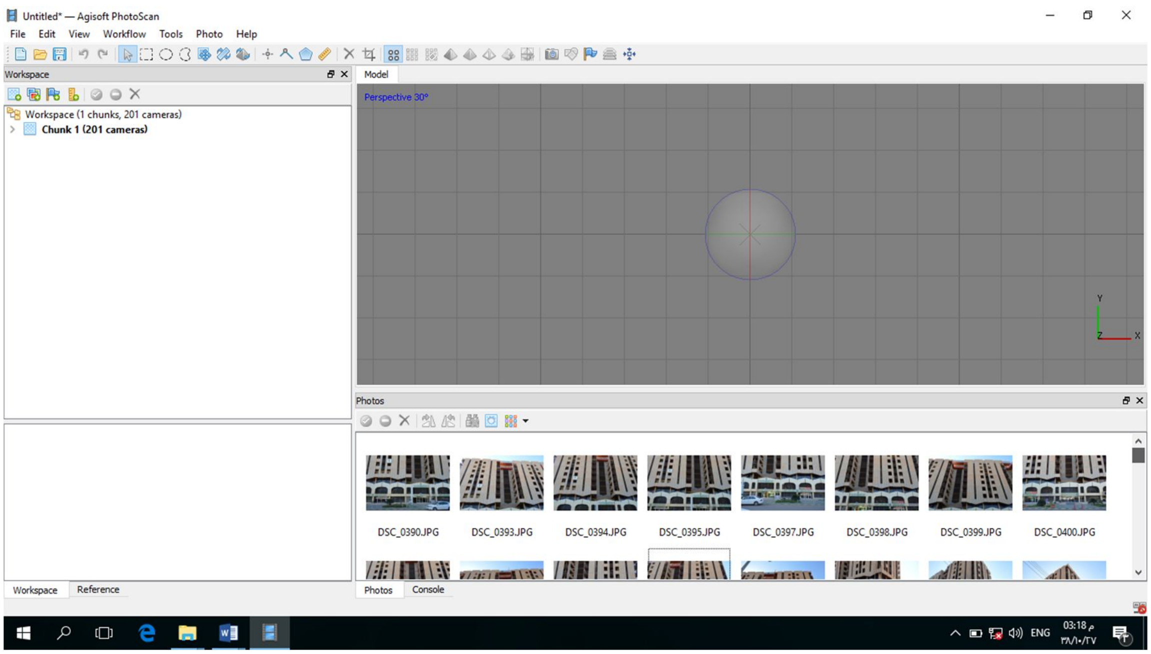


figure 5.5 AgiSoft program

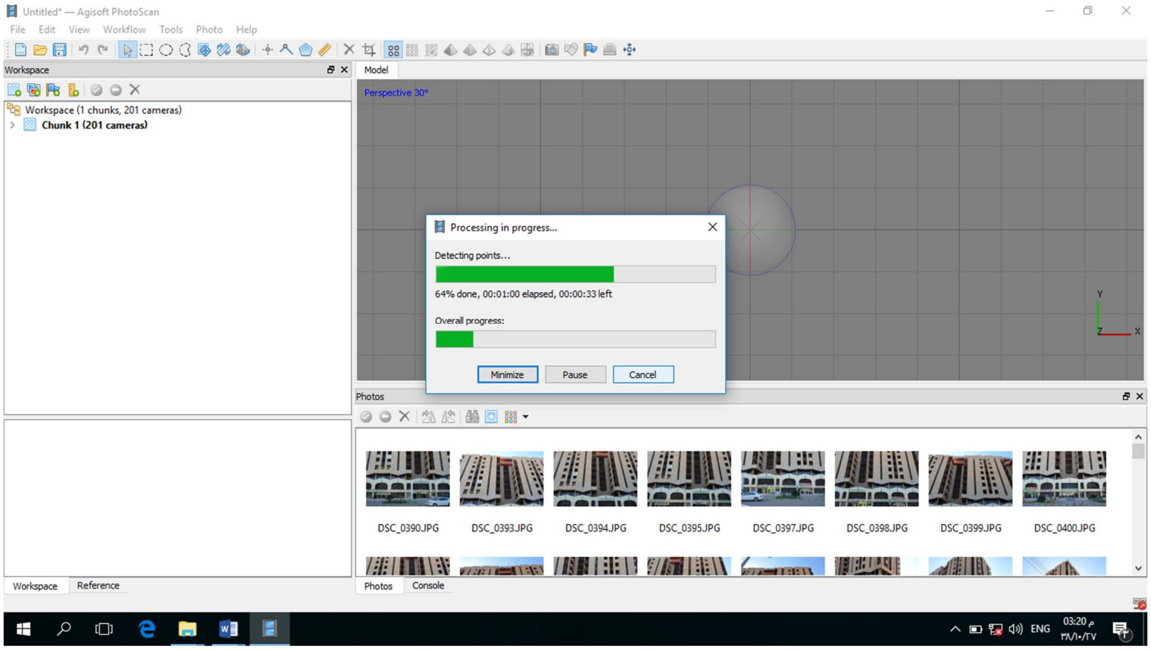


Figure 5.6 Align photo and point processing

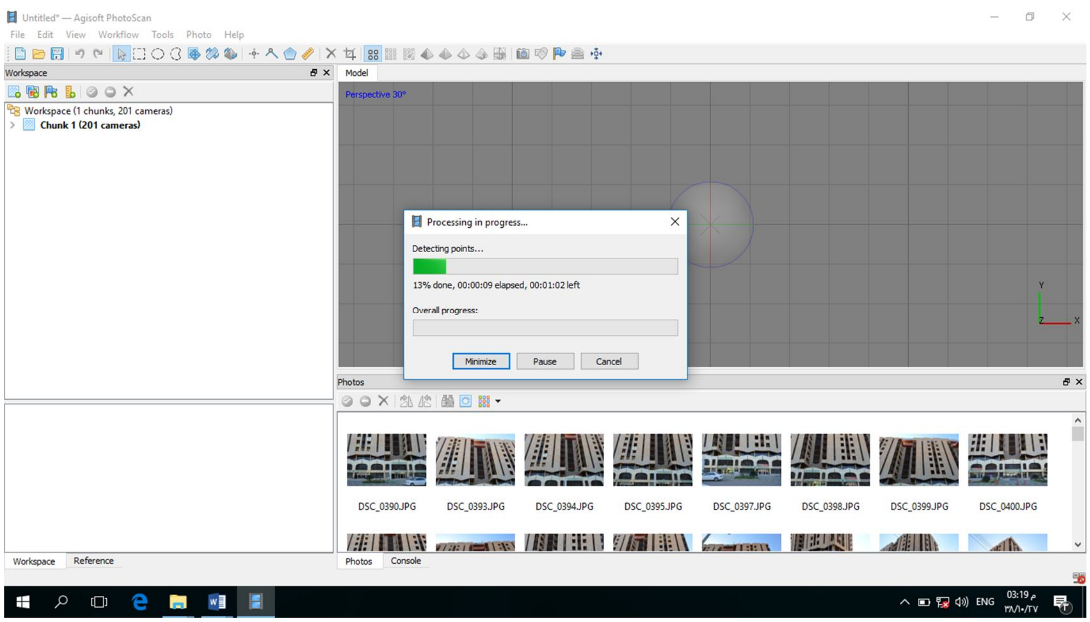


Figure 5.7 Second step build dense cloud

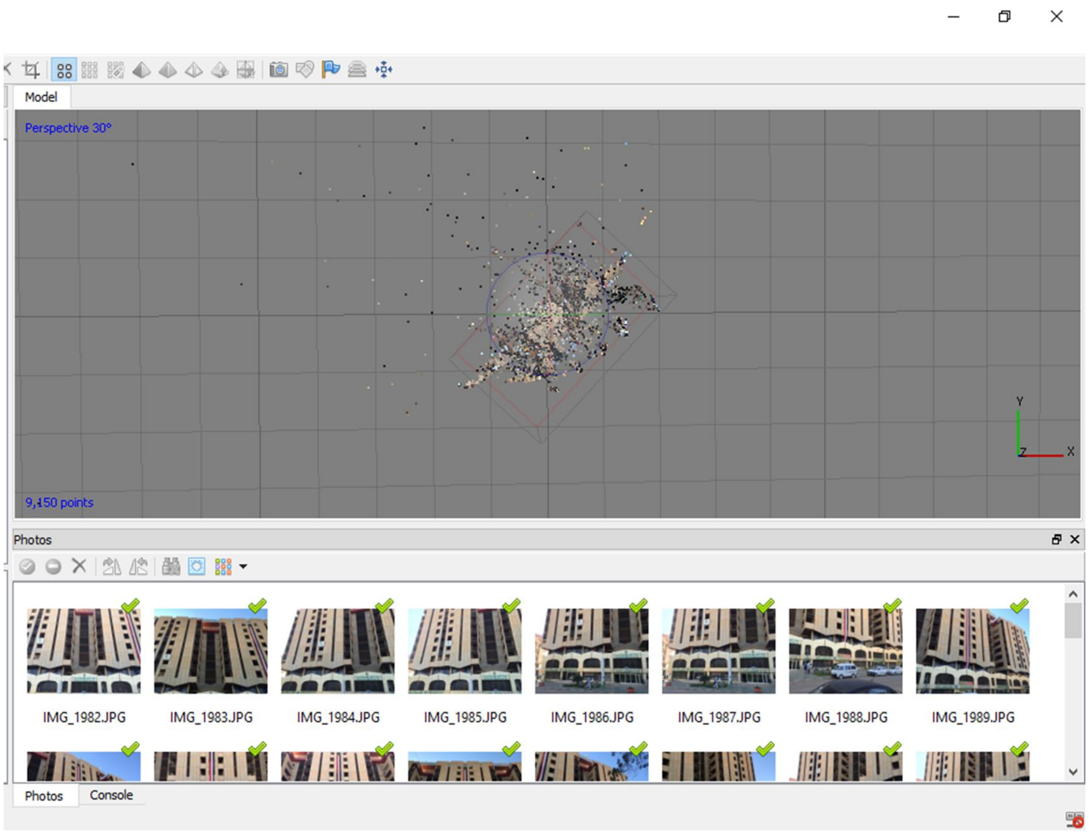


Figure 5.8 Result from (align photo) and (building dense cloud)

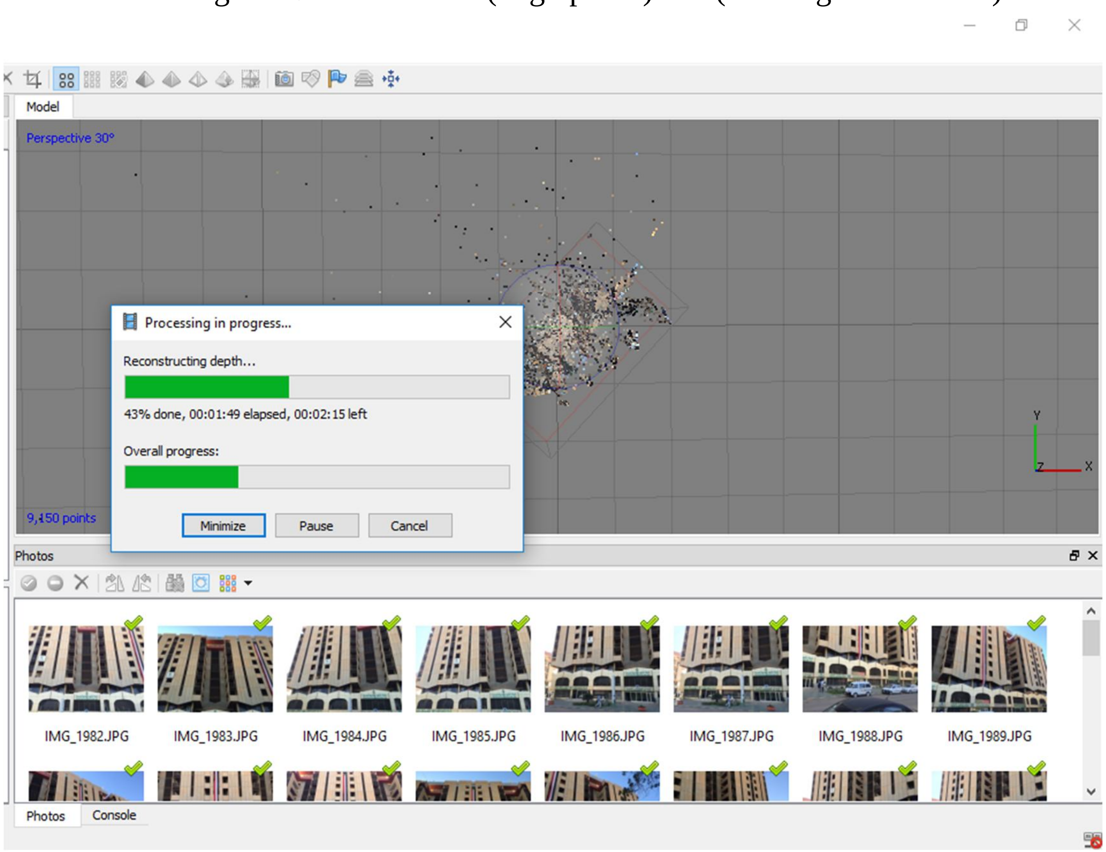


Figure 5.9 Third step build mesh

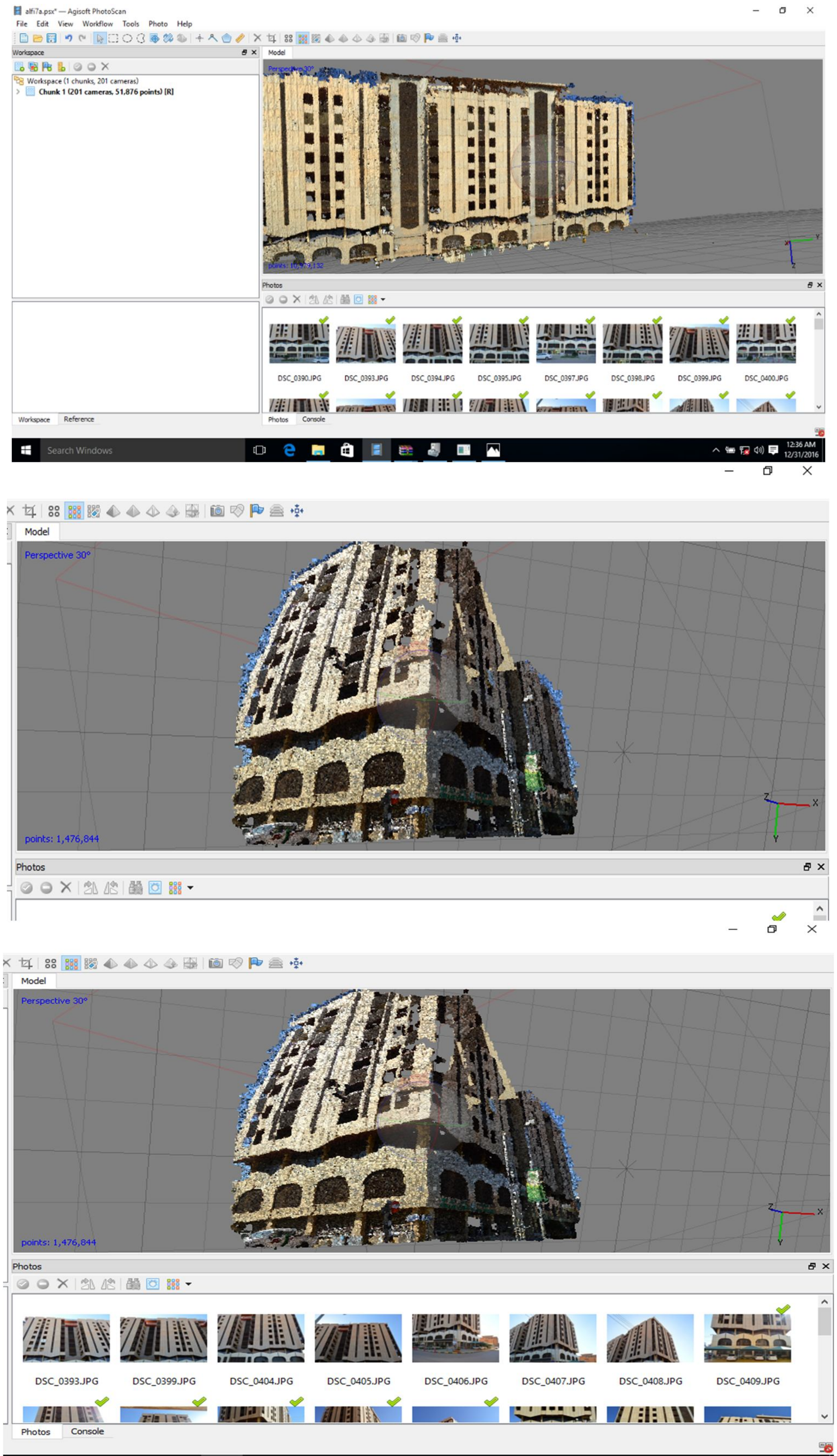


Figure 5.10 Final AgiSoft result for alfaiha center

Model Reconstruction

Reconstructing a 3D model is a combination of several processes or phases. 3D and 2D vector and raster data were created for the Region of Interest (RoI) using Trimble's SketchUp pro software and Esri's ArcGIS.

SketchUp

SketchUp software works well for texture mapping and allows to customize and duplicate any shape or repeated pattern. This procedure is useful for creating virtual reality models. The first step with SketchUp was importing the point cloud files and customizing the objects by filling gaps and clarifying building details and refining.

Undet Extension package was used for importing the point cloud (las format) files and adjusting objects. This works well with SketchUp (2015/2016 version) as an extension for importing numerous point cloud files, resulting from airborne LiDAR, Mobile Mapping Systems, Terrestrial Scanners, Handheld Scanners or Photogrammetry[11].

The second step was adding texture for the model to be built by customized point clouds. SketchUp synthetic textures and image textures used to guarantee better visualization and true virtual reality. This demonstrated in Fig (5.11).

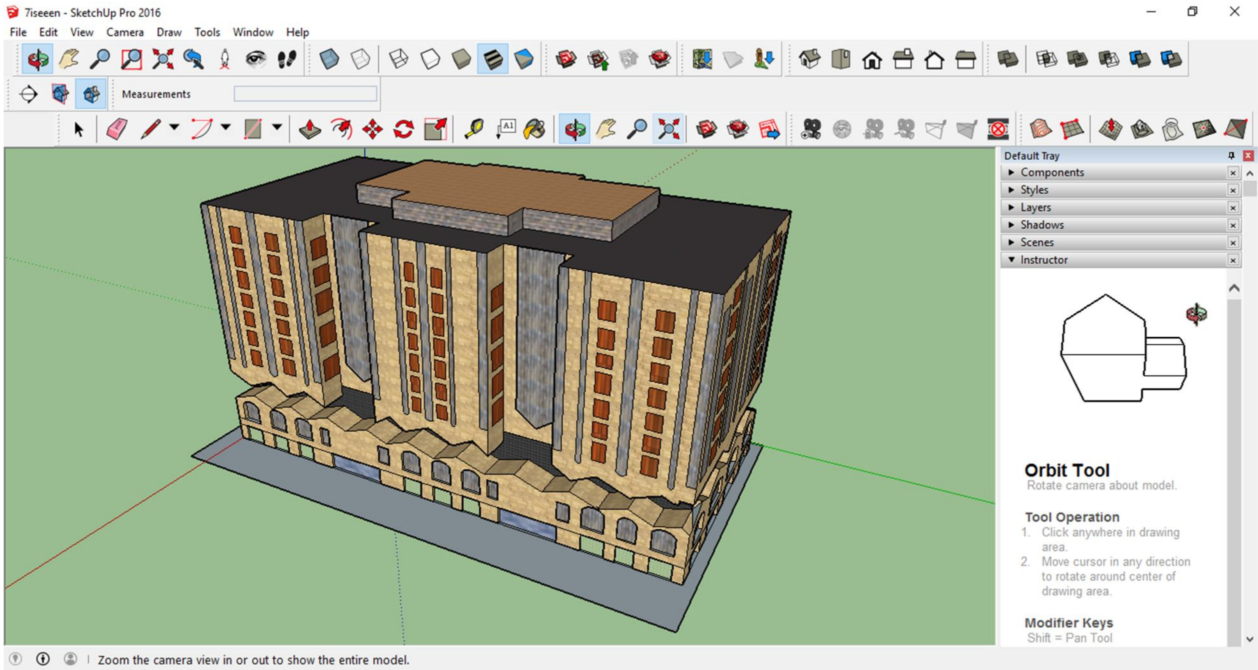


Figure 5.11 Final sketch up result for Alfaiha Commercial Center

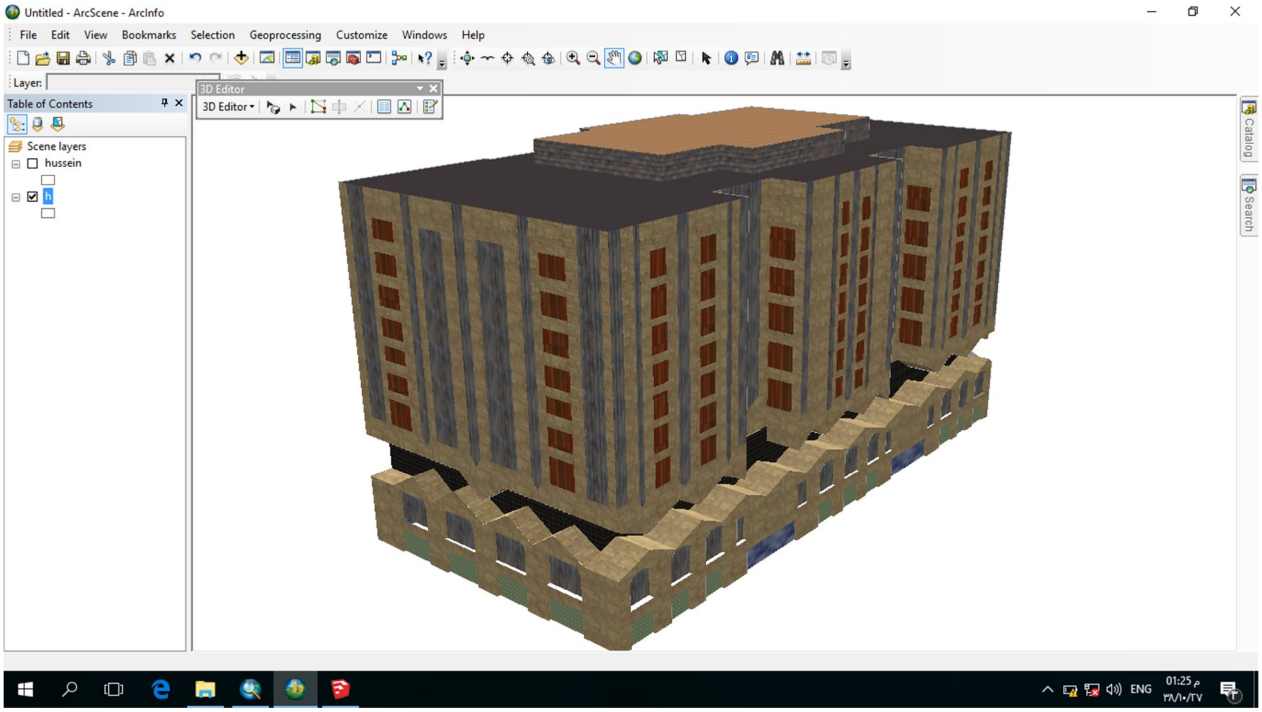
A 3D model has been extracted from this phase as a final textured model as shown in Fig (5.10) – (5.11), the output from this step is a 3D file in *.dae and *.3ds format.

ArcGIS.

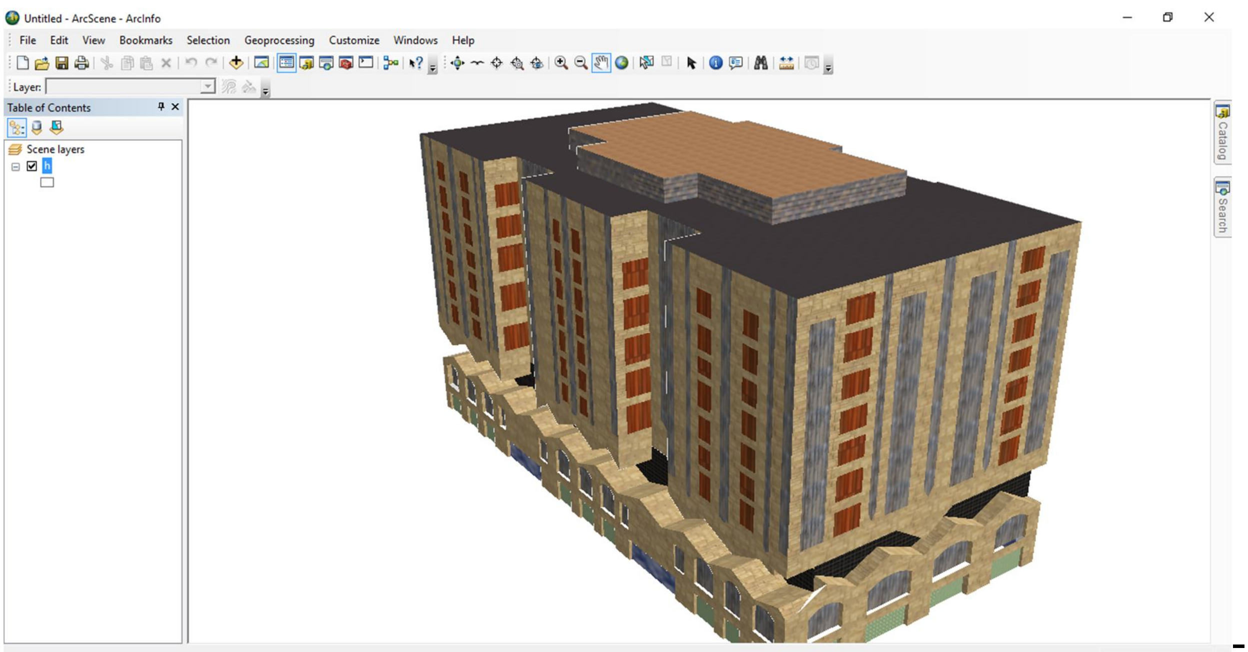
ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database [12].

ArcGIS is one of (COTS) software's that allow for emitting reality and building 3D geometric, vector and raster layers, and to provide geo-referencing[13]. Analyses help in decision-making. This step is concerned with extruding 3D buildings for 2D building vector layers – the results are 3D models, 3D buildings layer, as shown in Fig. Here a suitable coordinate system has to be chosen (vertical and horizontal) for which we selected the World Geodetic System WGS 1984 UTM Zone [35,36,37]N, covering Sudan. Finally, the layers had to convert to shapefiles as illustrated in Fig 5.12.

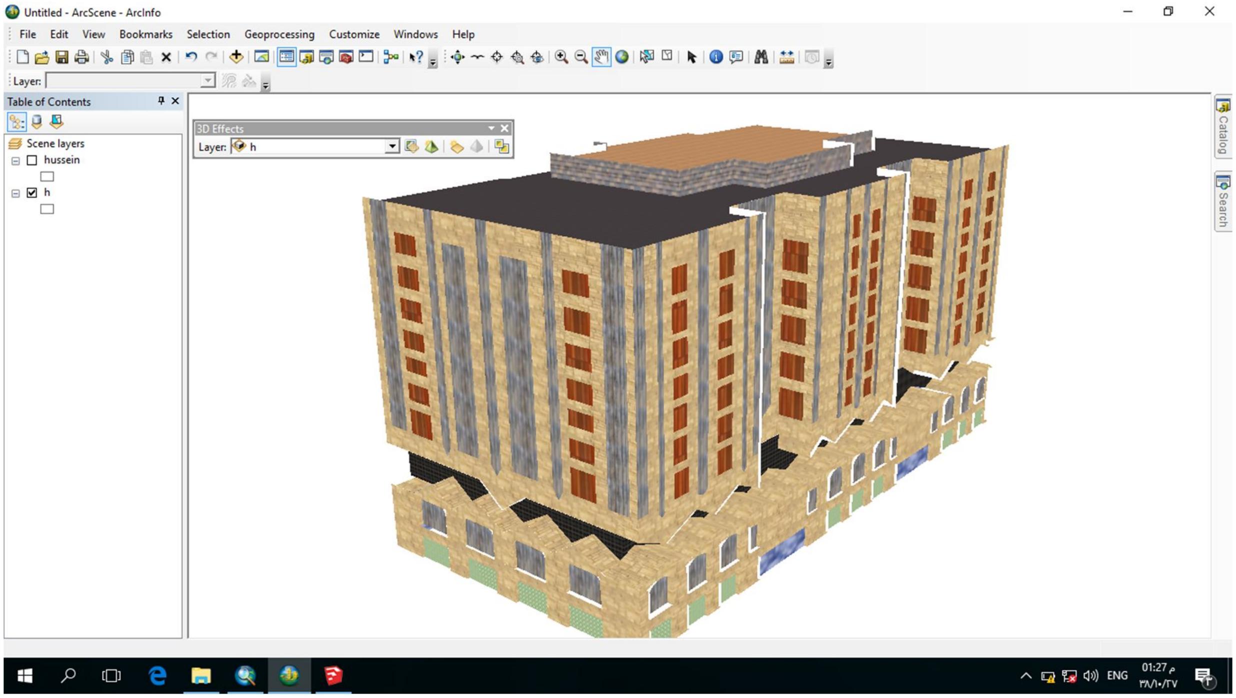
In this conversion to shape file take 5 minutes to convert alfaiha model to shapefile because the sensitivity of analysis this conversion illustrated in Fig 5.12


Untitled - ArcScene - ArcInfo
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Layer:
Table of Contents
3D Editor
3D Editor
Scene layers
hussein
h
Catalog
Search
ENG
01:25

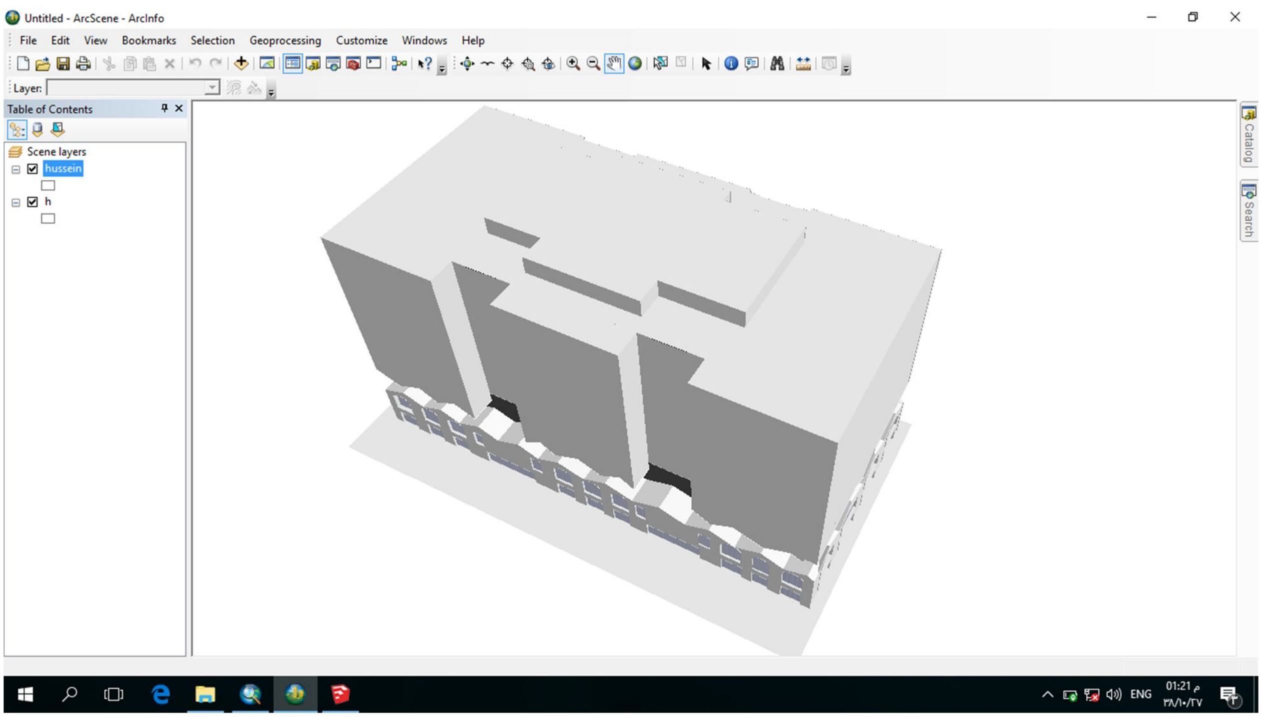
-A-


Untitled - ArcScene - ArcInfo
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Layer:
Table of Contents
Scene layers
h
Catalog
Search

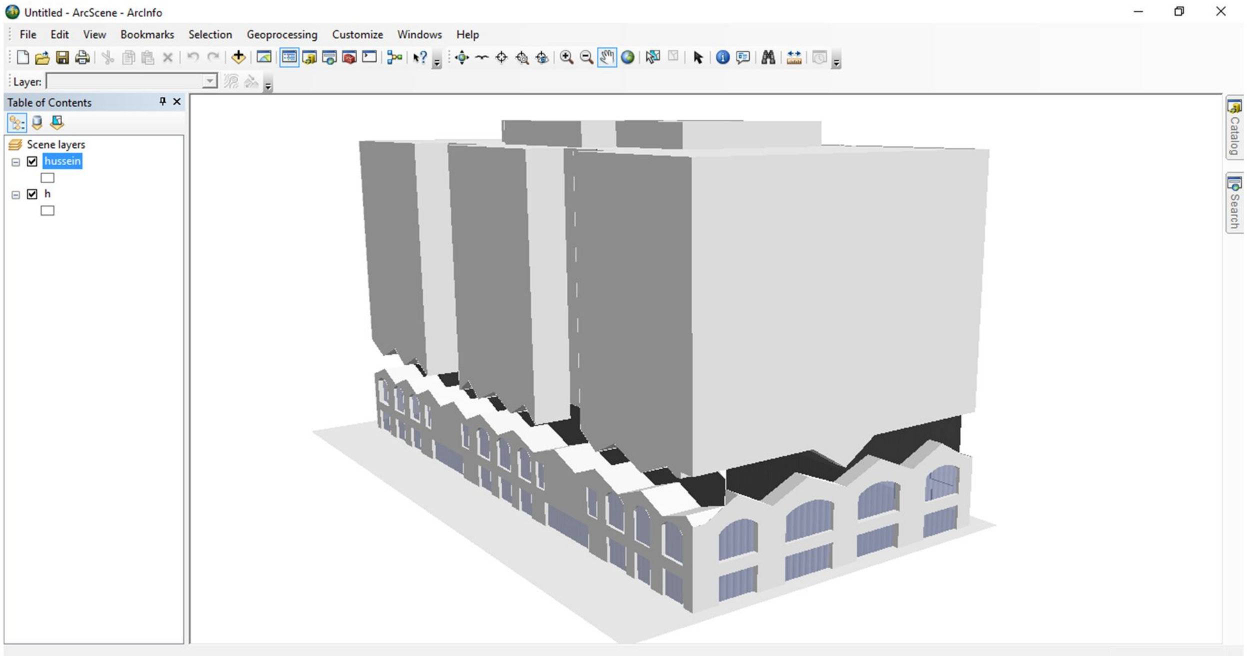
B-


Untitled - ArcScene - ArcInfo
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Layer:
Table of Contents
Scene layers
hussein
h
3D Effects
Layer: h
Catalog
Search
ENG

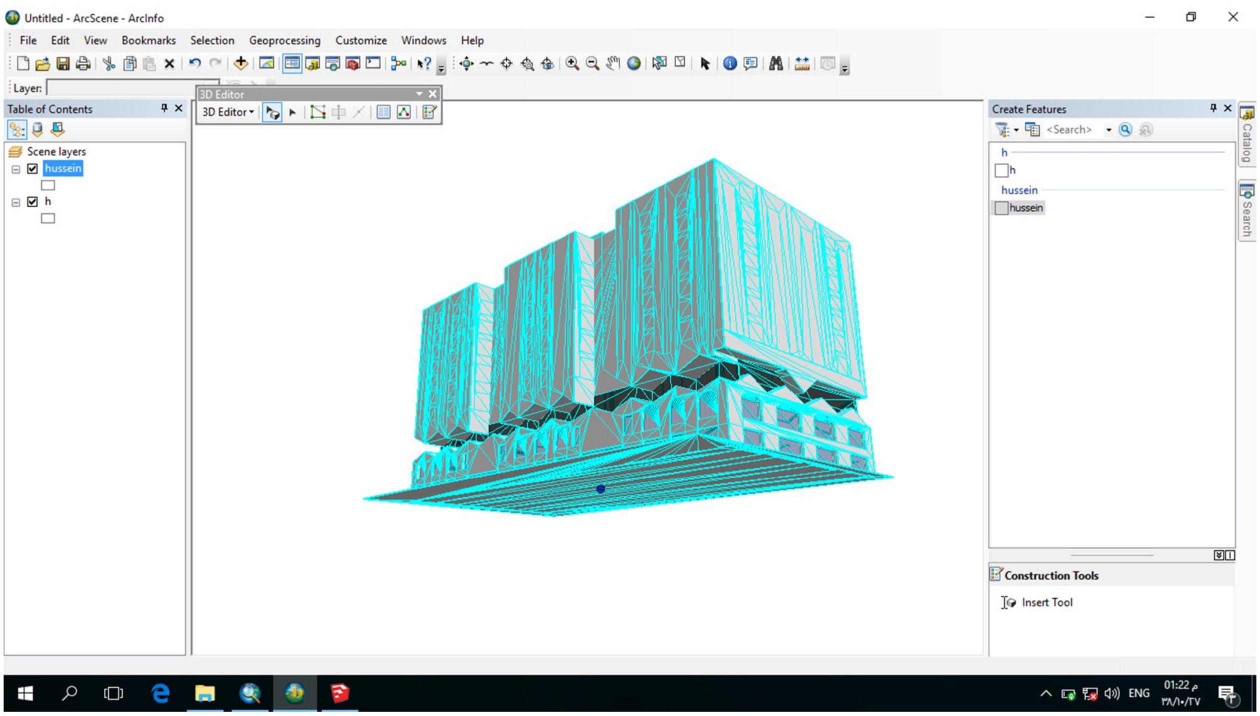
-C-


Untitled - ArcScene - ArcInfo
File Edit View Bookmarks Selection Geoprocessing Customize Windows Help
Layer:
Table of Contents
Scene layers
hussein
h
Catalog
Search
ENG

-D-



-E-



-F-

Figure 5.12 Alfaiha Commercial Center 3d model from different views shape file

Chapter 6

Conclusion and outlook

- Conclusion
- Recommendations
- References

Chapter 6

CONCLUSION

This thesis implements a 3D modeling system to reconstruct the 3D depth information. This work contributes to the field of 3D imaging. This chapter summarizes the contributions of this thesis and proposes several directions for future research.

Contributions

In this thesis, a complete system for 3D modeling and depth reconstruction is Implemented. The contributions of the thesis can summarized as follows:

- The 3D modeling system in this thesis implements feature detection and
- Image registration techniques to relate 3D model.
- Outlier removal and two-view geometry computation it implemented in this thesis.
- The projective reconstruction of the 3D scene it implemented in this thesis.
- This work is the result of research that explores the effective use of 3D modeling in various applications. The thesis illustrates the feasibility of using photogrammetry and software's in 3D GIS modeling.

Virtual reality modeling it used to build Alfaiha Commercial Center a three-dimensional model with texture mapping. That allows for virtual reality visualizations, orientations and navigations around the whole Alfaiha center without georeferenced data and databases.

More and more fields now need and adopt technologies of 3D modeling. There is number of directions in which we need to continue. Foremost among these is 3D model retrieval. To measure similarity of models, characters of 3D models, such as shape, topological construction and texture, are used. These characters are difficult to describe for users and complicated to calculate, while an effective retrieval function is necessary for an integrated 3D modeling system. Nowadays, the visual quality becomes one of the main points of attention. There is more and more demand for 3D content with higher accuracy. Information of scene and object could not collected absolutely during the 3D data acquisition, and some data is inevitably lost, we could not

recover the real word from videos or images by the current design. Therefore, it is worthy for us to explore new methods to digitize the real world. Dynamic model is our new direction for the future work. Dynamic models can simulate reciprocal actions of objects, which is also very helpful in exploring the discipline of thing's evolvement.
The approach used in this work presents a simple strategy that is suitable for the development of realistic views of buildings and the introduction of an accurate virtual reality environment.

This thesis essentially aims at using GIS technology to guide visitors and administrators in their navigations over the Alfaiha center without wasting time and efforts.

Recommendations

For more efficient and real views, the following suggestions recommended:

- Utilize GIS modeling for showing details inside the building, features and measurements
- Take advantages of GPS properties for users and administrators positioning.
- Add companies, agencies and all information related to alfaiha center 3d model.
- Connecting Alfaiha center 3D model directly with the web site to introduce easier access to visitors.

References

[1] The University of Maryland Libraries, Spatial Analysis Using ArcGIS 10" user manual 2012.

[2] Three-Dimensional modeling with Texture Maps for Khartoum International Airport, Elgasem Elfakki Ahmed Mohamed, November 2016

[3] Jinjin Li, ARIZONA STATE UNIVERSITY 3D Modeling Using Multi-View Images, December 2010.

[4] Huisman, O. & Rolf A" Principles of Geographical Information Systems", The International Institute of Geo-Information Science and Earth Observation (ITC) 2009 pp. 32-49.

[5] ünster, S., 2010, "Workflows and the role of images for virtual 3D reconstruction of no longer extant historical objects", Dresden University of Technology, Germany, 9/2013, pp. 2-5 and pp. 198-201.

[6] Al-Hanbali, N. 2007 " Texture Mapping and Implementation Aspects for 3D GIS Applications", Research Paper of Al-Balqa Applied University, 12/2007, pp. 2-16.

[7] Al-Rawabdeh, A., Al-Ansari, N. Attya1 H. &Knutsson S. 2014'' GIS Applications for Building 3D Campus, Utilities and Implementation Mapping Aspects for University Planning Purposes'', Journal of Civil Engineering and Architecture, ISSN 1934-7359, USA, pp 4-9.

[8] AgiSoft LLC ,2013, "AgiSoftPhotoScan User Manual", Professional Edition, Version 1.0.0, pp 1.

[9] "SketchUp Pro" retrieve from http://www.reuters.com/article/ustrimble-google-idUSBRE83P0V820120426 (May 22, 2016).

[10] "About sketchfap", retrieve from https://sketchfab.com/ (May 22, 2016).

[11] "About photogrammetry" http://www.photogrammetry.com/ (May 22, 2016).

[12] "About ArcGIS" http://www.esri.com/software/ArcGIS/ArcGIS (May22, 2016)