SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

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COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Three-Dimensional Modeling with Texture Mapping

For Omdurman Accident and Emergency Hospital

نمذجة ثلاثية الأبعاد مع خريطة تصميم الملمس لمستشفي ام درمان للطوارئ والاصابات

A Thesis Submitted In Partial Fulfillment of the Requirements of Master Degree in Computer Science

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الايـــــة

بسم الله الرحمن الرحيم

قال تعالي: (ويسئلونك عن الروح قل الروح من أمر ربي وما أوتيتم من العلم إلا قليل)

صدق الله العظيم

سورة الإسراء الاية (85)

DEDICATION

To:

My beloved parents, a precious thought to me.

To my brother and sisters, whose cheerful patience

and constant encouragement made this project

Possible.

To my supervisor and friends and all students who are interested in the

field of GIS.

I dedicate this work to them all for the support,

encouragement, love and prayers that they have

always had for us.

My Allah blesses them all and grants them happiness

all through

ABSTRACT:

In the past twenty years, three-dimensional modeling has been the focus of many projects. at present, with the new development of technology, fast processors, tools, digital devices, software and 3D modeling are becoming more feasible and require much less time and effort using appropriate procedures. The objective of this research is to provide information on all resources within the Emergency Hospital to assist new arrivals and visitors who would otherwise waste their time in searching for a specific place within the Emergency Hospital. Restructuring the Emergency Hospital, The purpose of the research is to benefit from GIS in providing an interactive environment to provide the best conceptual model for Omdurman Hospital for Emergencies and injuries for inquiries, planning and decision making. Especially Hospitals, universities and airports buildings are of main concern, which are changing continuously as well as Sections and Wards and offices according to the requirements of the country and by adding new buildings to take the decisions and to follow appropriate and best procedures to reduce as much complex Emergency building for any Hospital by providing a database full of data related to previous established building. In this proposed system, several software's will be employed and used in order to complete the required production, AgiSoft'sPhotoScan, Trimbles SketchUp Pro (version 2016), Esri's ArcGIS 10.1(Arcscene).

المستخلص:

في السنوات العشرين الماضية ، كانت النمذجة ثلاثية الأبعاد محور العديد من المشاريع. اما في الوقت الحاضر مع التطور الجديد للتكنولوجيا ، أصبحت المعالجات السريعة والأدوات والأجهزة الرقمية والبرمجيات والنمذجة ثلاثية الأبعاد أكثر جدوى وتتطلب وقتًا أقل وجهدًا أقل بكثير باستخدام الإجراءات المناسبة. الهدف من هذا البحث هو تقديم معلومات عن جميع الموارد داخل مستشفى الطوارئ لمساعدة الوافدين الجدد والزوار الذين يضيعون وقتهم في البحث عن مكان محدد داخل مستشفى الطوارئ. يهدف البحث إلى الاستفادة من نظام المعلومات الجغرافية في توفير بيئة تفاعلية لتوفير أفضل نموذج مفاهيمي لمستشفى أم درمان لحالات الطوارئ والإصابات للاستفسارات والتخطيط واتخاذ القرارات. خصوصا المستشفيات والجامعات والمباني والمطارات ، والتي تتغير باستمرار، وكذلك الأقسام والأجنحة والمكاتب وفقا لمتطلبات البلد وعن طريق إضافة مبان جديدة لاتخاذ القرارات ومتابعة مناسبة وأفضل الإجراءات للحد من مباني طوارئ المعقدة جدًا لأي مستشفى من خلال توفير قاعدة بيانات مليئة بالبيانات المتعلقة بالمبنى السابق. في هذا النظام المقترح، تم استخدام عدة برامج من أجل استكمال البحث وهي: AgiSoft'sPhotoScan, Trimbles SketchUp2016 , ArcGIS 10.1(Arcscene).

CONTENTS

LIST OF FIGURES:

LIST OF ABBREVIATION:

Abbreviation	Definition
BIM	Building Information Management
CAD	Computer Aided Drafting
CIM	City Information Model
CRP	Close Range Photogrammetry
COTS	Commercial Of The Shelf
DEM	Digital Elevation Model
DTM	Digital Terrain Model
GIS	Geographic Information Systems
GPS	Global Position System
LOD	Level Of Detail
LAS	Leaser
LiDAR	Light Detection And Ranging
2D	Tow Dimension
3D	Three Dimension
VRM	Virtual Reality Model
WGS	World Geodetic System
webGL	Web Graphics Library

CHAPTER 1

INTRODUCTION

1.1 Overview:

This chapter contains five main headlines, the first about the introduction of research, the second is Problem Statements, and the third is Research Hypothesis, and the forth in Project objectives, and the fifth in the Significant.

1.2 Introduction:

Demands for three-dimensional GIS modeling are increasing rapidly with the new evolving and supporting technologies for various applications. Three-dimensional modeling is the true Simulation of Reality, especially if it is accurate. On the other hand, using this model in GIS environment offers a flexible interactive system for providing the best visual interpretation, planning and decision making process. The built model becomes one of the most efficient technologies for spatial data management and analysis. In the past twenty years, three-dimensional modeling is the focus of many research activities. Nowadays with the new development of technology, fast processors, and digital devices tools, the software is becoming more feasible and requires much less time and efforts using proper procedures. Three-dimensional modeling using Digital Photogrammetry techniques to build 3-D models is one of the most suitable and efficient technologies for producing fast and accurate geographic data sources. It optimizes time and cost for producing 3D spatial data by indirect measurement technique rather than field surveying. Such models can be derived from photographs by the extraction and matching of features of interest, models of building exterior structures are demanded by many applications, from navigation to simulation. Exterior models can the geometric basis of semantic information, and virtual outdoor models support exterior designers to have a realistic dataset processing many photos taken from phone cameras.[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 airports, there is a continuous challenge to plan and add new buildings for public services.

The Emergency Hospital comprises numerous buildings and facilities, from Ambergrisand medicial facilities to administrative buildings. The essential objective of this work is to use photogrammetry to provide high precision visualization of the interested area and also to help visitors, doctors, nurses and patients to access the model remotely from anywhere and anytime via desktop or smartphone platforms.

1.3 Problem Statements

The Omdurman Accident & Emergency Hospital is a complex infrastructure and is presently suffering a low precision visualization of the interested areas. This is a weak point as it receives many emergencies, and visitors daily. Especially to new escorts and visitors, because they have a hard time to find orientating themselves and finding the destinations. Even if there are maps at some points in the Emergency Hospital, employees and 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.

1.4 Research Hypothesis

The existence Building Information Modeling (BIM) system will help to reach fast the desired places, especially in complex building blocks. It will provide information about all resources inside the Emergency Hospital taking the client always to the right direction.

1.5 Project Objectives

The main purpose of this research is to understand the benefits of utilizing interactive, three-dimensional (3D) visualization by designing a 3D model to assist escorts and visitors, when they need to reach a place inside the Emergency Hospital, Furthermore, it will.

- Explore the capabilities of current technology of photogrammetry and software such as ArcGIS to link the spatial information about the building features and utilities within the map, which helps on making routing decisions.
- Provides information about all resources inside the Emergency Hospital, when escorts and visitors make location queries and guides them to the right direction.
- Support any restructuring of the Emergency Hospital.

1.6 The Significance

Guiding the authorities and decision makers to take the right decisions for any routing problem and to follow appropriate and best procedures to reduce as much as possible complexities in any Emergency building for Hospitals. This will be done by providing a database full of data related to previous established buildings. The authorities in both ministries, the Ministry of Health and Ministry of Infrastructure in Khartoum State can use the created geo-referenced 3D Virtual Reality model to help freshmen and other inexperienced people to orient them on during an Emergency and how can they be supported using modern tools.

CHAPTER 2

RELATED WORK AND LITERATURE REVIEW

2.1 **Overview:** This chapter contains two main headlines, the first about the Theoretical Framework, the second is Literature Review.

2.2 Theoretical Framework

In the following we use methods of computer graphics, Geographic Information System (GIS) and photogrammetry to solve the problem of constructing Virtual Reality 3D models and to convert them into GIS objects, allowing for spatial analysis, such as short path analysis, buffering etc. Therefore, the strength of these three fields is presented first.

2.2.1 Computer Graphics

Computer Graphics is the discipline of producing images, drawings and maps using a computer including modeling – creation, manipulation, and storage of geometric objects and rendering – converting a scene to an image, or the process of transformations, rasterization, shading, illumination, and animation of the images [2] (see fig 2.1).

Fig 2.1:3D virtual reality models [14]

Many powerful tools have been developed to visualize data. Computer generated imagery can be categorized into several different types: two-dimensional (2D), three-dimensional (3D), and animated graphics. As technology has improved, 3D computer graphics have become more common, but 2D computer graphics is still widely used. Computer graphics has emerged as a sub-field of computer science, which studies methods for digitally synthesizing and manipulating visual content. Over the past decade, other specialized fields have been developed, like information visualization. Scientific visualization is more concerned with "the visualization of three-dimensional phenomena (architectural, meteorological, medical, biological, etc.) ", where emphasis is put on realistic renderings of volumes, surfaces, illumination sources, and so forth, perhaps with a dynamic (time) component.

2.2.2 Geographic Information System (GIS)

a) GIS Definition

GIS is computer software that links geographic with descriptive information. It is a computer based system for the acquisition and update, storage and query, analyses and simulation as well as output and presentation of spatial data. GIS can present many layers of different information, build to capture, manage and display all kinds of spatial or geographical data [3]. In simple words, GIS can be defined as an image that is referenced to the earth. GIS can be used to solve the location based question such as “What is located here” or “Where to find particular features?” GIS users can retrieve the value from the map, such as how much is the forest area on the land use map. This is done using the query builder tool. Next important features of GIS are the capability to combine different layers to show new information. For example, you can combine elevation data, river data, land use data and many more to show information about the landscape of the area. From that map you can tell where a high land is or where is the best place to build houses, which have the river view. Thus GIS may help to find new information with spatial relations.

One of the main usage of GIS is to help making decisions, management of resources, investigations of the earth's surface, that is scientific in nature, archeological uses, planning of locations and management of assets, urban & regional planning, criminology matters, impact assessment of the environment, the assessment and eventual development of infrastructure, studies of the demographics of an area plus its population analysis with regards to engineering. The fact, that we can only represent parts of the real world teach us to be humble about the expectation that we can have about the system – all information it can possibly generate for us in the future will be based upon the data which we provided to the system in the past and present [3] .

Data is the core of any GIS. There are two primary types of data that are used in GIS: vector and raster data. A geo-database is a database that is in some way referenced to locations on the earth (see fig. 2.2). Geo-databases are grouped into three different types: vector, raster and attributes. Vector data is spatial data represented as points, lines and polygons. Raster data is cell-based data such as aerial imagery and digital elevation models. Coupled with this data is usually data known as attribute data. Attribute data are generally defined as additional information about each spatial feature housed in tabular format. Documentation of GIS datasets is known as metadata. Metadata contains such information as the coordinate system, when the data was created, when it was last updated, who created it and how to contact them and definitions for any of the code attribute data.

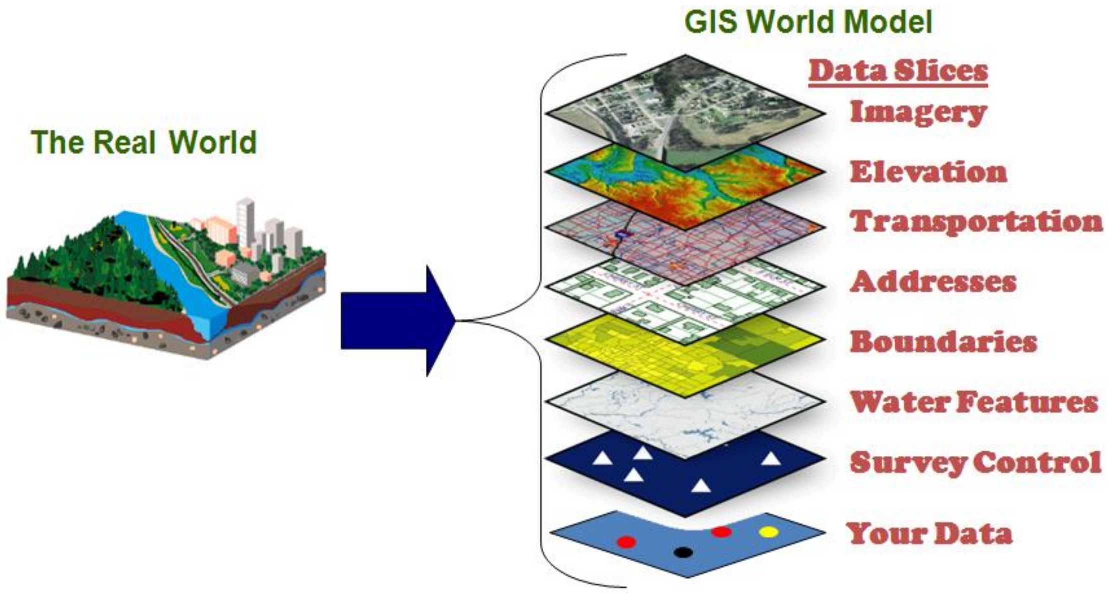


Fig 2.2: GIS Data Layers [15]

b) Models and Modeling

'Modeling' has many different meanings. A representation of some parts of the real world can be considered a model because the representation will have a certain characteristic in common with the real world. It also allows us to study and operate on the model itself instead of the real world, in order to test what happens under varies conditions, and helps to answer 'what if' questions.

The term model is quite often used as representation in a GIS environment. The most familiar model is a map. A map is a miniature representation of some part of the real world. A database is another important class of model, as it can store considerable varieties of data and also provide various information to operate on the stored data [3].

2.2.3 Photogrammetry.

Photogrammetry is the science of obtaining reliable geometric information about the properties of surfaces and objects without physical contact with the objects. It also is an engineering discipline and as such heavily influenced by developments in computer science and electronics. The ever increasing use of computers has had and will continue to have a great impact on photogrammetry. The discipline is as many others, in a constant state of change. This becomes especially evident in the shift from analog to analytical and digital methods. It may also be used to recover the motion pathways of designated reference points on any moving object, on its components, and in the immediately adjacent environment. Photogrammetric analysis may be applied to one photograph, or may use high-speed photography and remote sensing data to detect, measure and record complex 2D and 3D motion fields. Photogrammetry derives measurements from remote sensing and the results of image analysis can be fed into computational models in an attempt to successively estimate, with increasing accuracy, the actual, 3D relative motions.

Photogrammetry has been defined by the American Society for Photogrammetry and Remote Sensing (ASPRS) as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena.

The principle difference between photogrammetry and remote sensing is in the application. While photogrammetry is producing maps and precise three-dimensional positions of points, remote sensing specialists analyze and interpret images for deriving information about the earth's land and water areas (see fig. 2.3) [4]. Both disciplines are also related to Geographic Information Systems (GIS) in that they provide GIS with essential information. Quite often, the core of topographic information is produced by photogrammetry, which is a digital map.

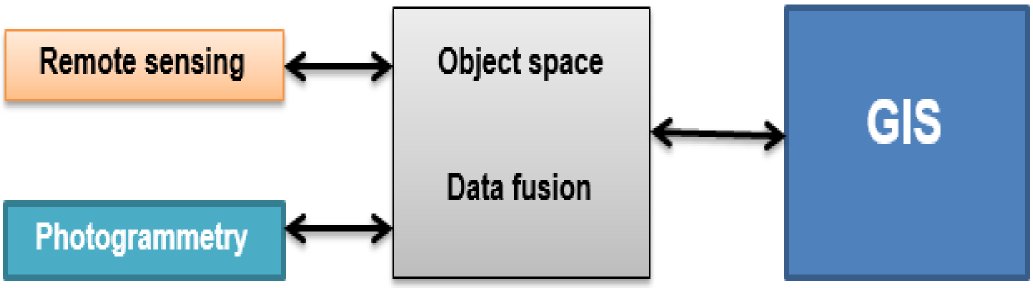


Fig 2.3: Relationship of photogrammetry, remote sensing and GIS. . [4]

Geometric information

Involves the spatial position and the shape of objects. It is the most important information source in photogrammetry.

Physical information

Refers to properties of electromagnetic radiation, e.g., radiant energy, wavelength, and polarization.

Semantic information

Is related to the meaning of an image. It is usually obtained by interpreting the recorded data.

Temporal information

Is related to the change of an object in time, usually obtained by comparing several images, which were recorded at different times. The most typical sensors are cameras, where photographic material serves as detectors. [4]

data acquisition	**photogrammetric procedures**	**photogrammetric products**
Camera photographs ---→	Rectifier	photographic products
		enlargements/reductions
↓	Ortho photo projector	rectifications
	comparator	Ortho photos
Scanner	stereo plotter	points
↓	analytical plotter	DEMs, profiles, surfaces
sensor ---> digital imagery	softcopy workstation	Maps
		topographic maps special maps

Fig 2.4 Photogrammetry portrayed as systems approach. The input is usually referred to as data acquisition, the "black box" involves photogrammetric procedures and instruments; the output comprises photogrammetric products. [4]

Passive systems fall into two categories: imaging systems and spectral data systems. We are mainly interested in imaging systems which are further subdivided into frame systems and scanning system. Image frame systems acquire all data at one instant in time. Scanning systems obtain the same information sequentially for example by collecting scan line by scan line. Image frame systems record radiant energy at different portion of the spectrum. The spatial position of the recorded radiation refers to a specific location on the ground. The image process establishes a geometric and radiometric relationship between spatial positions of the object and image space.

Amongst all of the sensing devices used to record data for photogrammetric applications, the photographic systems whit metric properties are the most frequently employed. They are grouped into aerial cameras and terrestrial cameras. Arial cameras are also called cartographic cameras. A panoramic camera is an example of non–metric aerial camera. Fig. 2.5 depicts digital cameras (airborne and terrestrial). It should be mentioned here, that nowadays all aerial and terrestrial photos are collected using digital camera systems, based on CCD and CMOS technologies. [3]

Fig. (2.5) (a) Aerial camera Hexagon DMC, (b) Kodak DSLR camera [4]

2.2.4 RGB-D Mapping

RGB-D cameras are novel sensing systems that capture RGB images along with per-pixel depth information. Cameras can be used for building dense 3D maps of outdoor environments. Such maps have applications in robot navigation, manipulation, semantic mapping, a full 3D mapping system that utilizes a novel joint optimization algorithm combining visual features and shape-based alignment. Visual and depth information are also combined for view-based loop-closure detection, followed by pose optimization to achieve globally consistent maps. [6]

Introduction

Building rich 3D maps of environments is an important task for mobile robotics, with applications in navigation, manipulation, semantic mapping, and telepresence.

Most 3D mapping systems contain three main components:

- The spatial alignment of consecutive data frames.
- The detection of loop closures.
- The globally consistent alignment of the complete data sequence.

3D point clouds are well suited for frame-to-frame alignment and for dense 3D reconstruction; they ignore valuable information contained in images. Color cameras, on the other hand, capture rich visual information and are becoming more and more the sensor of choice for loop-closure detection. RGB-D cameras are sensing systems that capture RGB (visual) images along with per-pixel depth information. RGB-D cameras rely on either active stereo or time-of-flight sensing to generate depth estimates at a large number of pixels. In fact, the key drivers for the most recent RGB-D camera systems are computer games and home entertainment applications

Fig 2.6 (left) RGB image and (right) depth information captured by an RGB-D camera. White pixels in the right image have no depth value, mostly due to occlusion, max distance, relative surface angle, or surface material. [6].

Techniques for 3D Mapping

3D Mapping is used for:

1. Robots to operate in the three-dimensional world
2. Three-dimensional maps, which support

- Object recognition.
- More accurate path planning
- More reliable localization and data association.
- Navigation on uneven terrain [2].

3D computer graphics

Three-dimensional computer graphics (3D computer graphics, in contrast to 2D computer graphics) are graphics, that use a three-dimensional representation of geometric data (often Cartesian) that is stored in the computer for the purposes of performing calculations and rendering 2D images. Such images may be stored for viewing later or displayed in real-time [2].

3D computer graphics rely on many of the same algorithms as 2D computer vector graphics. In computer graphics software, the distinction between 2D and 3D is occasionally blurred; 2D applications may use 3D techniques to achieve effects such as lighting, and 3D may use 2D rendering techniques.

3D computer graphics are often referred to as 3D models. Apart from the rendered graphics, the model is contained within the graphical data file. However, there are differences: a 3D model is the mathematical representation of any three-dimensional object. A model is not technically a graphics until it is displayed. A model can be displayed visually as a two-dimensional image through a process called 3D rendering or used in non-graphical computer simulations and calculations. With 3D printing, 3D models are similarly rendered into a

3D physical representation of the model, with limitations in accuracy and extensions.

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 infinitesimally thin eggshell). Almost all visual models used in games and film are shell models.

3D modeling software

3D modeling software is a class of 3D computer graphics software used to produce 3D models. Individual programs of this class are called modeling applications or modelers.
3D models represent a 3D object 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 (point and other information), a 3D model can be created by hand, algorithmically (procedural modeling), or by scanning.[3]

Modeling process

1- **Polygonal modeling -** point in 3D space, called vertices, are connected by line segments to form a polygonal 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 point. 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 include non-uniform rational B-spline (NURBS), splines, patches and geometric primitives

3- **Digital sculpting -** there are currently 3 types of digital sculpting: displacement, which is the most widely used among applications at this moment, volumetric and dynamic tessellation.

2.3 Literature Review

Through research on studies on the application of the concepts and techniques of 3D modeling, quite a number of publications have been produced. In the following we will restrict ourselves to review three papers:

2.3.1 Review of prior studies:

Case 1 :

Title of Study : Maarib Ahmed (2016), Three Dimensional Modeling whit Texture Mapping For University Of Science and Technology (SUSTECH).[8]

Name of the Researcher : Maarib Ahmed Altgany Mohammed

Study 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 SUSTECH to assist student and visitors when they need to reach a place inside the university.

- Provides information about all resources inside the university, when students make location queries and guides him/her to the right direction.
- Another objective in this study is to explore the capabilities of current technology of photogrammetry and software such as ArcGIS to link the spatial information about the building features and utilities within the map which helps on making decisions. [8]

Methodology and Project Planning

The main campus was selected to be generated as a 3D GIS model, which would include not only the campus buildings but also administration buildings, lecturs halls, restrooms, cafeterias, libraries, mosques and gates.

In this study, 3D modeling of the SUSTECH campus and its application for a campus information system consist of the following steps: 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 SUSTECH with texture mapping are given [8].

Scope of Study

The proposed system offers a 3D model for the main campus of SUSTECH and includes the following building: University Administration, Students' Deanship, the Secretariat of Academic Affairs, Scientific Research Council, College of graduate studies, College of Fine and Applied Art, College of Science, College of Computer Science and Information Technology, College of Technology, College of Languages, Institute of Islamic Research and Science, Personnel Office, Financial Administration, Legal Affairs Office, and Administration Affairs.

In addition, the gates and milestones for every colleges are on display, also mosques and restrooms for female students. The system offers 3D visualization for buildings as well and provides information using desktop and tablet computers and smart phones [8].

Case 2:

Title of Study: Elgasem Elfakki (2016), Three-Dimensional modeling with Texture Mapping for Khartoum International Airport. [9]

Name of the Researcher: Elgasem Elfakki Ahmed Mohamed

Study 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 Khartoum International Airport to assist the passengers, the airport administration and visitors when they need to reach any place inside the Airport.
- Restructuring of the airport.
- Provides information about all resources inside the Airport.[9]

Methodology and Project Planning

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

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 Khartoum International Airport 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 data bases.
- Texture Mapping [9].

Scope of Study

The proposed system offers a 3D model for the Khartoum International Airport and includes the following buildings: Airport Administration, Departure hall, Arrival hall, Domestic hall, Aircraft, Luggage store, also mosques and etc... The system offers 3D visualization for buildings as well and provides information using desktop and tablet computers [9].

Case 3:

Title of Study: Al-Hanbali, N., 2007, Texture Mapping and Implementation Aspects for 3D GIS Applications [7]

- **Name of the 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 a suitable procedure for documentation of cultural heritage objects and thus to serve as a tool to make information accessible for documentary purposes and research tourism.

It is also an application for any interested person, 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 non-graphical information such as the objects' history, conservation status and owner [7].

Methodology and Project Planning

In the following are the implementation steps applied to build a true reality 3D GIS model with texture mapping that implemented for King Hussein Park [7].

- Data modeling.
- Data measurements, Processing and Preparation.
- Built 3D GIS model.
- Built a 3D GIS model with all relational spatial data base.
- Texture Mapping.

Scope of Study

The scope of study includes Al Hussein Public Park, which is one of the landmarks in Amman, Jordan. The park includes a cultural village, sport fields, memorial building, historical passageway, decorated gardens, amphitheater, circular yard, automobile museum, children museum, Traffic Park, and walls and gates. The study aims at show-casing the cultural heritage once it has been reformulated and then presented in a contemporary way. It contains sites that embody the goal of preserving the architectural heritage and emphasize esthetics [7].

2.3.2 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 regulation on the 3D mapping systems using photogrammetry and viewing real world modules over PC's desktop and smartphone's environment.

CHAPTER 3

METHODOLOGY AND RESEARCH PLANNING

3.1 Overview

This chapter contains three main headlines, the first about the Community of Research, the second is System description, and the third one is Selected Methodology and Techniques.

3.2 Research Community

An Emergency Hospital is a complex infrastructure. Especially to new visitors and escorts because they have a hard time to orientate themselves and finding places. The Emergency Hospital under investigation comprises different buildings with up to three floors high - most of these buildings are far from each other. Even if there are maps at some points within the Hospital, the securities personnel cannot offer continuous help to get to the desired destinations. One can try to figure out a way to get to the target on these static maps, but as soon as one starts walking in the target direction, quite often there is no help anymore. So, how is it possible to help freshmen and inexperienced people to orientate them in the Emergency Hospital and how can they be supported using modern tools.

The Main Emergency Hospital includes the Hospital administration, the secretariat, a male surgery ward, a female surgery ward, spatial ward, insurance office, police office, cafeteria, a mosque, and medicine ward, and a radiology center, and finally Personal Office.

3.3 System description

3.3.1 Current System

The Omdurman Accident & Emergency Hospital consists of a number of Sections and Wards and offices, such as the Medical Director Office, secretariat offices, nurse’s offices, and pharmacy. The current system relies on labeling and signs with names of offices of every building. For new escorts and visitors during the search time slot of drugs or search time slots for doctors or even search time slots about nurses. At present some brochures and banners are offered for each building and some information about the departments and Wards and offices is made available. For escorts and visitors there are Point of Contac’s (PoC) appointed to help them as a guide.

3.3.2 Current System Problems

1. The escorts and visitors have no idea about the Omdurman Accident & Emergency Hospital and procedures before searching, unless an Emergency has to overcome.
2. Some privacy places for males/females are not cleared as well as prayers places.
3. Labels or Signs of buildings are not obvious, quite often they are very small.
4. Escorts and visitors, especially escorts and visitors who are coming for the first time, have to ask every time when they want to reach a particular place within the Emergency.
5. Delaying and loosing time and efforts asking about locations and procedures.
6. Wasting time to put these methods will not help the patient in a timely manner, especially as the patient who is attending his critical state of Emergency may lose his soul during his search for completing the Emergency procedures and looking for doctors, nurses and police departments. Cases of crime and dangerous situations cannot afford to waste time.

3.3.3 Proposed solutions

1. Definition of whole–length of Sections and Wards and Emergency buildings with photos on the website of the Hospital.
2. Distribute brochures about each Emergency Hospital from the beginning to Emergency admissions.
3. Design maps showing the main features of the buildings, departments and access.
4. Using GPS technology to identify sites via satellite navigation.

3.3.4 Proposed System Description

The main objective of 3D modeling and texture mapping is to build suitable procedures for the Emergency Hospital buildings and thus to serve as tools to make information accessible for escorts and visitors, who can investigate the Emergency without going to the site. The importance of Emergency planning focuses on offering 3D real world visualization for the Omdurman Accident & Emergency Hospital 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.

3.3.5 Scope of System

The proposed system offers a 3D model for the main Emergency building and includes the following buildings: Hospital Administration, Sections and Wards, the Medical Director Offices, Secretariat offices, and Nurse' offices and Mosques and etc. In addition, the gates, also mosques and rest halls for visitors are on display. The system offers 3D visualization for buildings as well and provides information using desktop and tablet computers and smart phones.

3.3.6 Proposed System Problems

The proposed system may face hardware and software problem as mentioned below:

1. Suggested software properly not found or it may be coasted.
2. Obtaining a high precision model is time and effort consuming because of lack of hardware scanning devices.
3. High technical requirement such as storage, processors and high precision resolution of the 3D models, which require streaming.

3.4 Methodology and Research Planning

The Emergency Hospital was selected to be generated as a 3D GIS model, which would include not only the Emergency building but also the administration building, the male surgery ward, the female surgery ward, the insurance office, police office, a cafeteria, a mosque, and medicine ward, and a radiology center, the personnel office, and gates.

In this study, 3D modeling of the Emergency Hospital and its transition into an information system consists of the following steps: data acquisition, generation of a 3D model, and the visualization of the 3D model. In the following the implementation steps required to build a true reality 3D GIS model with texture mapping are given.

3.4.1 Data Modeling

First of all data collection and processing of all available geospatial database objects and their attribute data is started, no matter it is done by

- Images, captured for structure-from-motion (SfM) and dense image matching (DIM) processing.
- Generation of point cloud files (Las data format).

- Post-processing of point clouds for the 3D model construction.
- Attribute database and documentation related to the Emergency Hospital information.

Secondly, GIS Data modeling is the logical follow-up to define all required geospatial databases including vector and raster classes and their relationship classes based on the defined objectives of the project.

This finally will draft, what is required and also missing to build the desired GIS data model.

3.4.2 Data Measurements, Processing and Preparation

To build the required 3D GIS information system, the following more detailed steps are required:

Data measurements and capturing: in this process the following items have to be solved

- Take a bunch of dense images of the area of interest, using a high precision camera (D-SLR etc.)
- Stereo images of the objects to build 3D models, what means, overlapping photos. The photos can also be used as filters, later on as source providing texture for the 3D models.
- Ground control points for the area using GPS.
- Building heights and reference points to provide proper scaling

After data measurements and collection **the Data Processing and Preparations** will follow**.** For this process the following steps are necessary:

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

- According to the GIS data model, build 2D layers and 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).

3.4.3 Build 3D Model:

At the beginning the needed features, based on required details and available spatial data and also according to the GIS data-model design, have to be defined. In the following, seven important implemented cases are described: [7]

Case I: Simple 3D Shape Geometry

For this case the 2D layer is built and the height dimension is 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 can be matched with survey measurements. A final 3D model is then verified and geo-referenced to get its exact position on a map (SketchUp software is 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 (AgiSoft PhotoScan is used).

Case IV: Some parts are available in 2D and others in 3D

A combination of case II and case III is used, but it is very important to use a consistent reference system to merge all 3D objects into one single object (SketchIp software works well in this case).

3.4.4 Build a 3D GIS Model with all Relational Spatial Databases that Correspond 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: [7]

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

Case I: Simple 3D shape geometry

In this case ArcScene builts 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 **Digital Terrain Model** is also specified as the 2.5D reference 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 the 3D shape file, then it can be inserted directly into the ArcScene environment. If the file cannot be imported into SketchUp software, 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 geo-database 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 geo-database formats. Also, it is important to note, to have geo-referenced the model to its exact position in ArcScene before exporting it.

Case III Only 2D layer is available:

In this case the close range photogrammetry such as PhotoModeler or other photogrammetry software such as SOCETSET 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:

The combination of **case II** and **case 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).

3.4.5 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: [5]

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

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

(1) 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 SketchUp or 3ds MAX software's.

(2) 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 3ds 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 geo-database format to ArcScene software.

Export the built up 3D model object with texture as point-symbols.

For this item the SketchUp software works perfectly in case of:

- The object is designed to provide general attributes of the whole building for example. If the objects are very complex and cannot be exported as true 3D model with texture, most probably pieces can be used. To make this happen one should split as much as possible a complex object to smaller objects in order to be able to export it easily.
- 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 3ds Max. [7]

The resultant 3D virtual 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.

3.5 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 study, several software are employed and used in order to complete the required production, which are the following:

a. AgiSoft'sPhotoScan

AgiSoftPhotoScan is an advanced image-based 3D modeling solution aimed at creating professional quality 3D content from still images. [10]
It will be used to extract the point clouds by Structure-from-Motion (SfM) and dense image matching (DIM) of the areas of interest.

b. Trimbles SketchUp 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 it was bought by Google in 2006, now boasts of millions of active users. The current owner is Trimble, a market leader in surveying hardware and software.
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, it is used 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.[13]

c. 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. [11]

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

d. Sketchfab:

Is the leading Internet platform to publish and find 3D and VR content, anywhere and anytime in online mode. Moreover, it is a good environment to upload files in almost any 3D format. [12]

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

CHAPTER 4

SYSTEM ANALYSIS AND DESIGN

4.1 Overview

4.2 System Requirements

4.3 Analysis and Design

4. Overview

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

4.1 System Requirements

4.1.1 Functional Requirements

1. The system provides 3D design for the Omdurman Accident & Emergency Hospital.
2. The system aims to provide information about all the Emergency buildings.
3. Also its aims to represent all resources within the Emergency Hospital in a hologram.
4. The system offers real world visualization, helps escorts visitors and administrators viewing the resources inside the Emergency and administration buildings.
5. It also supports virtual visualization over desktop platforms to be accessible anytime and anywhere.
6. The system illustrates locations of the departments and buildings.
7. It also illustrates locations of landmarks, gates and textured buildings.
8. It even identifies locations of mosques and other places of prayer in the Emergency by defining restrooms and private sections for male and female.
9. It illustrates locations of cafeterias.
10. At this point in time trees are not yet involved in the model.

4.1.2 Technical Requirements

The building 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 i7 processor.
- 12GB of RAM.

The number of photos that 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 10MPixel, 2GB RAM is sufficient to create a model based on 10 to 30 photos. 12GB RAM will allow to process up to 100-300 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)

4.1.3 Nonfunctional Requirements

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

1. 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.

2. Availability: the system needs to be available all the time, for every escorts / visitor over desktop and smartphone platforms.

3. Maintainability: the model also has to be updated due to the ongoing renewal of Emergency buildings.

4.2 Analysis and Design

4.2.1 Database Design

As well known, GIS layers are groups of features organized object-wise and are stored in a Shape file 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 building layers.

4.2.2 Database Transactions

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

- The 3D model of the Omdurman Accident & Emergency Hospital will be visible for each escorts and visitor online for better view and access over desktops (Web browser) and smartphones allowing them to orient the model or retrieve geo-data in response of a mouse click.

CHAPTER 5

SIMULATIONS AND RESULTS

5.1 Introduction and Overview

This chapter contains all documentation of the main interfaces of the system, which has been subdivided according to the implementation using 3D modeling software sequentially. Here, the taken photo-shots of the building sides using a smart phone camera with suitable resolution are stiched. In order to have good results, the camera axes should be as much as possible perpendicular to the view. Also, there should be no abstractions and occlusions between the camera and the object for the photo shooting.

5.2 Photogrammetry

- A 3D model of the main Emergency Hospital is created. An excerpt of an aerial photo from Google Maps has been taken illustrating the region and location of The Omdurman Accident & Emergency Hospital (Fig 5.1).
- The first step of the study was getting the point clouds of the buildings from a collection of overlapping images using Dense Image Matching (DIM). To build the required 2D and 3D GIS information system, some data measurements and processing were applied.
- Furthermore, we had to take much more images for this research.
- A set of overlapping images have been captured panoramically using a mobile phone camera.

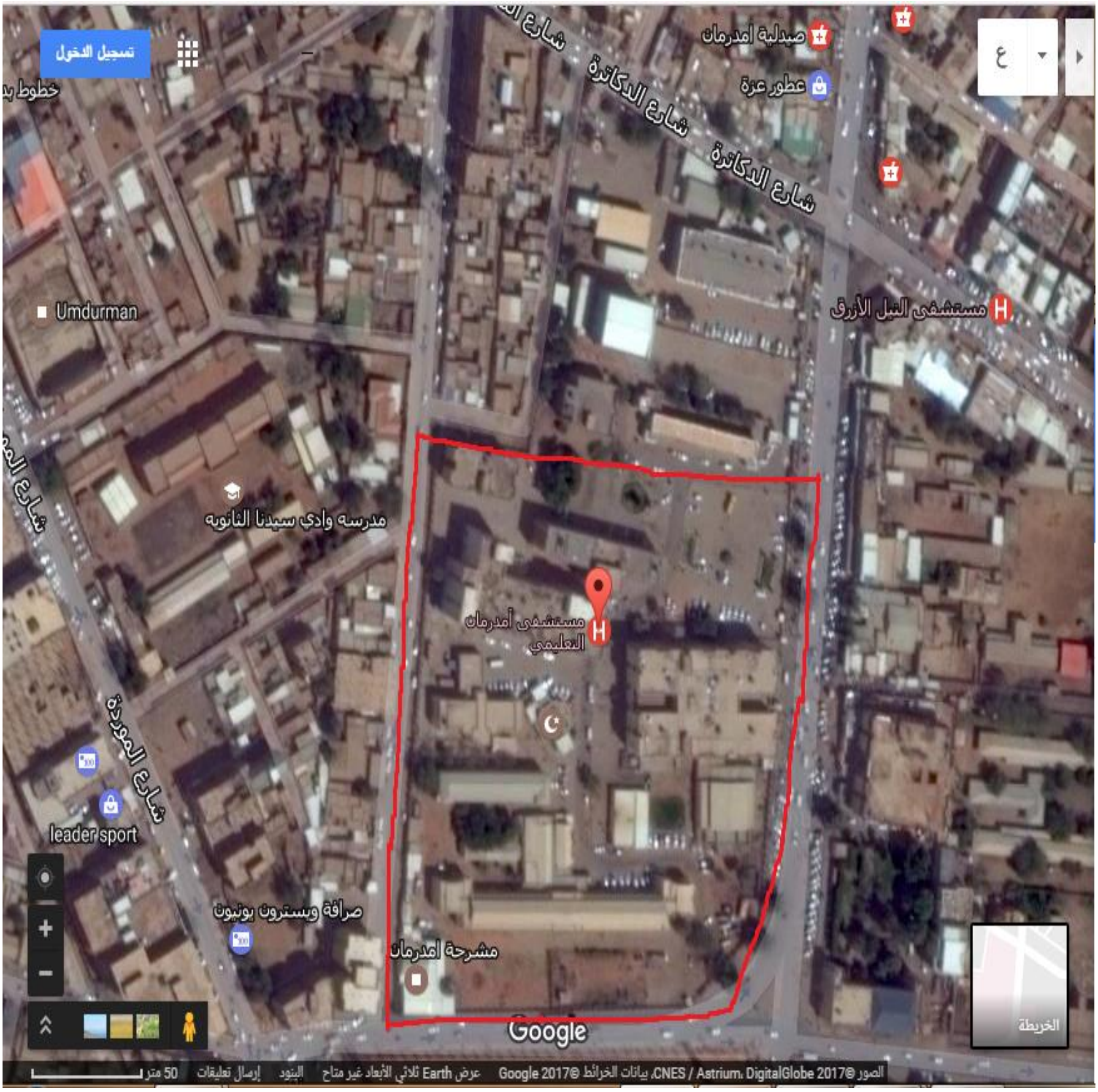


Fig 5.1 An image patch from Google Map excerpt illustrating the Geographical Location of the Emergency Hospital of Omdurman [16]

Fig 5.2 Several Photos "scanning" the departure the Emergency (outside)

5.2.1 AgiSoft

The PhotoScan software of AgiSoft provides the pose estimation and dense image matching. It is a stand-alone software product, that performs photogrammetric processing of digital images and generates 3D spatial data (see Figures 5.3-5.8).

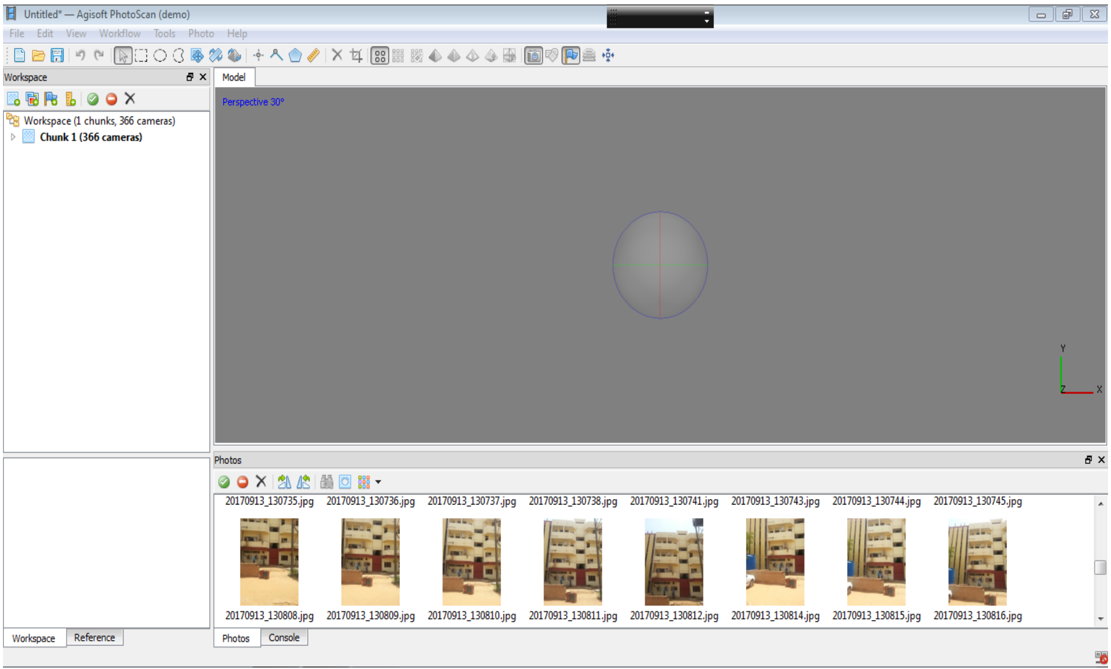


Fig 5.3 The Agisoft program GUI.

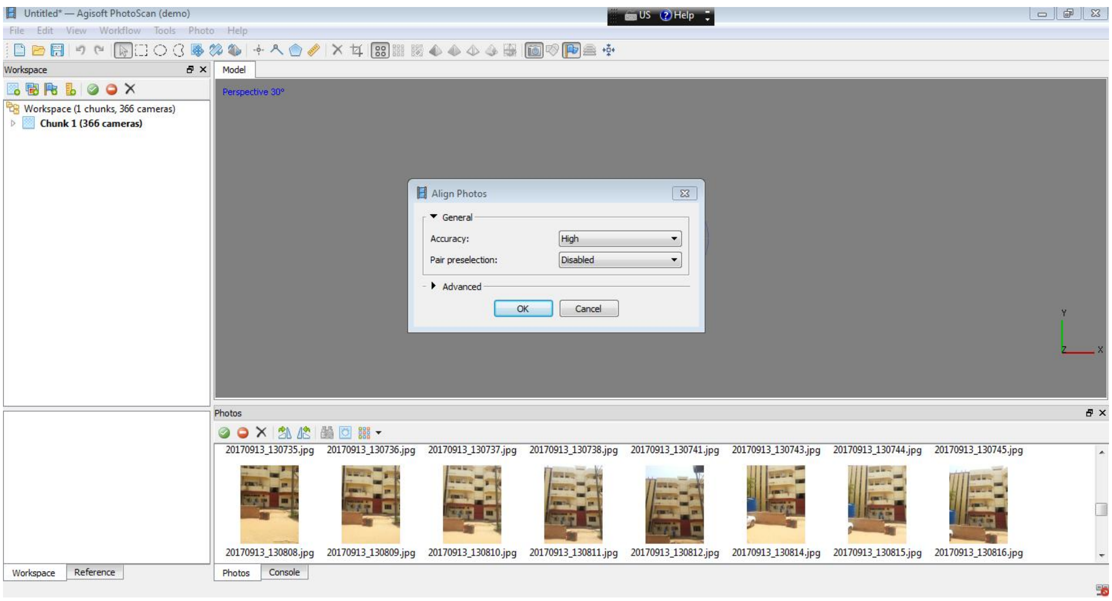


Fig (5.4) Align photos using PhotoScan

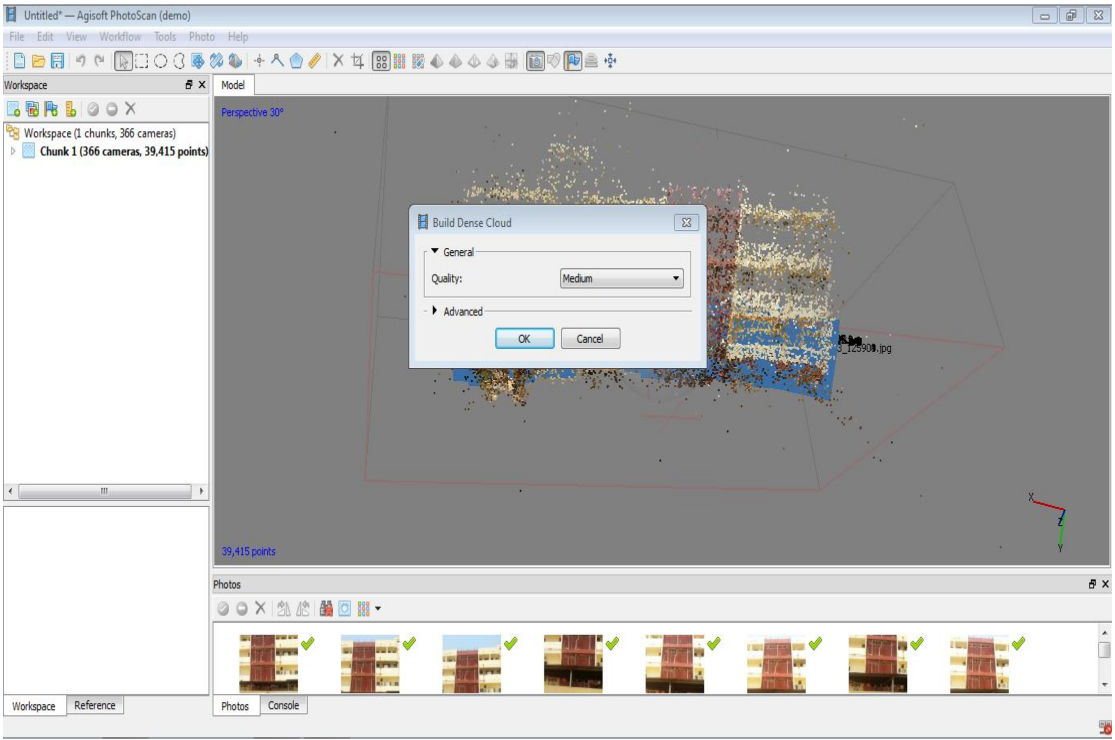


Fig (5.5) Build Dense Point Clouds in PhotoScan

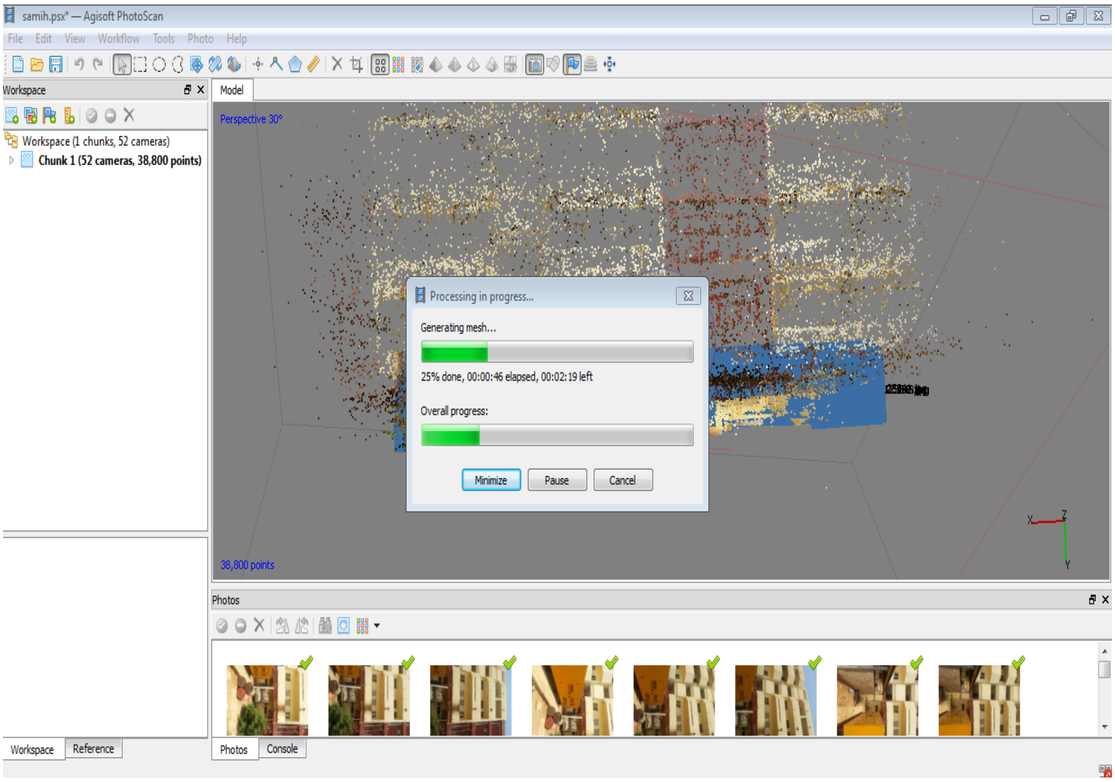


Fig (5.6) Build Mesh in PhotoScan

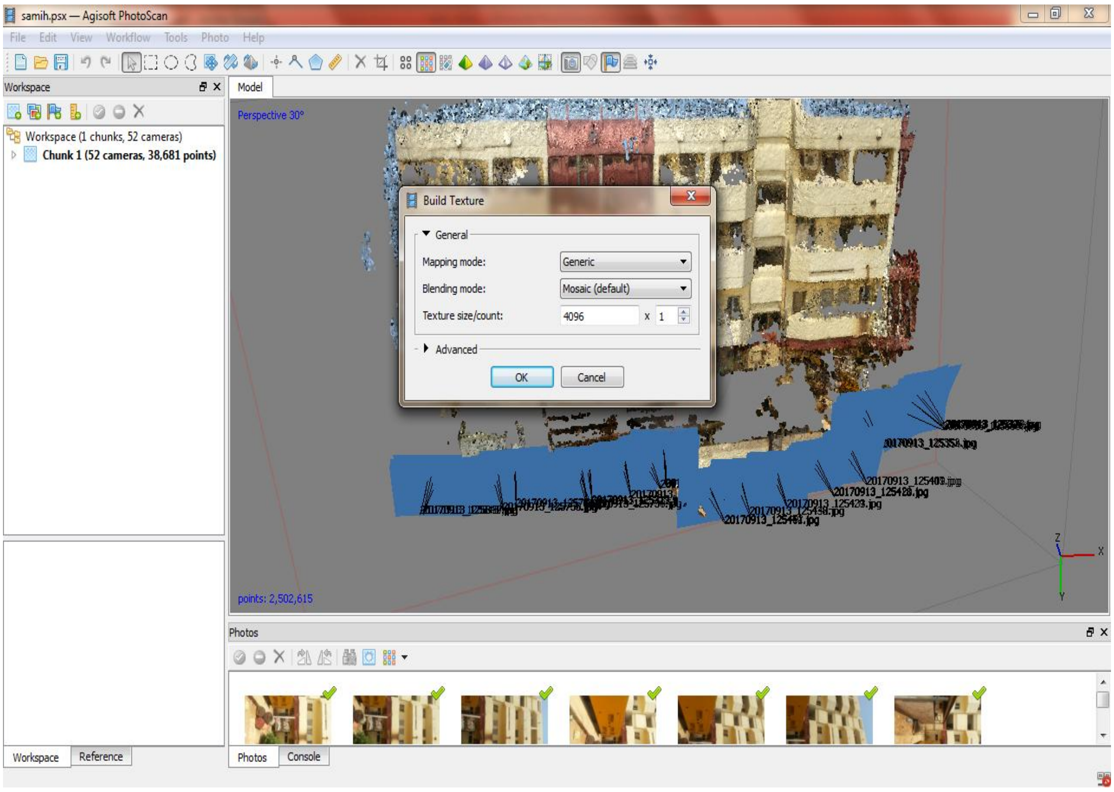


Fig (5.7) Build Texture in PhotoScan

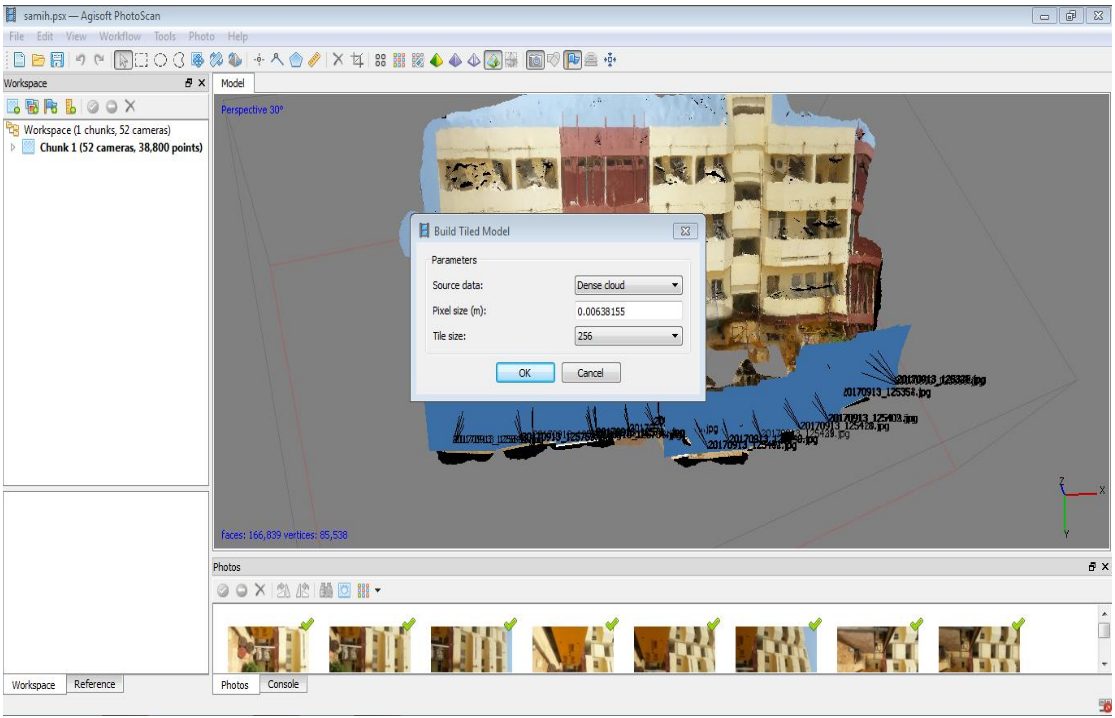


Fig (5.8) Build Tiled Models in PhotoScan

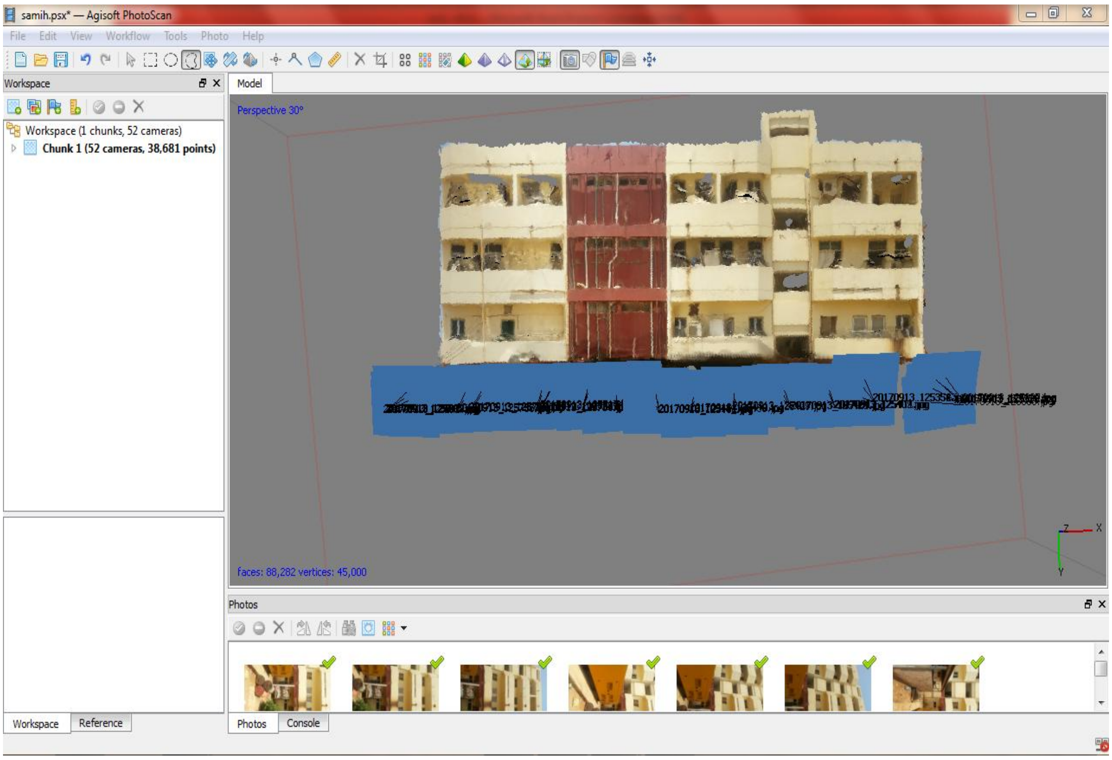


Fig (5.9A) Build Dense Cloud, Build Mesh, Build Texture,

Build Tiled Model in PhotoScan

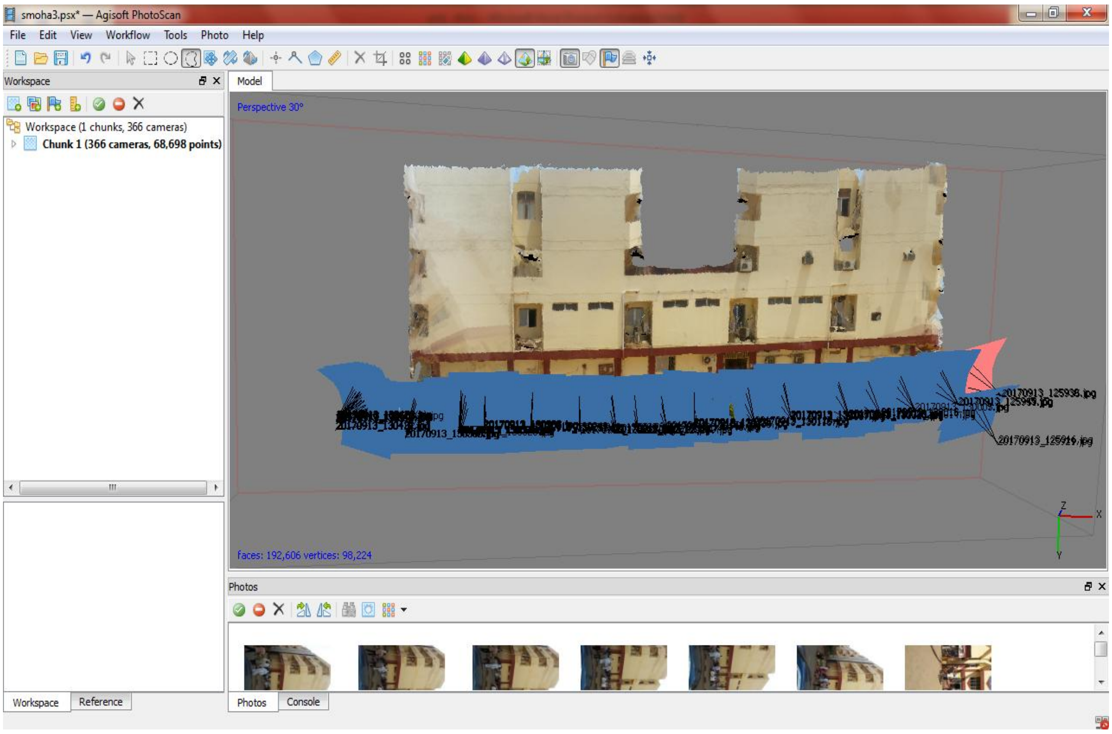


Fig (5.9, B) Build Dense Cloud, Build Mesh, Build Texture, Build Tiled Model in PhotoScan.

In this phase a point cloud file has been exported in *.dae format using AgiSoft's PhotoScan software for the generation of 3D building models as next step.

5.3 3D Model Reconstruction

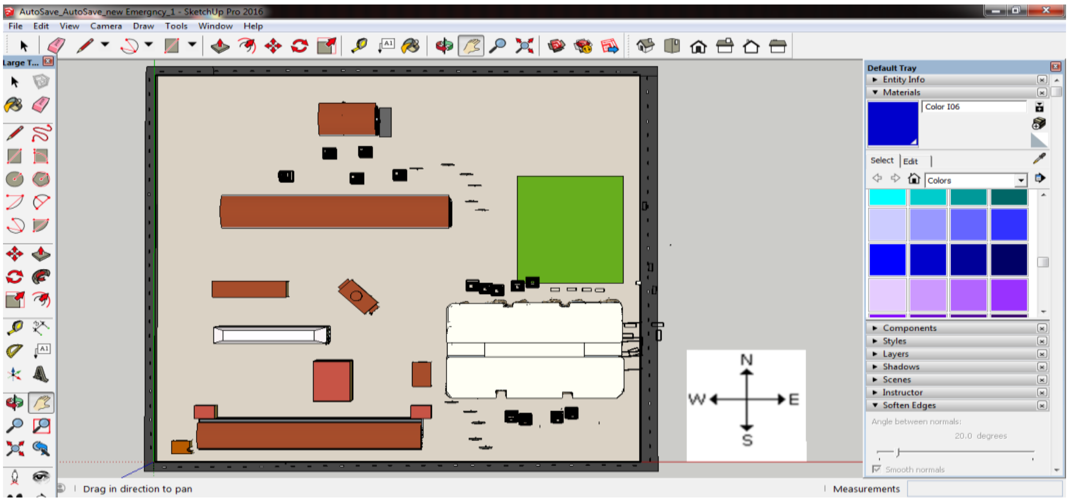
Reconstructing a 3D model is a combination of several processes or phases. 3D and 2D vector and raster data were created for the Region of Interest (RoI) using Trimble's SketchUp Pro software and Esri's ArcGIS.

5.3.1 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.

The Undet Extension package was used for importing the point cloud (dae.* 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.

The 2nd step was adding texture for the model to be built by customized point clouds. SketchUp synthetic textures and image textures were used to guarantee better visualization and true virtual reality. This is demonstrated in Fig (5.10).



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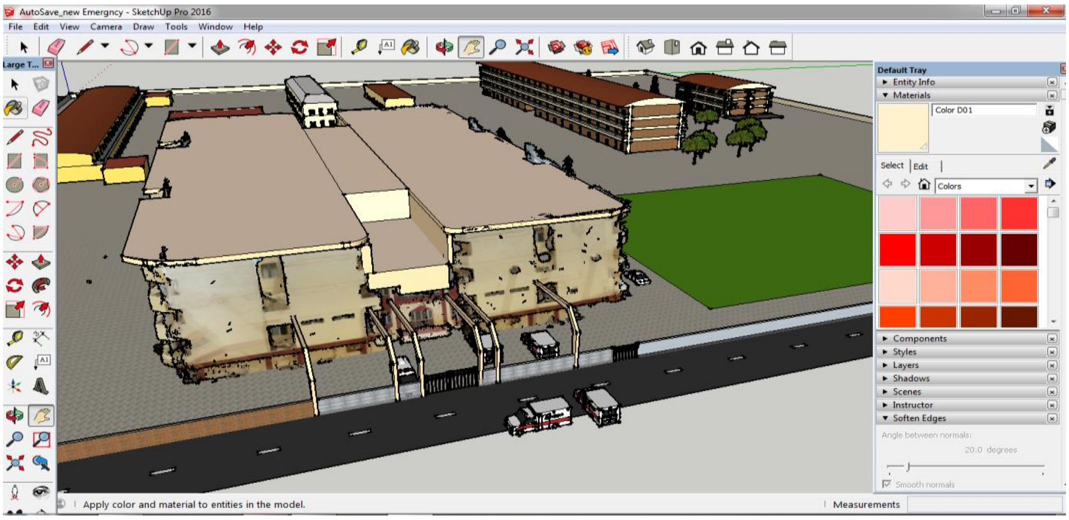

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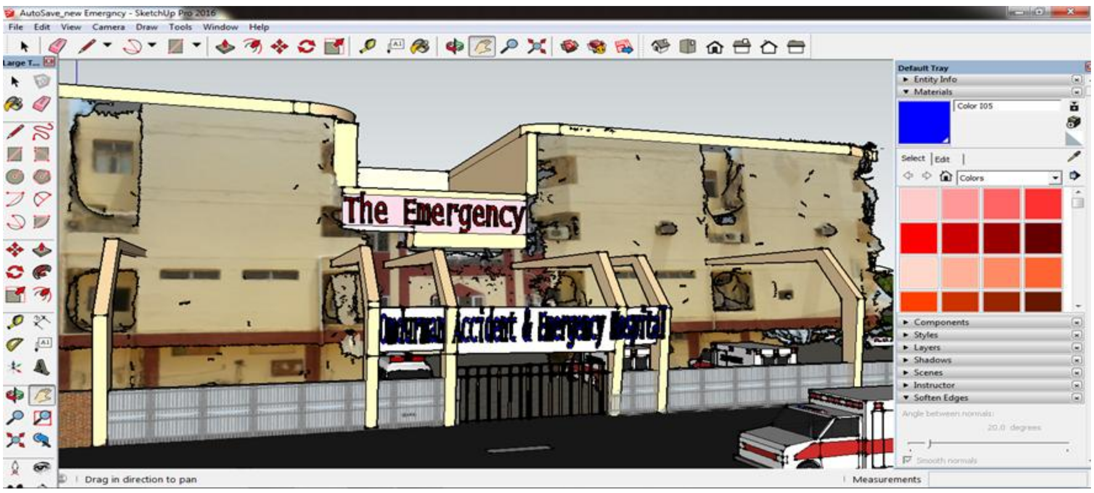

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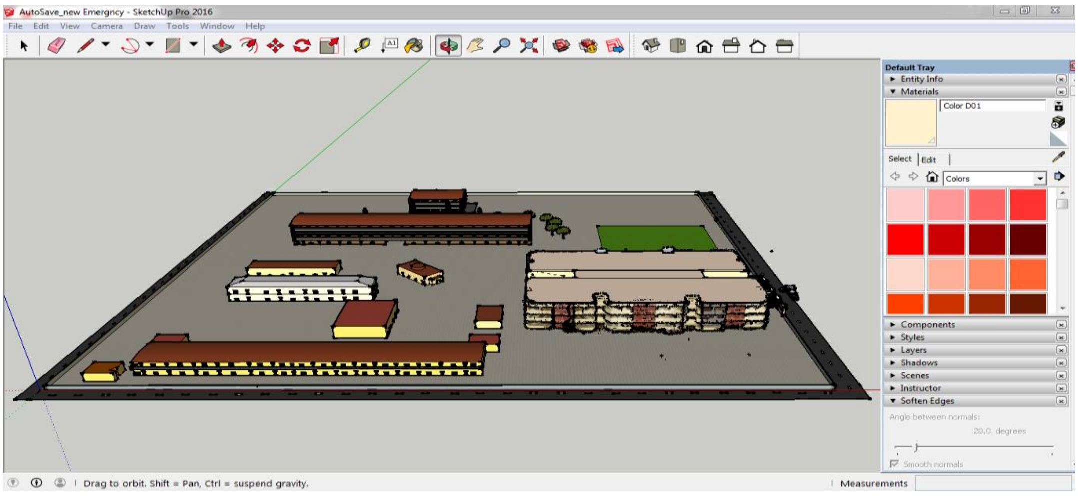
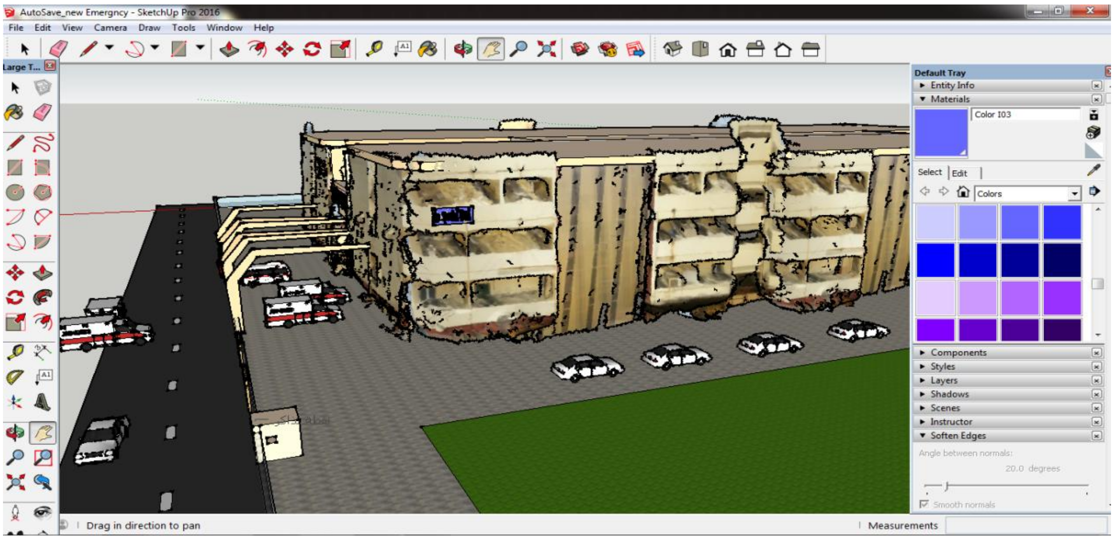
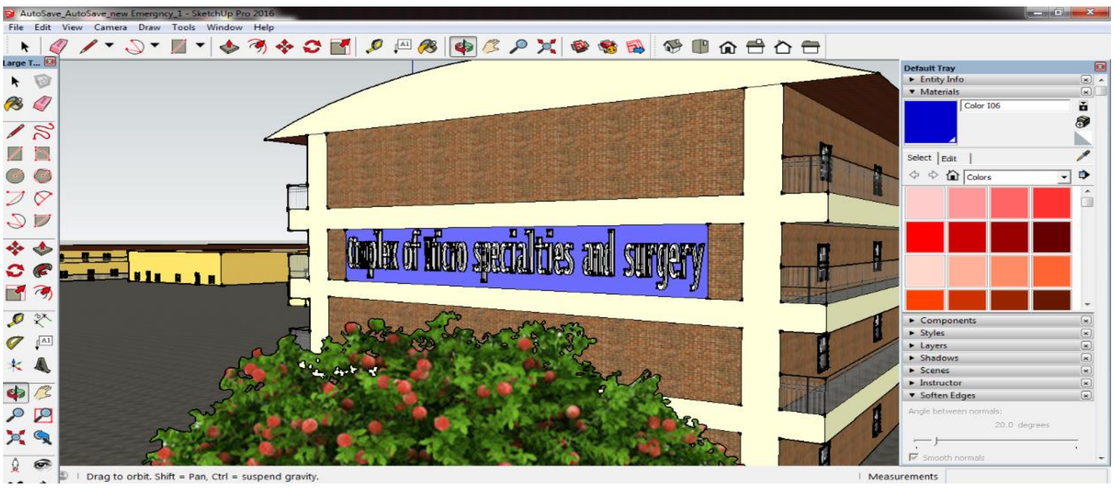


(D)

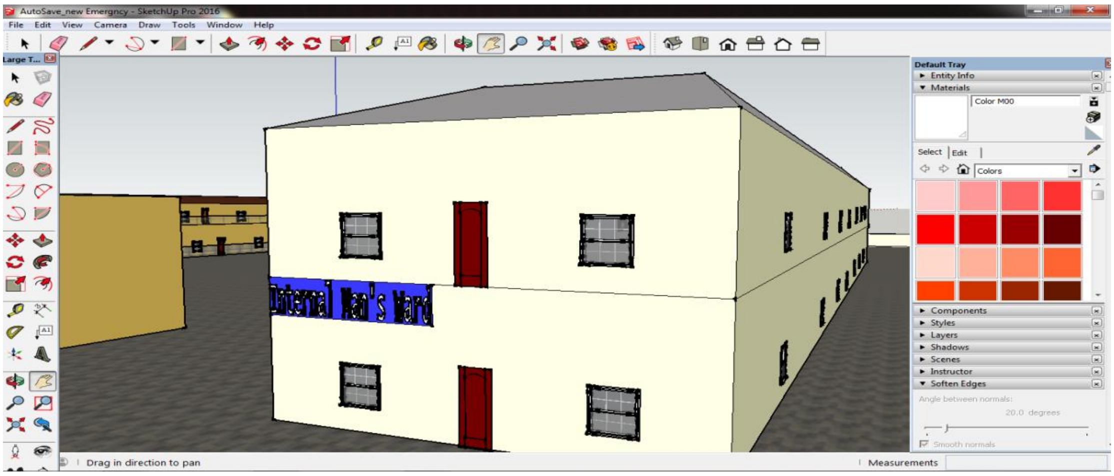


(E)

Fig. 5.10 (A, B, C, D, and E) Final SketchUp results For the Omdurman Emergency from different views



(F)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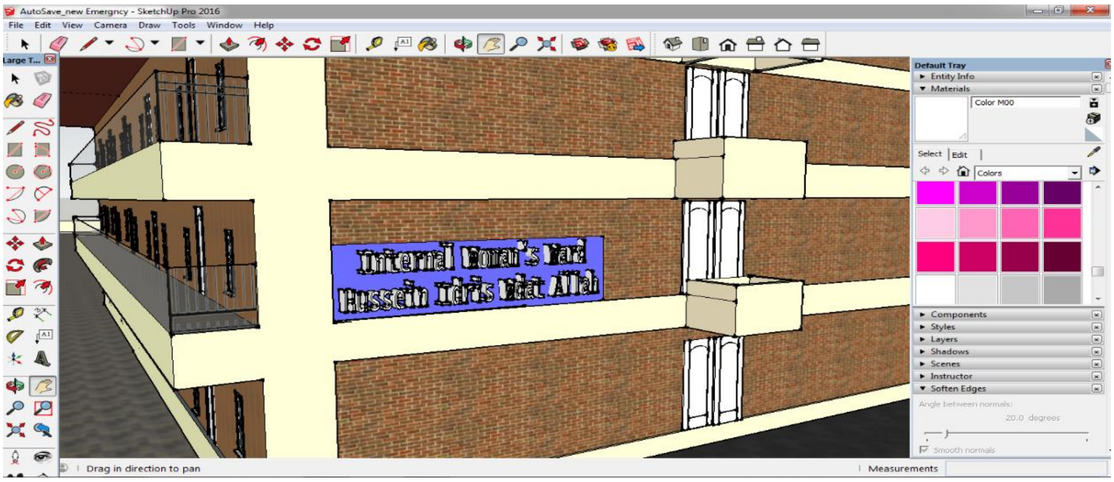
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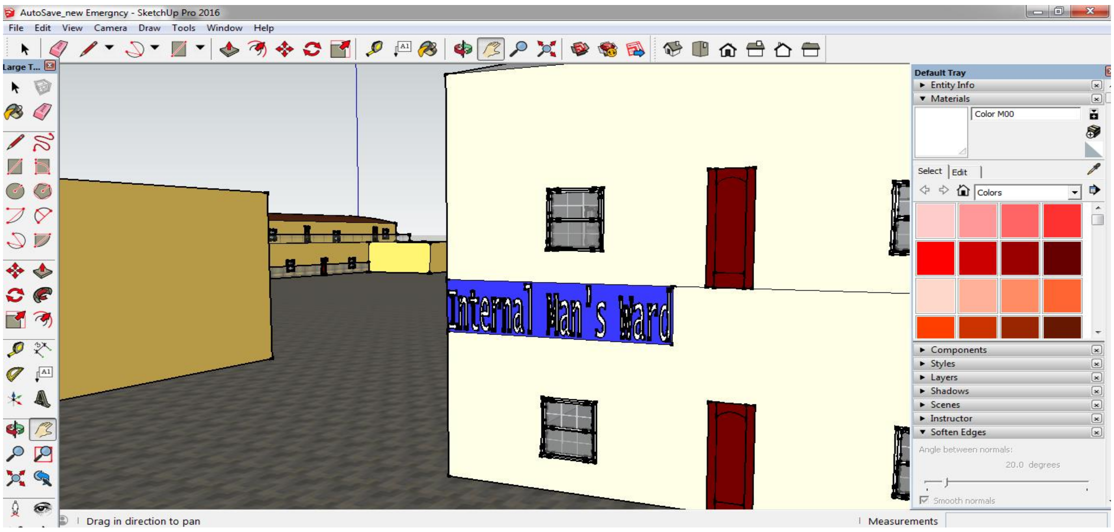
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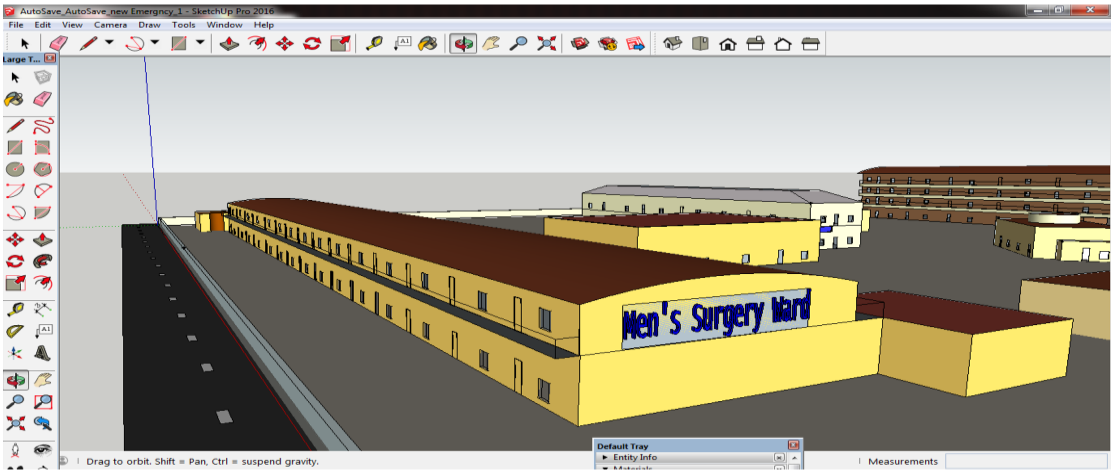
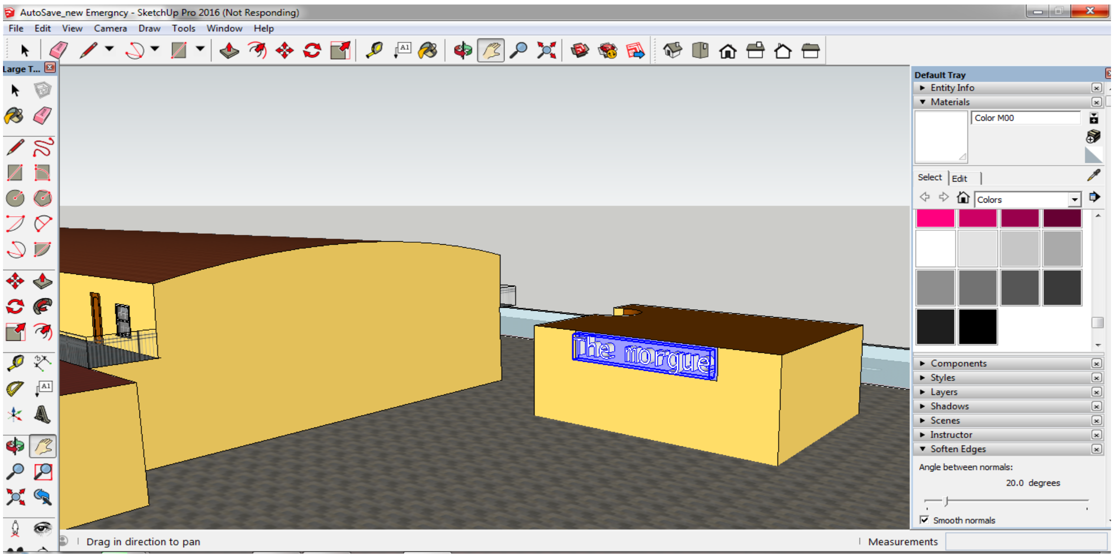


(J)



(K)

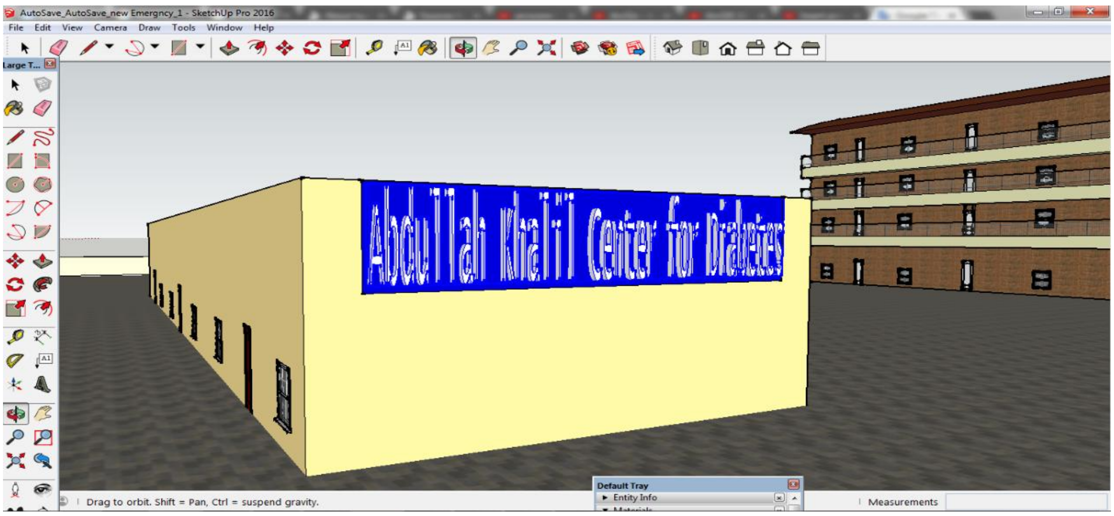


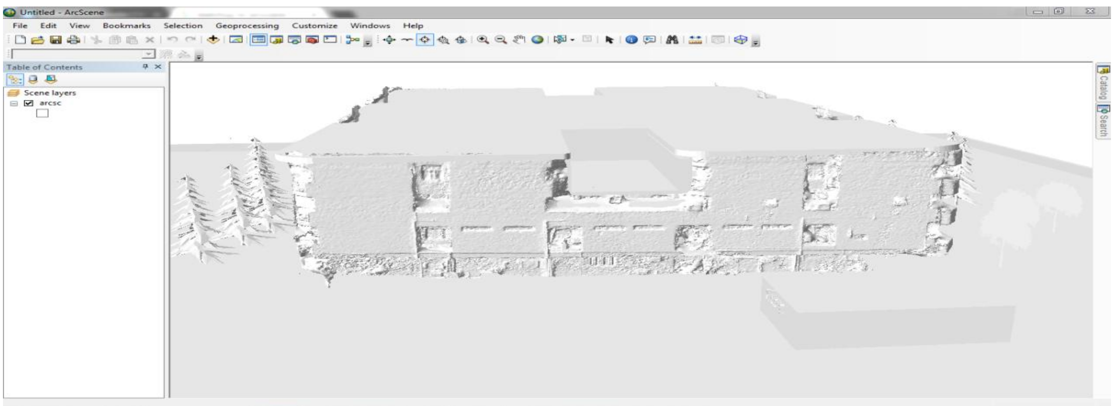
Fig. 5.11 (F, G, H, I, J, K): Final SketchUp results For the Omdurman Accident & Emergency Hospital 3D Model, from different views.

5.3.2 ArcGIS.

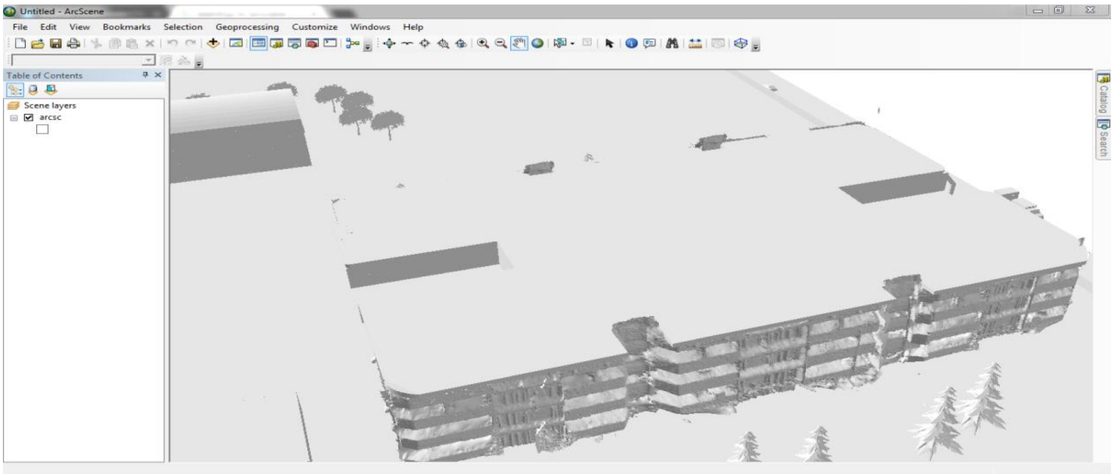
ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications;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

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. 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 and the Builds layer. Here a suitable coordinate system has to be chosen (vertical and horizontal), for which we selected the World Geodetic System WGS 1984 UTM Zone (36, 35) N, covering Sudan. Finally, the layers had to be converted to shape files as illustrated in Fig. 5.12 (A, B, C).

In this conversion to shape files it takes 30 minutes to convert Emergence Hospital model to a shape file, because of the sensitivity of analysis for this conversion – it is illustrated in Fig (5.13), (5.14).



(A)



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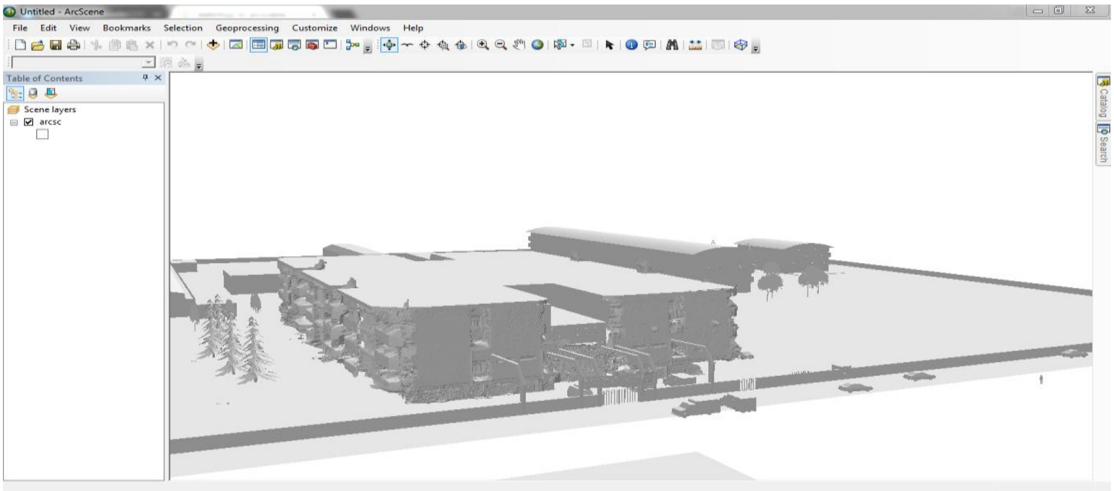

(C)

Fig. 5.12 (A, B, C) Emergence Hospital 3D Model from different views shape file.

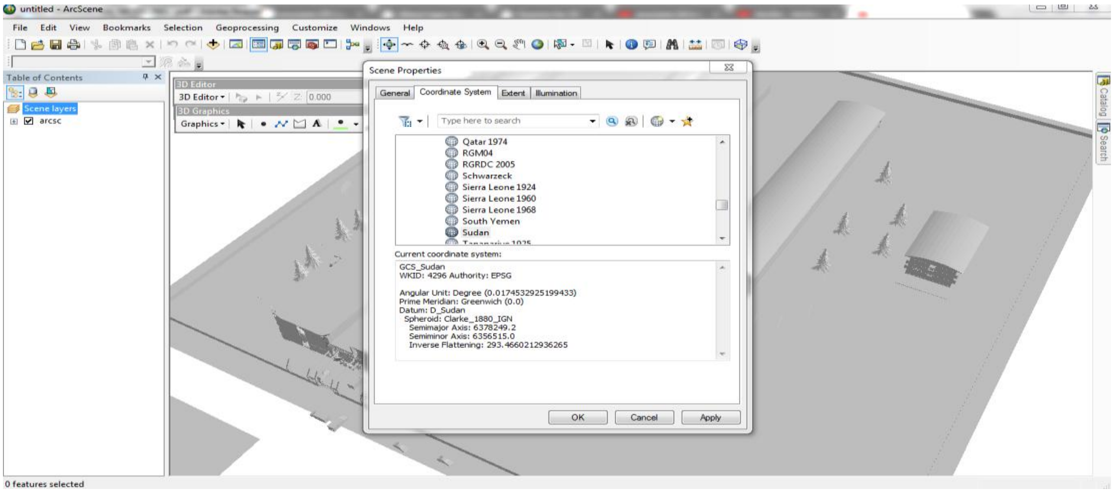

Fig. (5.13) Coordinate System Proprieties.

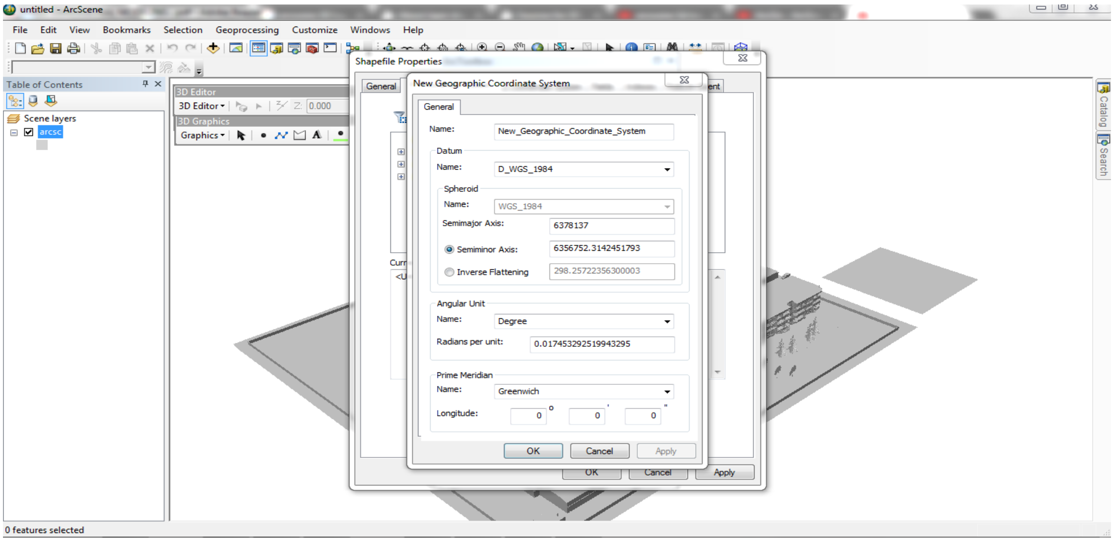

Fig. (5.14) View shape file proprieties

Chapter 6

Conclusions and Outlook

6.1 Conclusions

6.2 Strength of the Thesis

6.3 Weakness of the Thesis

6.4 Opportunities of the Thesis

6.5 Threat of the Thesis

6.6 Recommendations

6.1 Conclusions

3D GIS provide urban designers and planners with a useful tool for modeling and analysis. The 3D GIS application was developed in order to evaluate urban space efficiently and to provide information about urban planning to local communities. This application enables users to visualize complicated urban planning information in the 3D way, to evaluate the allowable capacity of the block and to simulate building plans. With visualization and analysis capability, 3D GIS are considered a powerful tool to solve various issues of modern Emergency Hospital environments to offer a three-dimensional model with texture mapping that allows for virtual reality visualizations, orientations and navigations around the Emergency Hospital with geo-referenced data and databases.

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 research corresponds to the complete production workflow of the new trend in building up three-dimensional models of a complex of interest using photogrammetry techniques.

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

Provides information about all resources inside the Emergency Hospital, when escorts and visitors make location queries and guides them to the right direction, especially escorts and visitors who are coming for the first time haven't to ask every time when they want to reach a particular place within the Emergency, and support any restructuring of the Emergency Hospital.

6.2 Strength of the Thesis

This thesis uses freely available technologies and tools, under a flexible license policy. I has derived 3D representation of building geometry, and is the hull for further BIM details. BIM contains rich semantic information, improving the complex building interiors. Above all, this thesis represents the state-of-the art of 3D reconstructions, giving a clear representation of an Emergency Hospital to new escorts and visitors, to move into the right directions.

6.3 Weakness of the Thesis

Because of the lack of professional training of open source GIS, this thesis could only make a contribution for the 3D outside design of the Emergency Hospital. But it is clear that the 3D interior design must be given, to give more help to new escorts and visitors to reach final direction place also inside new.

6.4 Opportunities of the Thesis

In this section, the opportunities and threats appear by the implementation of 3D GIS and BIM in a geospatial environment. Those are classified into themes, to improve the complex building by using 3D GIS modeling of urban environment of entries and for an evacuation of the Emergency Hospital. Based on this thesis new work may follow: to operation, facilitating the analysis and the design of a complex building, and facilitating 3D Modelling of urban environment, with public participation.

6.5 Threat of the Thesis

The threat of this thesis is its limitation of our concept of 3D GIS and the security aspects of 3D GIS based on the fact, that an unauthorised access to this type may happen. Thus, taking pictures for complex buildings or any public buildings serve peoples (i.e. buildings in-risk, such as Hospital, airport, museum and government buildings), but can cause security threats at national level, as the access to this kind of information can aid in terrorist attacks (by enabling accuracy in finding the targets when attacking to a specific part of a building). Considering security aspects would make the access more difficult.

6.6 Recommendations

In the following, some recommendations for using the work of this thesis and future work are given. First of all, we may take advantages of GPS properties for user positioning. In future we will have many Global Navigation Satellite Systems (GPS, Glonas, Galileo, Baidou, etc.) for navigation, thus, it becomes a daily service for any outdoor positioning with high accuracies.

Furthermore the outer 3D hull of The Omdurman Accident & Emergency Hospital should be filled with interior elements, to come to a complete Building Information Model (BIM). This will take advantage from the combination of 3D GIS and BIM.

Another important issue would be to connect the Emergency Hospital 3D model directly with the web site to offer an access anytime, and from anywhere.

In future, this research can also be used in robotics to access the destination and help people quickly.

And finally, utilize GIS modeling for showing high level of building details, features and measurements.

A short SWOT analysis (Strength, Weaknesses, Opportunities and Threats) may help those, who would like to get an Executive Summary of the findings of this thesis.

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