**Sudan University of Science and Technology**
**College of Graduate Studies**
**Computer Science and Information Technology**

# Three-Dimensional Modeling with Texture Mapping.
# Case Study: Omdurman Ahlia University

## نمذجة ثلاثية الأبعاد مع خريطة تصميم الملمس
## دراسة الحالة: جامعة امدرمان الأهلية

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

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# الآية

بسم الله الرحمن الرحيم

**قال تعالى: ﴿ ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ مُضْغَةً فَخَلَقْنَا الْمُضْغَةَ عِظَامًا فَكَسَوْنَاالْعِظَامَ لَحْمًا ثُمَّ أَنشَأْنَاهُ خَلْقًا آخَرَفَتَبَارَكَ اللَّهُ أَحْسَنُ الْخَالِقِينَ ﴾**

صدق الله العظيم

**سورة المؤمنون الآية (14)**

## DEDICATION

*All praise to Allah, today we fold the days' tiredness and the errand summing up between the cover of this humble work.*

*To the utmost knowledge lighthouse, to our greatest and most honored prophet Mohamed - May peace and grace from Allah be upon him*

*To whose precious to my heart … mother, father, brothers and sisters.*

*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 last twenty years, three-dimensional (3D) modeling has been the focus of many projects. At the present time and with the new development in the technology of digital equipment and devices and the remarkable development in personal computers, processors, RAM, storage units and software, 3D modeling has become more feasible and requires little time and effort.

The objective of this research is to provide information on all resources within the Omdurman Ahlia University (OAU) campus to assist new students and visitors who are wasting their time to searching for a specific place within the OAU campus which is known to be very complex. The current system for guidance relies on labeling and signs with names of collage unites offices of every building, and two maps at the main gates of a university.

The aim of the research is to make use of geographic information system (GIS) to provide an interactive environment to provide the best conceptual model of campus that provides information on the all sources within it to save time and effort to search for, as well as to provide a building information model (BIM) system that helps in planning, development and improvement, Interior of the campus.

The methodology used is very flexible and can be used and applied to many projects and applications and can be used especially in hospitals, universities, airports, buildings that constantly change according to the requirements of the country or by adding new buildings to make decisions and follow the appropriate procedures and best to reduce the size of complex construction and provide A database filled with data on previous buildings.

In this proposed system, several software's was employed and used in order to complete the required production.

**المستخلص:**

في السنوات العشرين الماضية ، كانت النمذجة ثلاثية الأبعاد محور العديد من المشاريع. اما في الوقت الحاضر ومع التطور الجديد في التكنولوجيا من معدات وأجهزة رقمية والتطور الملحوظ في الحاسبات الشخصية معالجات،رام و وحدات تخزين وبرمجيات أصبحت النمذجة ثلاثية الأبعاد أكثر جدوى وتتطلب القليل من الوقت والجهد .

الهدف من هذا البحث هو تقديم معلومات عن جميع الموارد داخل حرم جامعة امدرمان الأهليه لمساعدة الوافدين الجدد من طلاب وزوار الذين يضيعون وقتهم في البحث عن مكان محدد الحرم والذي يعرف بأنه شديد التعقيد، كما أن النظام المتبع حالياً للإرشاد يعتمد على وضع العلامات بأسماء مكاتب وحدات الكلية في كل مبنى ، وخريطتان على البوابة الرئيسية لجامعة.

يهدف البحث إلى الاستفادة من نظام المعلومات الجغرافية في توفير بيئة تفاعلية لتوفير أفضل نموذج مفاهيمي لحرم الجامعة بتوفير معلومات عن المصادر داخله لتوفير الوقت والجهد المبزول للبحث عنها، بالإضافة إلى توفير نظام نموذج معلومات البناء والذي يساعد في التخطيط والتطوير والتحسين بالإضافة لاتخاذ القرارات بخصوص البنية الداخلية للحرم.

أن المنهجية المستخدمة مرنة للغاية ويمكن استخدامها وتطبيقها على العديد من المشروعات والتطبيقات و يمكن الإستفادة منها خصيصاً في المستشفيات والجامعات و المطارات ، والمباني التي تتغير بإستمرار وفقاً لمتطلبات البلد أو من خلال إضافة مبانٍ جديدة لاتخاذ القرارات واتباع الإجراءات المناسبة وأفضلها لتقليل حجم البناء المعقد و توفير قاعدة بيانات مليئة بالبيانات المتعلقة بالمباني السابقة، في هذا النظام ، تم استخدام عدة برامج للوصول للصورة النهائية للمشروع

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**LIST OF ABBREVIATION:**

| Definition | Abbreviation |
|---|---|
| OAU | *Omdurman Ahlia University* |
| 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* |
| LiDAR | *Light Detection and Ranging* |
| 2D | *Tow Dimension* |
| 3D | *Three Dimension* |
| VRM | *Virtual Reality Model* |
| WGS | *World Geodetic System* |
| webGL | *Web Graphics Library* |

# CHAPTER ONE

## Introduction

**1.1 Overview**

**1.2 Problem Statements**

**1.3 Research Hypothesis**

**1.4 Research Objectives**

**1.5 Research Significance**

# CHAPTER ONE
# Introduction

## 1.1 Overview

Texture mapping has become a popular tool in the computer graphics industry in the last few years because it is an easy way to achieve a high degree of realism in computer-generated imagery with very little effort. Over the last decade, texture mapping techniques have advanced to the point, where it is possible to generate real-time perspective simulations of real-world areas using texture mapping for every object surface with texture from photographic images. The techniques for generating such perspective transformations are variations on traditional texture mapping that in some circles have become known as the Image Perspective Transformation or IPT technology.

This thesis first presents a background survey of traditional texture mapping. It then continues with a description of the texture-mapping variations that achieve these perspective transformations of photographic images of real-world scenes. The style of the presentation is that of a resource survey rather than an in-depth analysis. [1]

3D visualization with texture mapping is the true simulation of reality, especially if it is relatively accurate. The current off-the-shelf software products facilitate constructing 3D models by existence of flexible GIS environments. Several methodologies are used to build up 3D virtual reality models with dissimilar accuracies and applied techniques. One way to obtain such data is to let skillful workers create building models manually based on building blueprints, aerial and terrestrial images and other data sources.

This solution, however, requires a large amount of manual work, thus it is both slow and expensive. Photogrammetry provides a 3D point cloud, which samples the site in an accurate and fast approach, and on the other hand, 3D GIS models provide the best analysis and decision-making processes.

The **OAU** main campus has a vaulty region, comprise collages and administrative buildings. The essential objective of this work is to use photogrammetry to provide high precision visualization of the interested and area also to help new students, teachers, administrators and visitors to access the model remotely from anywhere and anytime on desktop or mobile computers.

## 1.2 Problem Statements

The OAU campus is very wide and have very complex infrastructure Which is an obstacle to access to the destinations within, especially to new student and visitors, because they have a hard time to orientating themselves and finding their way, even if there are maps at some points in the campus, but they do not have continuous help to get to their destination, and as soon as they start walking in the target direction they are without help anymore, Especially that the current system of guidance relies on labeling and signs with names of buildings and offices of every building and two maps in the main gates of campus.

## 1.3 Research Hypotheses

The following research hypotheses are formulated:

Due to continuous improvements in university buildings it is necessary to have a map showing the basic parameters and the definition of buildings in the university, according to the progress of modern technology in photogrammetry and geographical information systems.

The System provides a three-dimensional design of all buildings for OAU and shows all colleges, landmarks, and individual buildings associated with semantic information.

The university allows the student using its resources such as lecture halls, student laboratories, offices, libraries and cafeterias and other resources. The system facilitates access of those resources and provides some information about it.

## 1.4 Project Objectives

The main purpose of this research is to understand the benefits of utilizing interactive, 3D visualization by designing a 3D model to assist new students, teachers, administrators and visitors when they need to reach a place inside the university.

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.

Provides information about all resources inside the university campus when new students, teachers, administrators and visitors make location queries and guides to the right direction.

### 1.4.1 Three-dimensional (3D) Modeling

Three-dimensional modeling of an object can be seen as the complete process that starts from data acquisition and ends with a 3D virtual reality model visually accessible in interactive mode on a computer. Often 3D modeling is meant only as the process of a measured point cloud into a triangulated network mesh or textured surface, while it should describe a more complete and general process of object reconstruction. Three-dimensional digital models are required in many applications such as inspection, navigation, object identification, visualization and animation. The most general classification of 3D object measurement and reconstruction techniques can be divided into contact methods (for example, using coordinate measuring machines, calipers, rulers and/or bearings) and non-contact methods (X-ray, photogrammetry, laser scanning, etc.).

Nowadays the generation of a 3D model is mainly achieved using non-contact systems based on light waves, in particular using active or passive sensors. [2]

Considering active and passive sensors, four alternative methods for object and scene modeling can currently be distinguished:

**1. Image-based rendering (IBR):**

This does not include the generation of a geometric 3D model but, for particular objects and under specific camera motions and scene conditions, it might be considered a good technique for the generation of virtual views. IBR creates novel views of 3D environments directly from input images.

The technique relies on either accurately knowing the camera positions or performing automatic stereo matching that, in the absence of geometric data, requires a large number of closely spaced images to succeed. Object occlusions and discontinuities, particularly in large-scale and geometrically complex environments, will affect the output. The ability to move freely into the scene and view objects from any position may be limited depending on the method used. Therefore, the IBR method is generally only used for applications requiring limited visualization. [2]

**2. Image-based Modeling (IBM):**

This is the widely used method for geometric surfaces of architectural or for precise terrain and city modeling, in most cases, the most impressive and accurate results still remain those achieved with interactive approaches. IBM methods (including photogrammetry) use 2D image measurements (correspondences) to recover 3D object information through a mathematical model or they obtain 3D data using methods such as shape from shading, shape from texture, shape from contour (medical applications) and shape from 2D edge gradients. Passive image-based methods acquire 3D measurements from multiple views, although techniques to acquire three dimensions from single are also necessary.

IBM methods use projective geometry or a perspective camera model. They are very portable and the sensors are often low cost. [2]

**3. Range-based modeling:**

This method directly captures the 3D geometric information of an object. It is based on costly (at least for now) active sensors and can provide a highly accurate representation of most shapes. The sensors rely on artificial lights or pattern projection. These sensors are still expensive, designed for specific ranges or applications and they are affected by the reflective characteristics of the surface. They require some expertise based on knowledge of the capability of each different technology at the desired range, and the resulting data must be filtered and edited. Most of the systems focus only on the acquisition of the 3D geometry, providing only a monochrome intensity value for each range value. Some systems directly acquire color information for each pixel while others have a color camera attached to the instrument, in a known configuration, so that the acquired texture is always registered with the geometry. However, this approach may not provide the best results since the ideal conditions for taking the images may not coincide with those for scanning. The accuracy at a given range varies significantly from one scanner to another. Also, due to object size, shape and occlusions, it is usually necessary to perform multiple scans from different locations to cover every part of the object the alignment and integration of the different scans can affect the final accuracy of the 3D model. Furthermore, long-range sensors often have problems with edges resulting in blunders or smoothing effects. [2]

**4. Combination of image- and range-based modeling:**

In many applications, a single modeling method that satisfies all the project requirements is still not available.

Photogrammetry and laser scanning have been combined in particular for complex or large architectural objects, where no technique by itself can efficiently and quickly provide a complete and detailed model. [2]

## 1.5 The Significance

3D visualization can be a useful tool in guiding students and visitors to reach places inside campus and be very use full tool when used effectively, that will save time and yields a heightened awareness of buildings inside campus.

In general, the benefits associated with 3D visualization represented in enabling students and visitors to know the way of reaching university resources and that help to maximize effective time to complete the required task, illustrating features of buildings (e. g. offices, libraries, laps and lecture halls) and providing visual support of the university management when needs to make some improvements by adding or modernizing buildings.

Beside understanding and visualizing inaccessible locations buildings outside student collage.

# CHAPTER TWO

## Literature Review

**2.1 Theoretical Framework.**

**2.2 Literature Review.**

# CHAPTER TWO

## Literature Review

### 2.1 Theoretical Framework

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

#### 2.1.1 Computer Graphics

Computer graphics would state that it refers to taking a model of the objects in a scene (a geometric description of the things in the scene and a description of how they reflect light) and a model of the light emitted into the scene (a mathematical description of the sources of light energy, the directions of radiation, the distribution of light wavelengths, etc.), and then producing a representation of a particular view of the scene (the light arriving at some imaginary eye or camera in the scene).[3]

Computer graphics has been used in a broad sense to describe "almost everything on computers that is not text", as demonstrated by Fig.2.1. Very lively 3D virtual reality models can be created.

*Fig. 2.1 3D reconstruction of a building (Taj Mahal). [4]*

### 2.1.2 Geographic Information Systems (GIS)

While many consider GIS to be software programs that manipulate spatial data, this definition is very restrictive. As the name implies, geographic information systems are systems designed to input, store, edit, retrieve, analyze, and output geographic data and information.

Like all systems (e.g., ecosystems, digestive systems, ventilation systems, etc.), the GIS is composed of an orchestrated set of parts that allow it to perform its many interrelated tasks. These parts include a computer and its basic functions. [5]

#### A. GIS Definition

GIS is a computer-based system that provides the following four sets of capabilities to handle georeferences and data (see Fig. 2.2):

1. Data capture and preparation (input).
2. Data management, including storage and maintenance (database).
3. Data manipulation and analysis.
4. Data presentation (output).

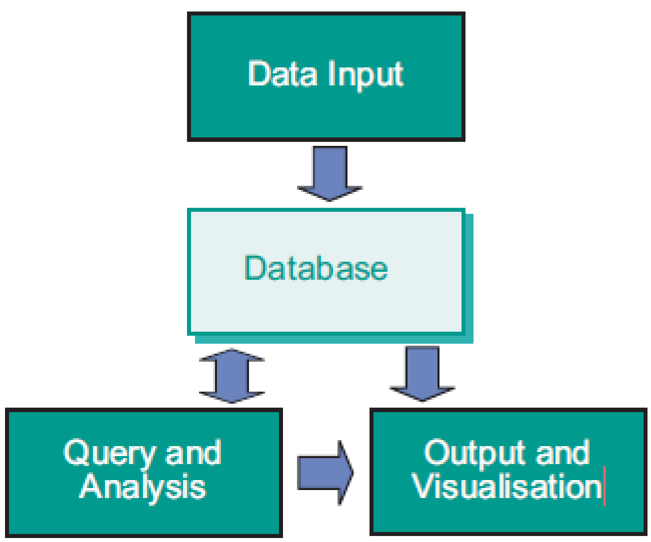



*Fig. 2.2 Functional component of GIS. [6]*

GIS provides spatial representation and analysis of information (attribute data) that is positioned to correspond to the same X, Y coordinates throughout the various map layers (see Fig. 2.3). [6]

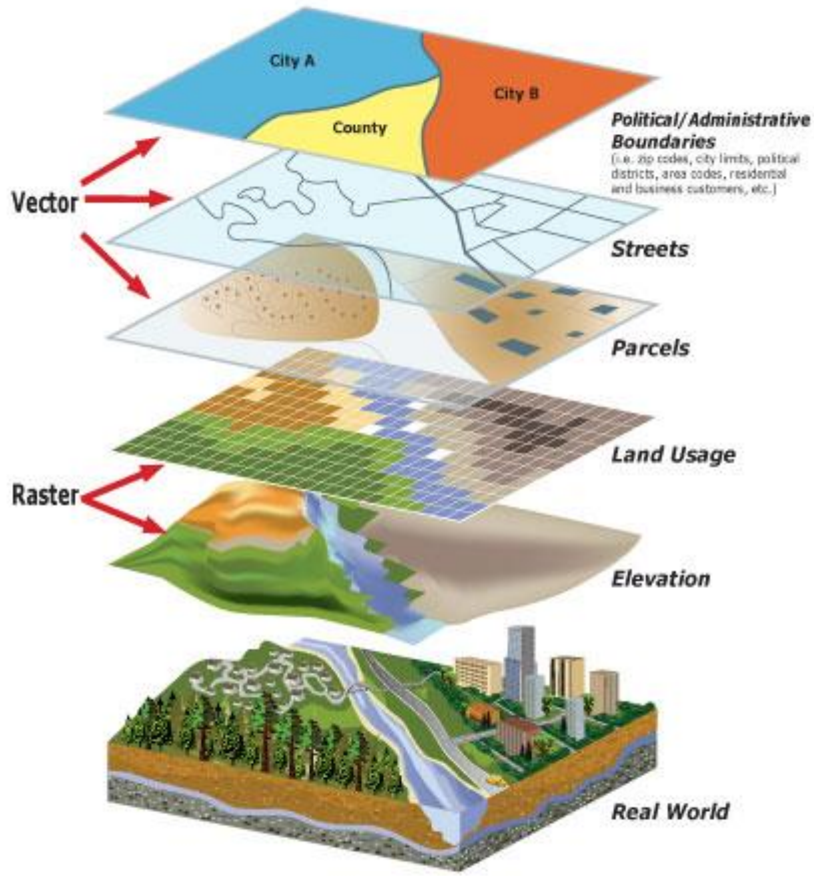
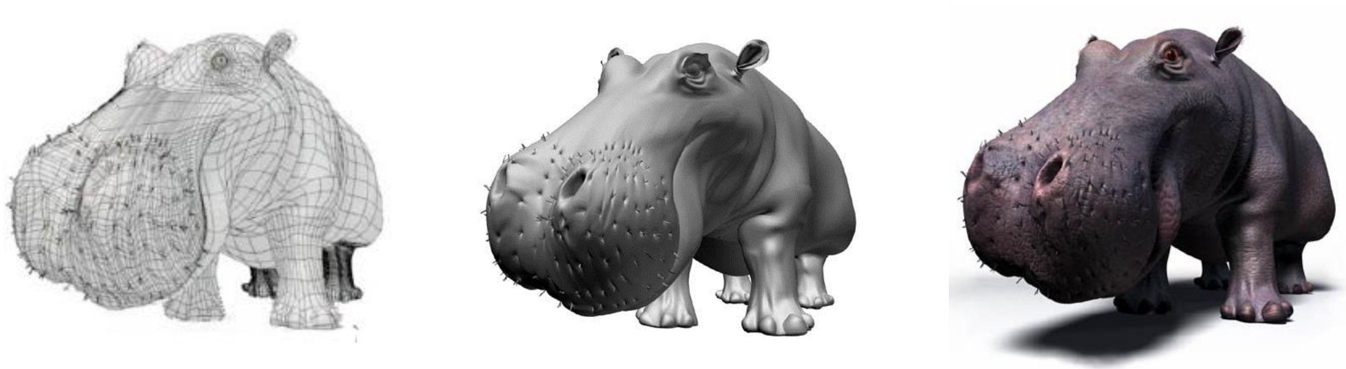



*Fig. 2.3 An example of map layers used altogether in GIS. [7]*

One of the main uses of GIS is to assist in decision-making. And reflect the fact that parts of the real world represent only modest expectations of bringing the system out. The information that can be generated in the future depends on those data provided to the system in the past and present. [6]

**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 varying conditions, and helps to answer "what if" questions (see Fig. 2.4).



**(A) Model** **(B) Model + shading** **(C) Model + shading + texture**

*Fig. 2.4 (A),(B) and (C) how get Quest for Visual Realism in Modeling[8]*

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 parts of the real world. Databases are another important class of models as they can store considerable varieties of data and also provide various information to operate on the stored data. [6]

### 2.1.3 Photogrammetry

Photogrammetry is the science of obtaining reliable information about the prosperities of surfaces and objects without physical contact with the objects, and of measuring and interpreting this information.

In order to simplify understanding the abstract definition above and to get a quick grasp of the complex field of photogrammetry, a system approach has been adopted as illustrated in Fig. 2.5. But this overview is more or less old-fashioned and belongs to the era of "analytical photogrammetry. [9]

It should be mentioned here, that modern photogrammetry – also called "digital photogrammetry" is providing high resolution point clouds, derived by dense image matching methods, which have the same quality and higher resolutions than those of laser scanning. The photos are located by photogrammetric Bundle Block adjustments and/or Structure-from-Motion algorithms of Computer Vision, before the pixel-wise matching is performed.

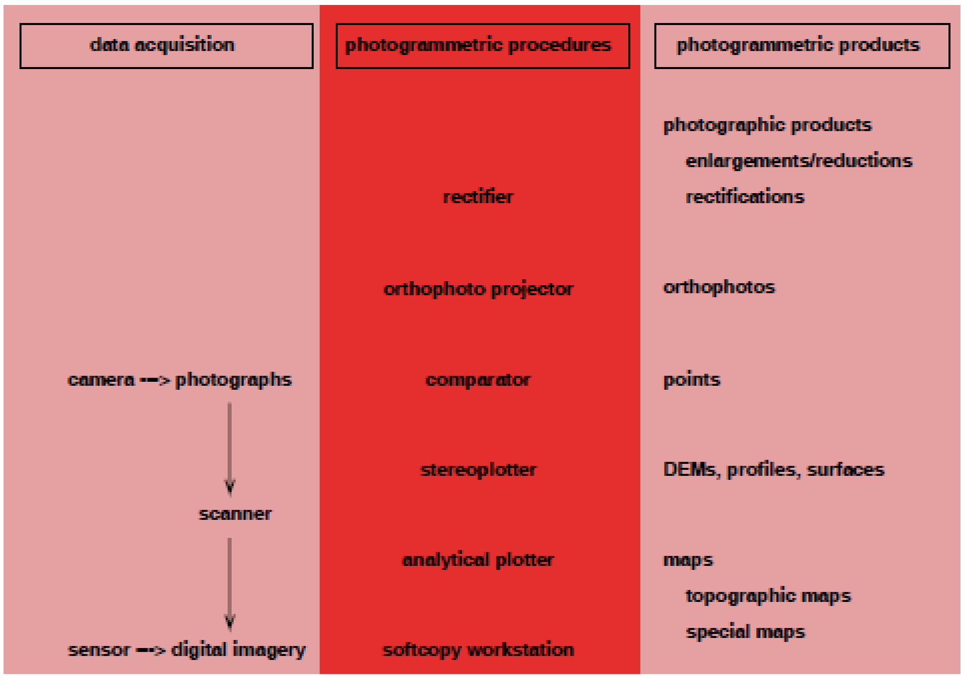



*Fig. 2.5 Analytical Photogrammetry portrayed as systems approach. The input is usually referred to as data acquisition, the "black box" involves photogrammetric procedures and instruments; the output comprises photogrammetric product. [9]*

### Photogrammetric Camera

The term sensor has been introduced as a generic name for sensing and recording radiative energy. Figure 2.6 shows a breakdown of different types of sensors.

An example of an active sensing device is radar. An operational system sometimes used for photogrammetric applications is the side looking airborne radar (SAR). Its main advantage is the fact that radar waves penetrate cloud and haze. [9]

Passive systems fall into two categories: image forming systems and spectral data systems. In this study, the main focus is on image formation systems which are divided into coordination systems and scanning systems. Image forming systems acquire all data at one instant in time. Scanning systems obtain the same information sequentially for example by collecting scanline by scanline. Image forming 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. [9]

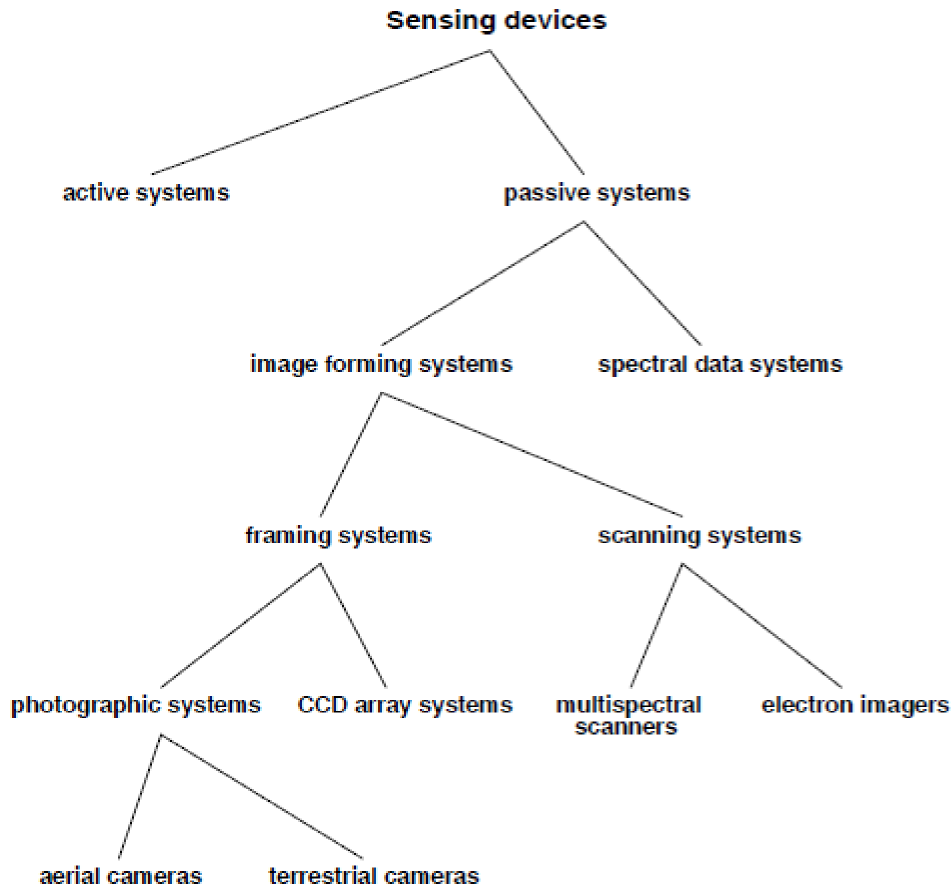



*Fig. 2.6: Classification of sensing devices. [9]*

Amongst all of the sensing devices used to record data for photogrammetric applications is the photographic systems with metric properties. They are grouped into aerial cameras and terrestrial cameras in more detail in appendix.

Panoramic cameras are examples of non-metric aerial cameras. Fig. 2.7 depicts an old aerial based camera on the left and a new system on the right. [9]

It should be mentioned here, that nowadays all aerial photos are collected using digital camera systems, based on CCD and CMOS technologies.

(A)


(B)

*Fig. 2.7: (A) Aerial analog camera Wild Aviophoto RC20. (B) Some digital camera systems*

### 2.1.4 RGB-D Mapping

RGB-D 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 based loop closure detection, followed by pose optimization to achieve globally consistent maps. [10]

**Introduction**

Establishing 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 and the globally consistent alignment of the complete data sequence.

While 3D point clouds are extremely well suited for frame-to-frame alignment and for dense 3D reconstruction, they ignore valuable information contained in images. [10]

RGB-D cameras are sensing systems that capture images with per pixel depth information (see Fig 2.8).

RGB along RGB-D cameras allow for the collection of reasonably accurate mid-resolution depth and appearance information at high data rates. [10]

*Fig. 2.8 (left) RGB image and (right) depth information captured by an RGB-D camera.*

In general, RGB-D image is simply a combination of a RGB image and its corresponding depth image, a depth image is an image channel in which each pixel relates to a distance between the image plane and the corresponding object in the RGB image.

In the past years, new camera systems provide both color and dense depth images became readily available in more detail in appendix B.

There are great expectations that such systems will lead to a boost of new 3D perception-based applications in the fields of robotics and visual and augmented reality.

**Techniques for 3D Mapping**

3D Mapping is used for robots operating in the 3D world,3D maps, which support object recognition with more accurate path planning, reliable localization, data association and Navigation on uneven terrain. [10]

**3D Computer Graphics**

3D computer graphics (in contrast to 2D computer graphics) are graphics that use a three-dimensional representation of geometric data (often Cartesian) hat 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. [10]

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

Solid: These models define the volume of the object they represent (like a rock). These are more realistic, but more difficult to build. Solid models are mostly used for non-visual simulations such as medical and engineering simulations, for CAD and specialized visual applications such as ray tracing and 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. These are easier to work with than solid models. Almost all visual models used in games and film are shell models.

### A. 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 (points and other information), 3D models can be created by hand, algorithmically (procedural modeling), or by scanning.

### B. Modeling Process

Polygonal modeling- Points 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 be using many polygons.

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 include non-uniform rational B-spline (NURBS), splines, patches and geometric primitives.

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.

### 2.2 Literature Review

Extensive research and developments have been carried out in the last years. Here is an excerpt and cited in more details.

#### 2.2.1 Review of prior studies:

**A. Case 1:**

Title of Study: Texture Mapping and Implementation Aspects for 3D 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 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 owners. [11]

In the following methodology and project planning there are implementation steps applied to build a true reality 3D GIS model with texture mapping that is implemented for King Hussein Park, those steps are data Modeling, data Measurements, Processing and Preparation, build 3D model, build a 3D GIS model with all relational spatial data base and texture mapping[11]

The scope of study includes Al Hussein Public Park, which is one of the landmarks in Amman, Jordan. The Park includes a cultural village, sports fields, memorial building, historical passageway, decorated gardens, amphitheater, circular yard, automobile museum, children museum, Traffic Park, and walls and gates. The study aims at showcasing 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 [11]

One result of the research is the exploration to effectively use a 3D GIS, modeling in various applications, virtual city modeling to build three dimensional GIS models, that allow for 3D spatial analysis for various applications. The approach used in this work presents a simple strategy that is suitable for required spatial applications and provide more realistic views and virtual reality environments. Moreover, two procedures to add texture mapping to the 3D objects are discussed and compared. [11]

Conclusions and Future work focus on important of define an automatic procedure for fitting available vector data such as streets to DTM and orthophoto to build virtual 3D GIS models. More work and investigation are being made for 3D virtual city models for cadastral applications, such as adding details for Building Texture and Building Floors using CAD drawing details adding attributes to these floors, adding streets features based on texture captured from orthophotos and populating these models on the internet through web-mapping applications. [11]

Society and sample of study is tourists and visitors a sample has been taken by selected in order to study the possibility of applying the study. [11]

**B. Case 2:**

Title of Study: Workflows and the role of images for virtual 3D reconstruction of no longer existent historical objects.

Name of researcher: S. Munster, Media Centre, Dresden University C Technology, D-1062 Dresden, Germany.

Study objectives: 3D reconstruction of historic objects

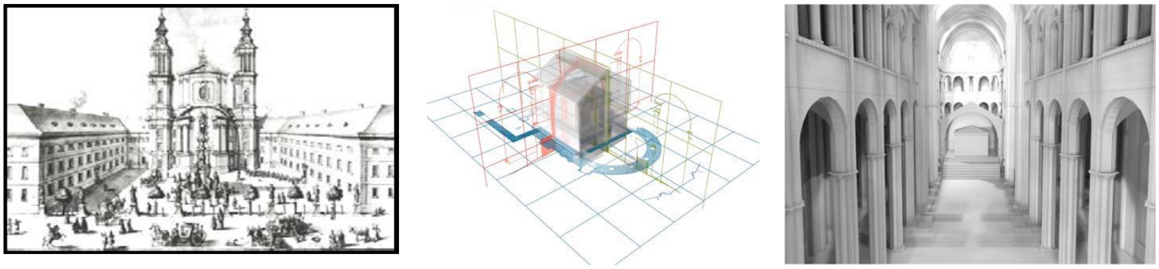
Generally, research about the usage of images is nothing new and takes place in relation to their usage in various contexts, such as engineering, design, architecture or for scientific and research context. [12]

In methodology and project planning the author performed three stages of analysis using widely established methods from social sciences: the first stage was a qualitative content analysis for publications to examine current usage scenarios. The investigation included a sample of 452 journal articles and conference proceedings dealing with 3D reconstruction of historic items. A second stage performs a qualitative content analysis with a sample of another 26 international publications dealing with a reconstruction of no longer existent objects, and a third stage includes four case studies exploring 3D reconstruction projects of historic buildings over time to examine aspects of visual communication and their evolution during a project creation process. [12]

This Study was implementation at a glance, images are widely used for the reconstruction of existent objects. Especially reconstructions of no more existent or never realized objects are mostly practiced by interdisciplinary teams including modelers and researchers. For these projects images are the most important sources. That results in comparison to textual sources not only from their richness and clearness of included information about visible aspects like objects, situations, geometries or sometimes surfaces, but also from their easy visual transferability and comparability with visual 3D models. [12]

The Results of this study performs a qualitative, explorative research using methods from social sciences. That indicates a possibly subjective decision taking. Moreover, the sample is, in relation to similar investigations, relatively small and based mostly on ex post material and should be further increased. Fig.2.9 demonstrates the workflow until the final visualization. [12]

The conclusions and future work were insights for performing 3D reconstruction of historic objects could be that many suggestions from project and innovation management would fit for that kind of task and could foster working processes. While there are many efforts to make sources used for reconstruction visible in results, too, there are only a few possibilities and practically used approaches to making the decision and creation processes transparent. In addition, it would be important to find strategies to include a creation process in scientific discourse.



**Sources**

**Historical sources**

- Hist. images: panoramas, plans

- Additional hist. sources: i.e. text

**Contemporary sources**

- Visual: sites, plans, photography

- Data: laser scans, photogrammetry

**Logical "sources"**

- Architectural systems

- Analogies

- Inner model logic

**Modeling**

**Semi-automated modeling:** algorithmic reconstruction

**Procedural generators**

**Manual CAD/VR modeling**

**Visualization**

**Static images**

**Animations**

**Interactive Visualization:** i.e. games

**Data Output:** i.e. for manufacturing

*Fig. 2.9 Classification schema: Sources, Modeling, Visualization. [12]*

Society and sample of study has been taken by doing 9 interviews with key role team members; in addition, 6 direct and participating observations of team meetings were carried out. Also, a significant number of documents, including log files, communication data, protocols, sources and model renderings were included in investigation. [2]

## C. Case 3:

Title of Study: GIS Applications for Building 3D Campus, Utilities and Implementation Mapping Aspects for University Planning Purposes.

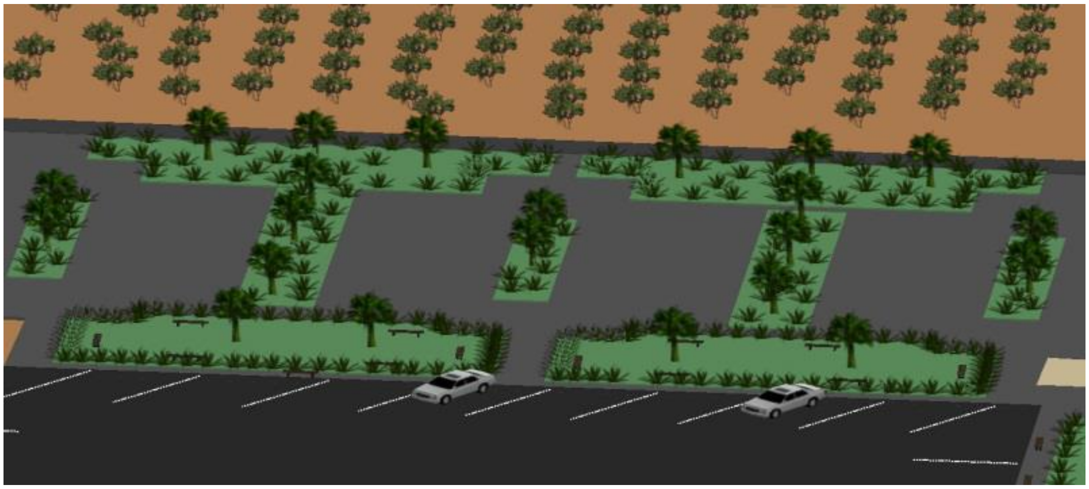
Name of researcher: A. Al-Rawabdeh, N. Al-Ansari, H.Attyal and S Knutsson. Study objectives: real 3D GIS model for the campus of the Al al-Bayt University.

The following study-built 3D GIS map and all utility information for Al al Bayt University campus as an example. The primary objective is to improve data management (e.g. Maps, plans, usage of facilities and services) and to develop methods using 3D spatial analysis for specific applications at the university. [13]

The methodology and project planning of this case following steps are implemented to build a real-world visualization of Al Bayat University: data acquisition, generation of a 3D model, visualization of the 3D model. Detailed information on these works is presented in existing GIS layers: Layers are groups of features organized into an object called a Shape file. In this study, different vector layers were available from the Department of Maintenance and Engineering inside the campus. These layers are: buildings layer, road networks layer and utility layers, AutoCAD files (CAD format data) made available from the scanned maps of the area and construction drawings. Raster imagery such as Google earth image for the area of interest and attribute database and documentations related to the park's information.

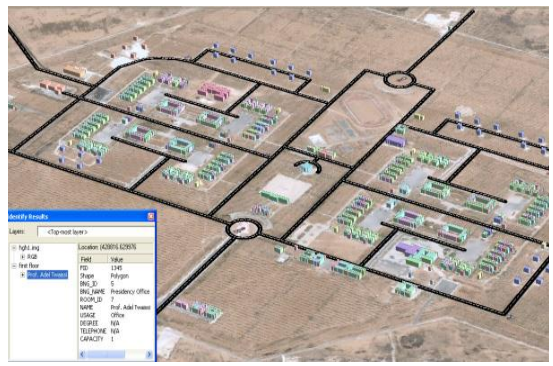
Scope of study was Al-Bayt University is one of the public universities in Jordan. It was established as one of the landmarks within the Al-Mafraq municipality. It contains parks sports fields, gardens space, museum, faculty, buildings, mosque and gates. [13]

The main results were 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. The 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, as illustrated in Fig (2.10). [13]



**(A) Green space 3D models with color texture using 2D vector layer in the ArcScene environment**

**(B) 3D visualization: scenario prototype of main campus.**



**(C) Identify tool in the 3D view and 3D campus model with roads networks layer .**

*Fig. 2.10 (A), (B) and (C) Prototype models of 3D visualization.*

### 2.2.2 Own comments on previous studies

Own comments on 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 and smartphone's environment.

# CHAPTER THREE

## Methodology and Research Planning

# CHAPTER THREE

## Methodology and Research Planning

### 3.1 Research community

Established in 1985 as Omdurman Ahlia College **(OAC),** it was initially conceptualized as a logical expansion for non-governmental education which has been sustained by our Sudanese nationals' long-standing initiative and contributions before independence, in 1995 it's emerged as a full-fledged university with seven academic faculties and one center in the fields of humanities, technology, arts and medical sciences. The Faculty of Engineering and Architecture was recently established in year 2004.

OAU has been a pioneer in the fields of Medical Laboratories and Computer Science as well as vanguard in B.Sc. programmes of Environmental Studies at country level. As such, these programmes have been subsequently emulated by other higher education institutions.

The population students are about eight thousand pursuing different academic disciplines and qualifying them for either B.Sc. or intermediate diploma, also it's offers M.Sc. programmes in Environmental Sciences as well as postgraduate Diplomas in Applied Physics and Statistics. Postgraduate programmes are expected to be launched in Economics, Medical Laboratories, Languages (Arabic, English & French) and Sudanese Studies.

In pursuance of its lofty and noble goals, OAU has established cordial and fruitful academic and research coordination efforts and relations with renowned higher education institutions at country, regional and international levels.

The university campus is a complex infrastructure. especially to new students and visitors because they have a hard time to orientate themselves and finding the right places. it has different buildings with up to two floors high - most of these buildings are far from each other. Even if there are maps at some points on campus, users 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 university campus and how can they be supported by using modern tools.

The campus includes the University Administration, Students' Deanship, the Secretariat 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, Documentation and Information Center, Personnel Office, Financial Administration, Legal Affairs Office, Administration Affairs.

### 3.2 Methodology and Research Planning

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

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

**A. 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 or attribute database and documentations related to the OAU information.

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

**B. Data Measurements, Processing and Preparation:**

To build the required 3D GIS information system needs data measurements, processing and preparation.

Data measurements and Capturing: In this process the following important data measurements have to be taken: Dense images of the area of interest using a high precision camera, stereo images of objects to build 3D models and photos of required texture to be used as filters later on to map texture to the 3D models.

Data Processing and Preparations: In this process the following important processing steps are carried out: Build point clouds for the area of interest (AgiSoft PhotoScan software is used), 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 and also add their attribute data (Esri ArcMap is used) and at last build relational databases within the GIS data model layers (Esri ArcMap and Esri ArcEditor used).

**C. 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:

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 (Agisoft PhotoScan and Photomodeler softwares are used).

Case IV - some parts are available in 2D and others in 3D: Combination o 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).

D. Build a 3D GIS model with all relational spatial data bases:

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: For 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 the Trimble 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 Photo Modeler or other photogrammetry software such as SOCET SET or ZI 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 the 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 works well in this case).

**E. 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 attribute of the whole building for example, if the object is very complex and cannot be exported as true 3D mode with texture or the objects are standard and are very similar in shape, such as villa compounds, to be built using software 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.

### 3.3 Selected methodology and techniques

The suggested methodology is very flexible and can be utilized and implemented for various types of applications, that are becoming essential in future projects. Photogrammetry exploration and texture mapping is now becoming feasible with low cost and less efforts. For this purpose, several software will be employed and used completely in the required production workflow, which are the following:

**A. Agisoft's Photoscan:**

Agisoft Photoscan is an advanced image-based 3D modeling solution aimed at creating professional quality 3D content from still images, it will be used to extract the point clouds by dense image matching of the area of interest. [14]

**B. Trimble's SketchUp 2017 (version 2017):**

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 counts millions of active users. [15]

It will be used to import point clouds in las format (see appendix C) 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. [15]

**C. Esri's ArcGIS 10.5:**

ArcGIS Desktop is comprised of a set of integrated applications, which are accessible from the Start menu of your computer: with **ArcMap**, Arcscene and ArcCatalog. you can create maps, ArcMap is the main mapping application, which allows to 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 the ArcCatalog.ArcToolbox contains tools for geoprocessing, data conversion, coordinate systems, projections. [16]

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

**D. Sketchfab:**

Is the leading Internet platform to publish and find 3D and Virtual reality (VR) content, anywhere online Moreover, it is a good environment to upload files in almost every graphics format, it will be used to visualize the 3D model in VR mode by uploading the model to be accessible online. [17]

# CHAPTER FOUR

## System Analysis and Design

**4.1 System Requirements.**

**4.2 Database Analysis and Design.**

# CHAPTER FOUR

## System Analysis and Design

### 4.1 System Requirements

#### 4.1.1 Functional Requirements

1. The system provides 3D design for OAU Main Campus.
2. The system aims to provide information about all the campus buildings.
3. Also, its aims to represent all resources within the campus in a hologram.
4. The system offers real world visualization, helps new students, teachers, administrators and visitors viewing the resources inside the campus and administration buildings.
5. It also supports virtual visualization over Smartphone platforms to be accessible anytime, including laboratories and lecture halls.
6. The system illustrates locations of the library, registers halls, clinic, etc.
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 university by defining restrooms and private sections for male and female students
9. It illustrates locations of cafeterias and stationery shops.
10. It marks each faculty with its statues and logos.
11. 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 considered.

The processing of the photographs and the 3D model construction comprises the following main system requirements:

Minimal configuration: operating system Windows XP or later (32 or 64 bit), Mac OS X Snow Leopard or later, Debian/Ubuntu (64 bit), processor intel Core 2 Duo processor or equivalent and 2GB of RAM.

Recommended configuration operating system Windows 7 or later (64 bit), Mac OS X Snow Leopard or later, Debian/Ubunt (64 bit), processor Intel Core i7 processor and 16GB 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 10 Mega Pixel, 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).

#### 4.1.3 Nonfunctional Requirements

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

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

### 4.2 Analysis and Design

#### 4.2.1 Database Requirements

OAU's main campus consists of a number of colleges and administrative buildings: Faculty of applied sciences & computer, Faculty of economics administrative sciences, Faculty of applied studies faculty of arts, Faculty of engineering and architecture, Faculty of health sciences, Faculty of human &technological development, Faculty of environmental sciences, Faculty of medicine, Mohammed Omar Bashir center, clinic, The University Library, English Center, Basketball Court, Football Field, Clinic, Vice - Chancellor Office, Deputy Vice -

Chancellor Office, Warehouse, Souad El Sabah Computer Center, financial management, student affair, scientific affairs, security office.

Each college has its own buildings: lecture halls, laboratories, offices of professors and college registration offices, also, the university campus contains some other resources such as: cafeterias, restrooms for males/females and the grand mosque.

### 4.2.2 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 building layer and the college layer. Fig. 4.1 shows the GIS layer structure and hierarchy.

#### A. Database Transactions

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

The 3D model of the university will be visible for each student and visitor online for better view and access over desktops (WebGL browser) and Smartphones allowing them to orient the model or retrieve geodata in response of a mouse click.

#### B. Geodatabase schemas

The 3D-map database employed in this study is a database involving the characteristics shown in Fig 4.1. The geospatial data in the contemporary GIS are organized in one of many geo-databases also called GIS or spatial databases. Commonly, a geo-database is an object-relational database designed to store, query, and manipulate quantitative data, such as geometry and coordinate data types, as well as qualitative data called attribute data types. The geometry and coordinate data types represent the shape and the location of an object in the physical world. All geospatial data are organized in relational tables (Fig.4.1).

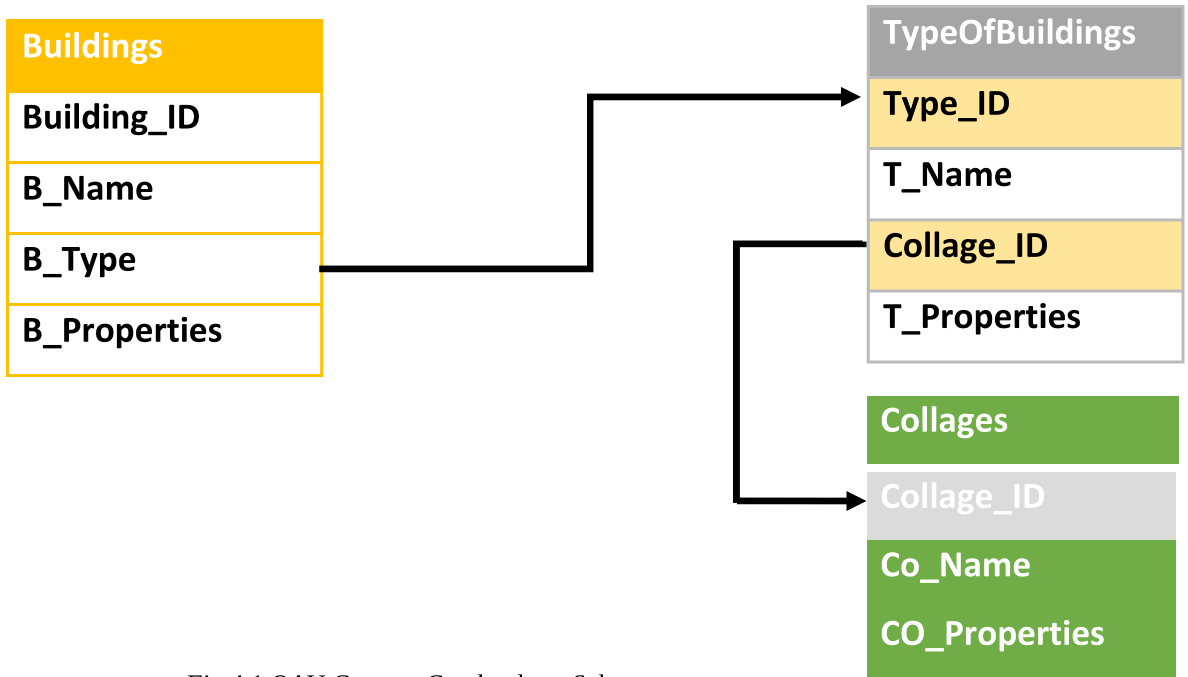



*Fig.4.1 OAU Campus Geodatabase Schema.*

**Geospatial data structure and methodology**

The key thematic data layers of such a GIS described above comprise campus, buildings and colleges data. These layers need to build the spatial and attribute data that are necessary for the acquiring and management function executions. Fig 4.2 illustrates the GIS layer structure and hierarchy.

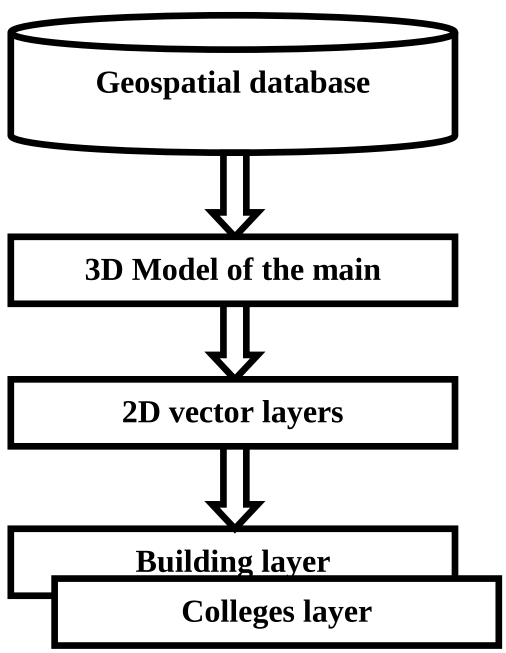



*Fig. 4.2 GIS Layer Structure and Hierarchy*

The following section deals with a detailed workflow and methodology used for 3D GIS building visualizations for OAU. The GIS data modeling part is an important step to build a 3D Model starting from data acquisition, either it is semantic data or photogrammetry data, to create a virtual reality 3D model with geospatial database layers. Fig. 4.3 shows the workflow of 3D visualization model.

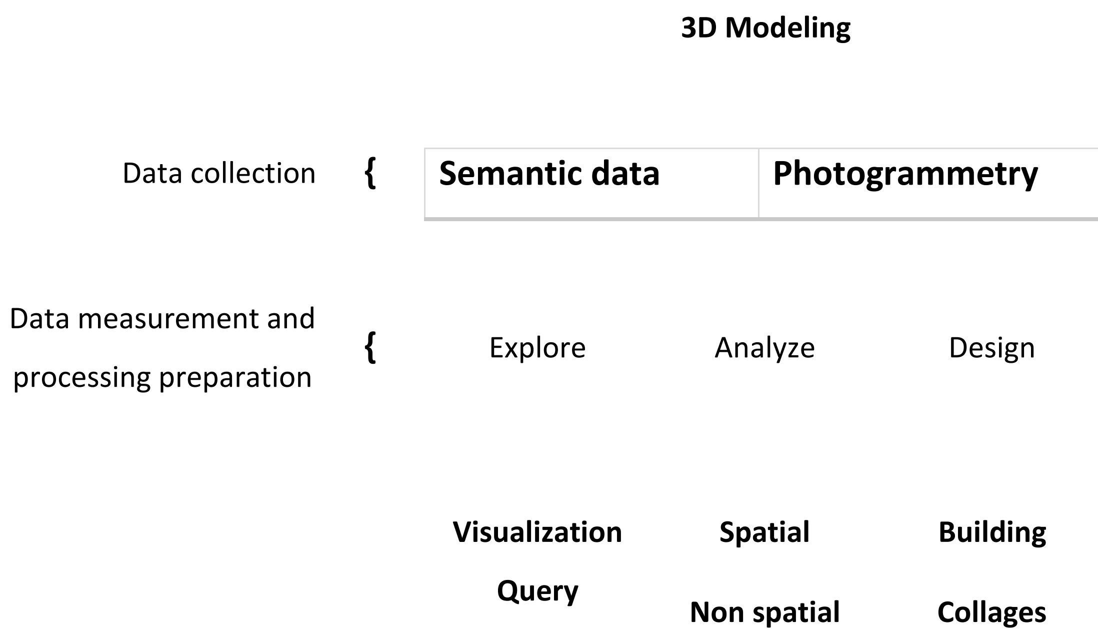



*Fig. 4.3 The workflow to build a 3D model*

The overall methodological steps are graphically represented in Fig. 4.4. As illustrated in this figure, the methodology consists of several steps. Starting from gathered data that is used to build the 3D model for OAU, photogrammetric methods are carried out to extract the point clouds from the photos. Furthermore, 2D maps are utilized to create a planimetric campus database, specifying target areas and parameters for simulations. Finally, the 3D GIS model comprises three layers: the colleges layer, the buildings layer and the 3D layer of OAU refined by texture mapping.

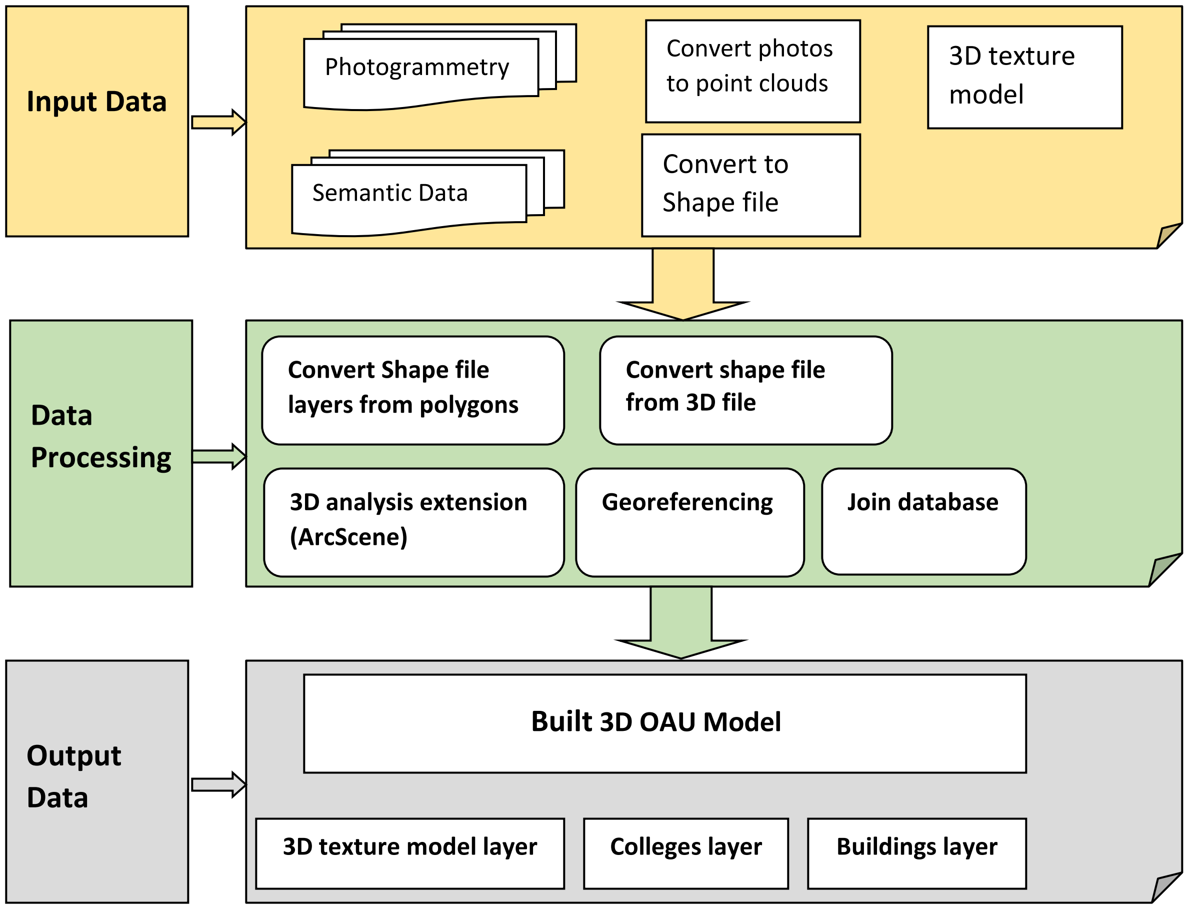



*Fig. 4.4: Schematic diagram of the methodology study scenario to build a 3D data campus model.*

# CHAPTER FIVE

## Simulations and Results

### 5.2 Photogrammetry

### 5.3 3D Model Reconstructions

# CHAPTER FIVE
## Simulations and Results

### 5.1 Photogrammetry

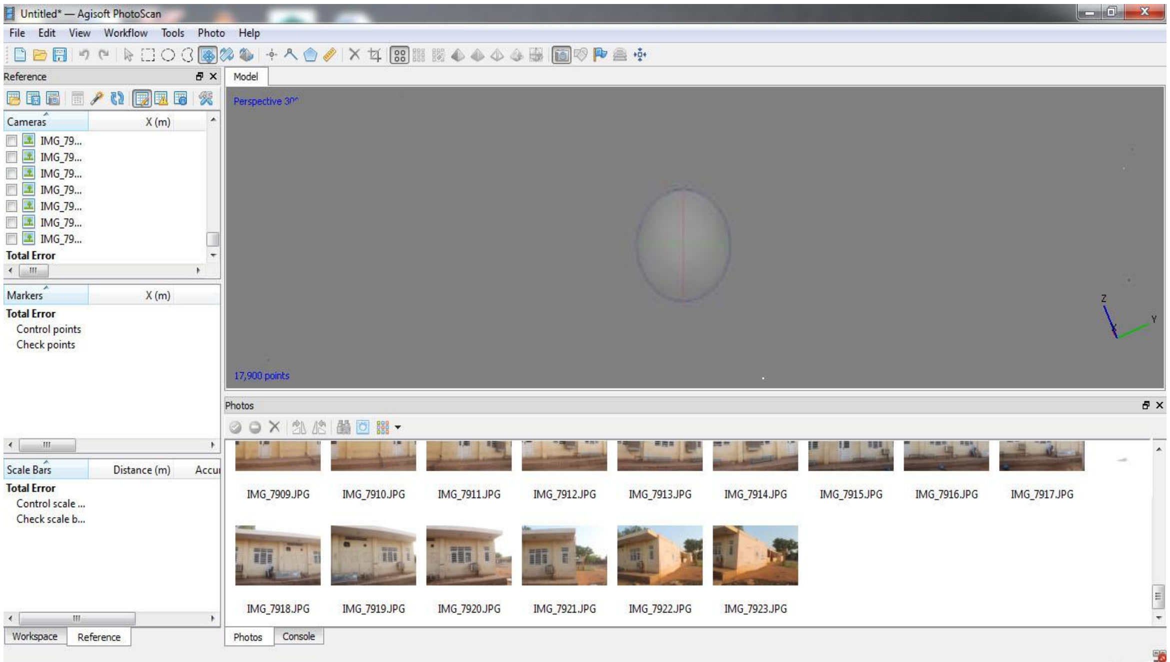
- A 3D model of OAU main campus is created. An excerpt of an aerial photo from Google Maps has been taken illustrating the region and location of Omdurman Ahlia University (Fig 5.1).
- The first step of the study was getting the point clouds of the buildings from a collection of overlapping images using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


*Fig 5.1 An aerial image patch from Bing Map excerpt illustrating the Geographical Location of Omdurman Ahlia University [18]*


*Fig 5.2 Several Photos "scanning" the faculty of engineering and architecture buildings (outside)*

### 5.1.1 AgiSoft

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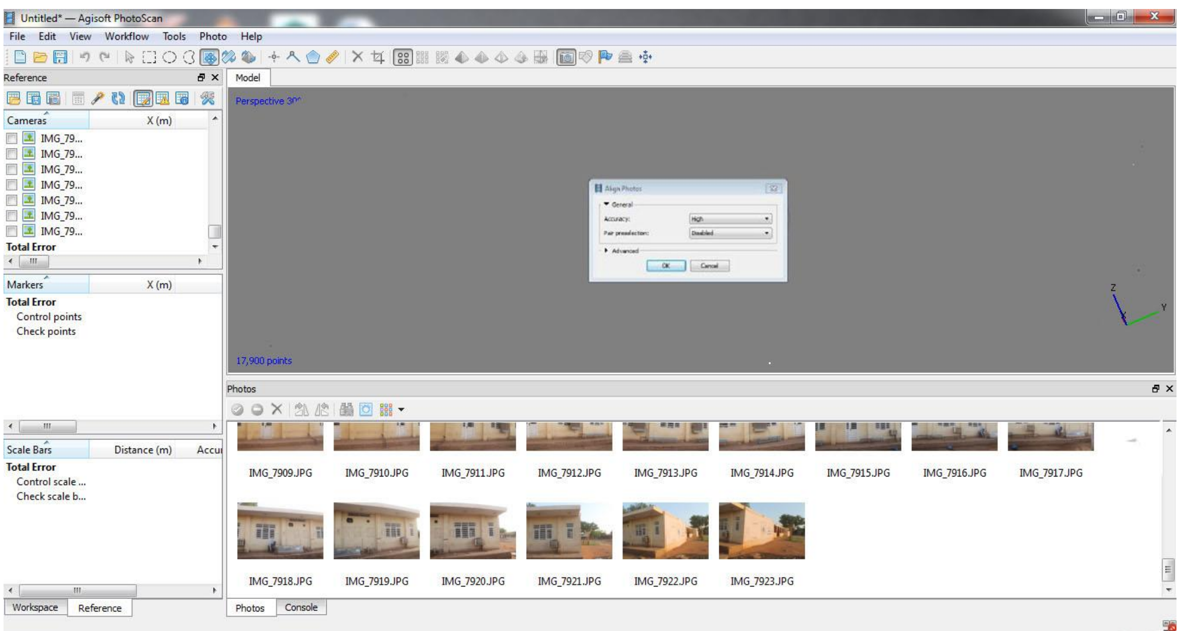
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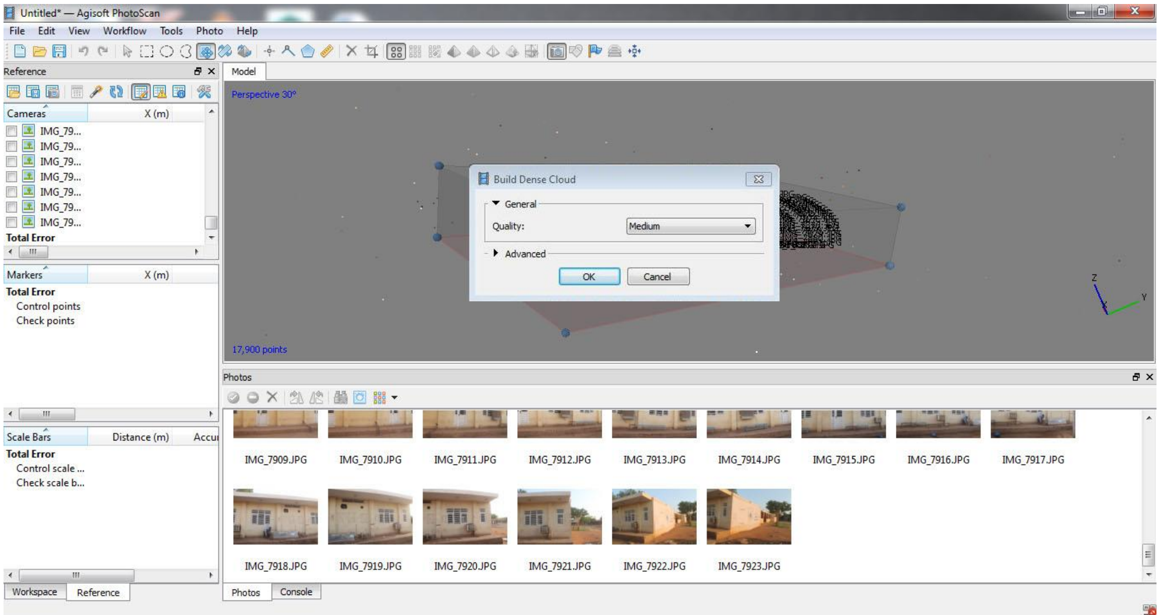
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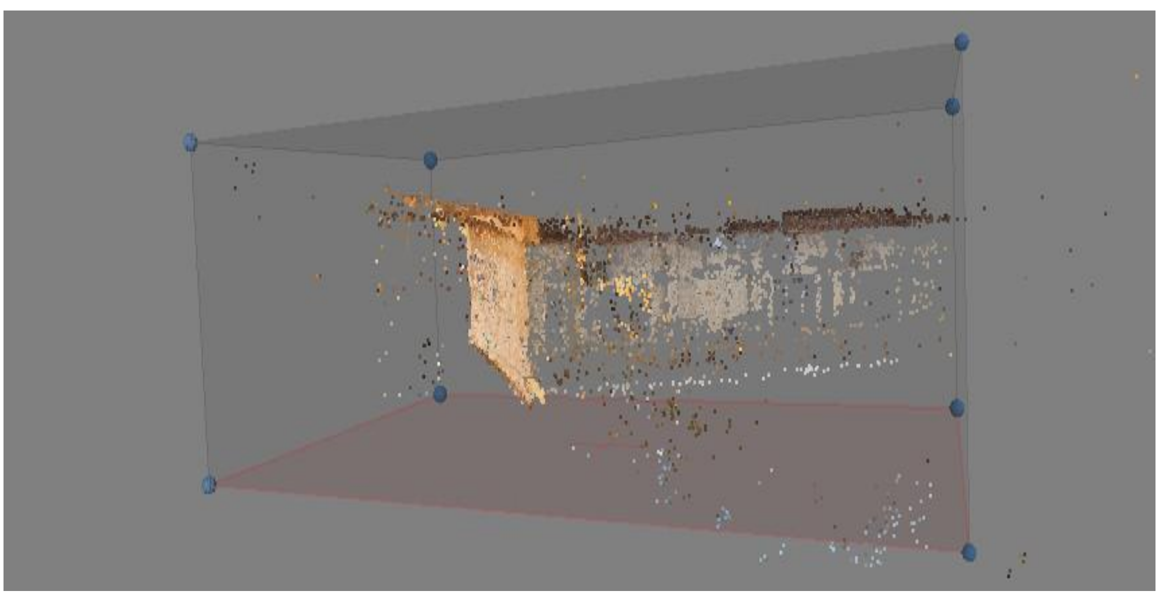
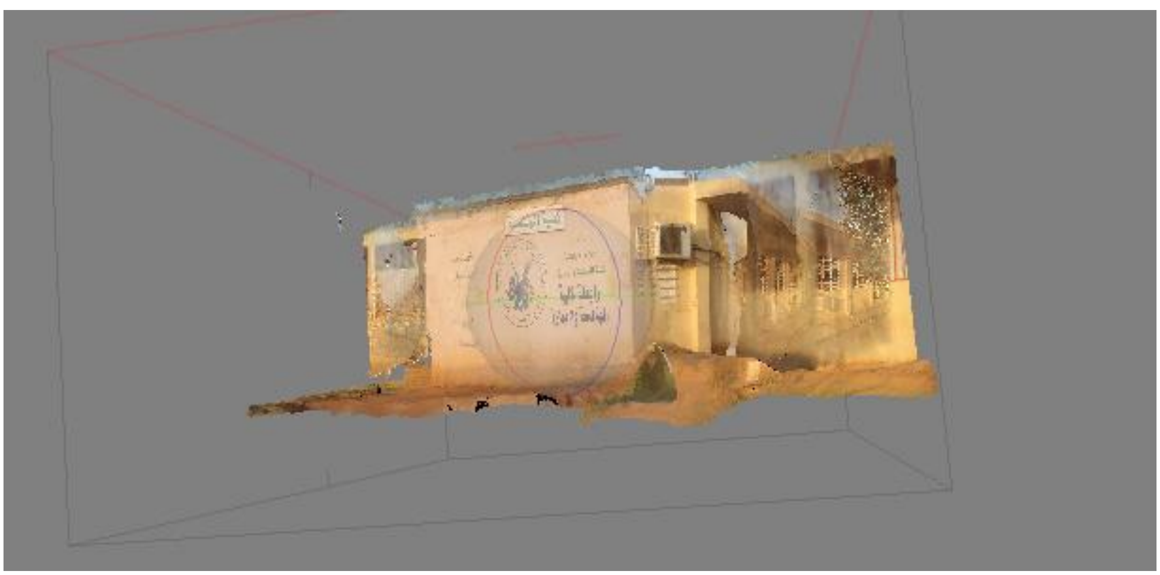
**(C)**



**(D)**


**(E)**



**(F)**

*Fig 5.3 AgiSoft – Photoscan Image processing: (A): The Agisoft program GUI (B): illustrating photos and detecting points. (C): Build Dense Point Clouds (D): Build Mesh in PhotoScan , (E): Build Texture in PhotoScan ,(F): Build Tiled Models 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.

### 5.2 3D Model Reconstruction

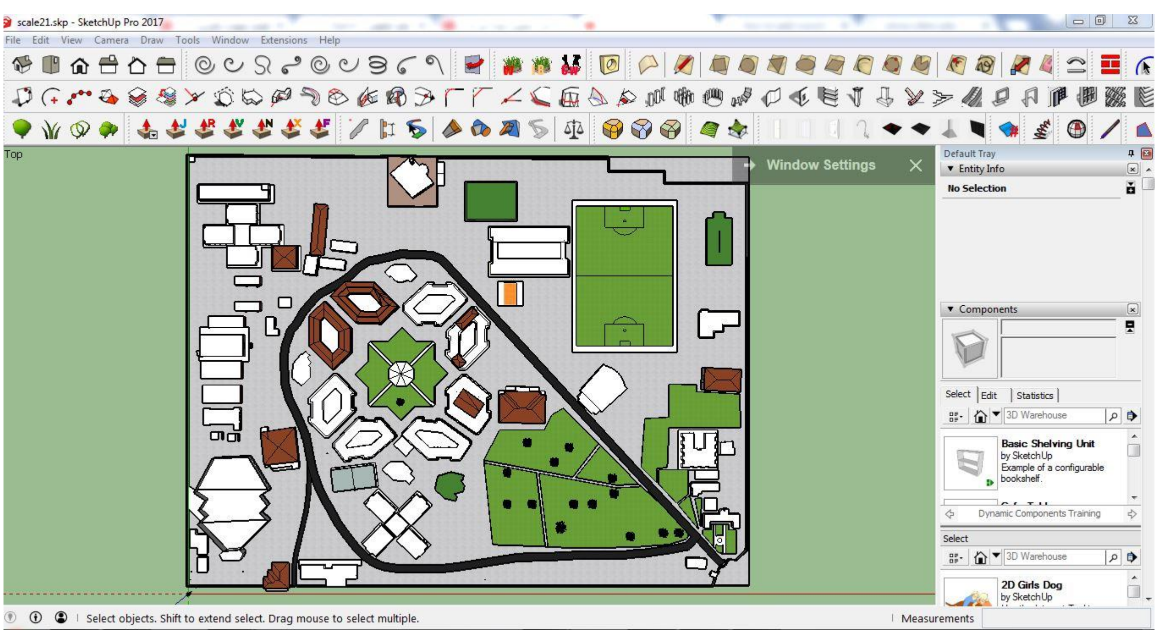
Reconstructing a 3D model is a combination of several processes or phases. 3D and 2D vector and raster data were created for the Region of Interest (RoI) using Trimble's SketchUp Pro software and Esri's ArcGIS (ArcScene).

#### 5.2.1 SketchUp

Trimble's 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 Under-Extension package was used for importing the point cloud (*.dae format) files and adjusting objects. This works well with SketchUp version 2017 as an extension for importing numerous point cloud files, resulting from airborne LiDAR, Mobile Mapping Systems, Terrestrial Scanners, Handheld Scanners or Photogrammetry.

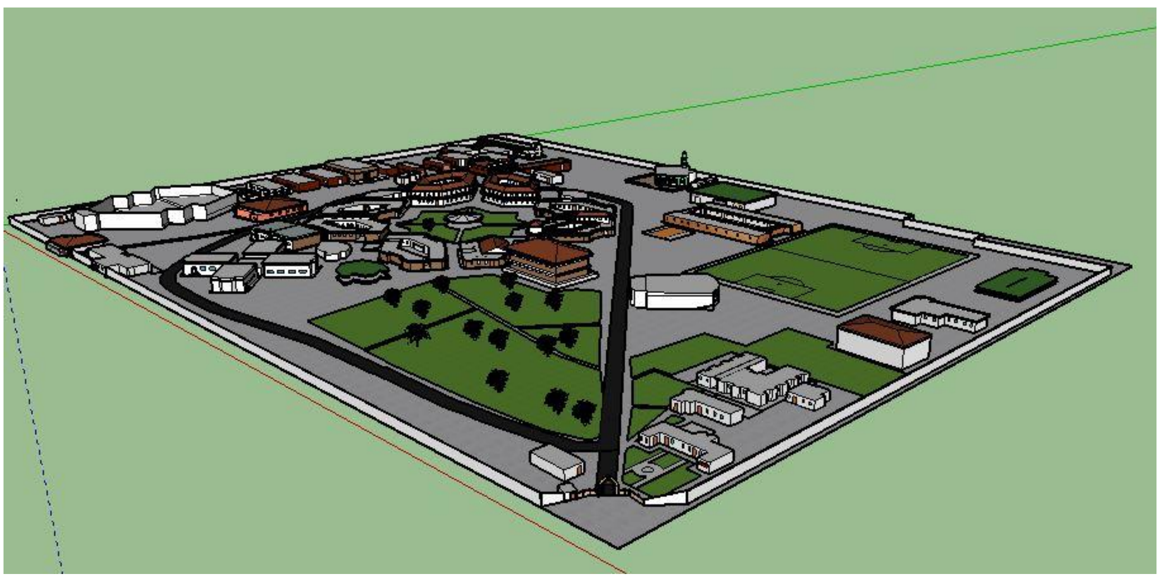
The 2nd step was adding texture for the model to be built by customized point clouds. SketchUp synthetic textures and image textures were used to guarantee better visualization and true virtual reality. This is demonstrated in Fig (5.4), (5.5).



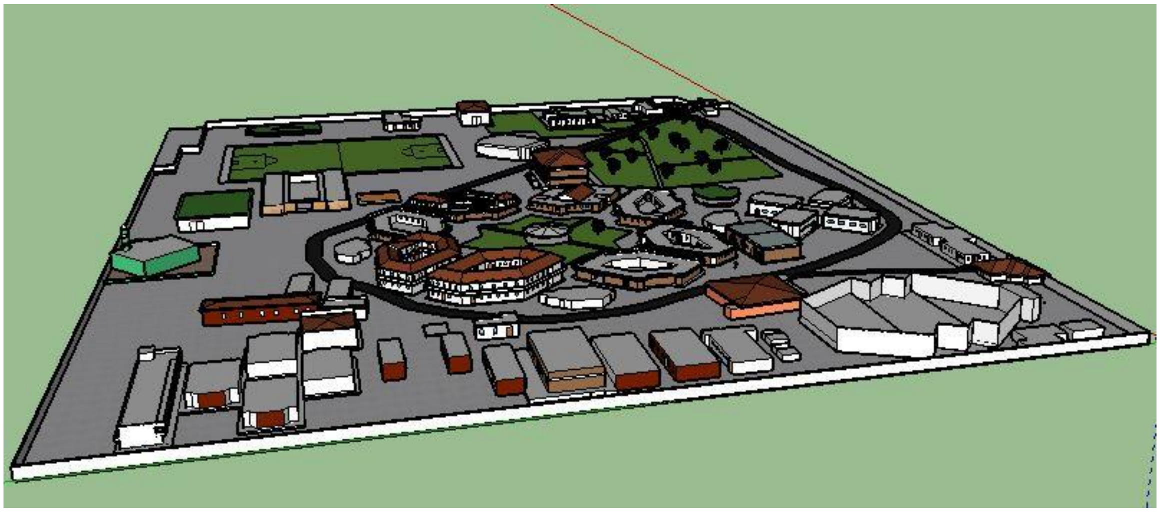
(A)

(B) (C)

*Fig. 5.4 (A, B and C) Final SketchUp results For the Omdurman Ahlia University from different views*



(A)



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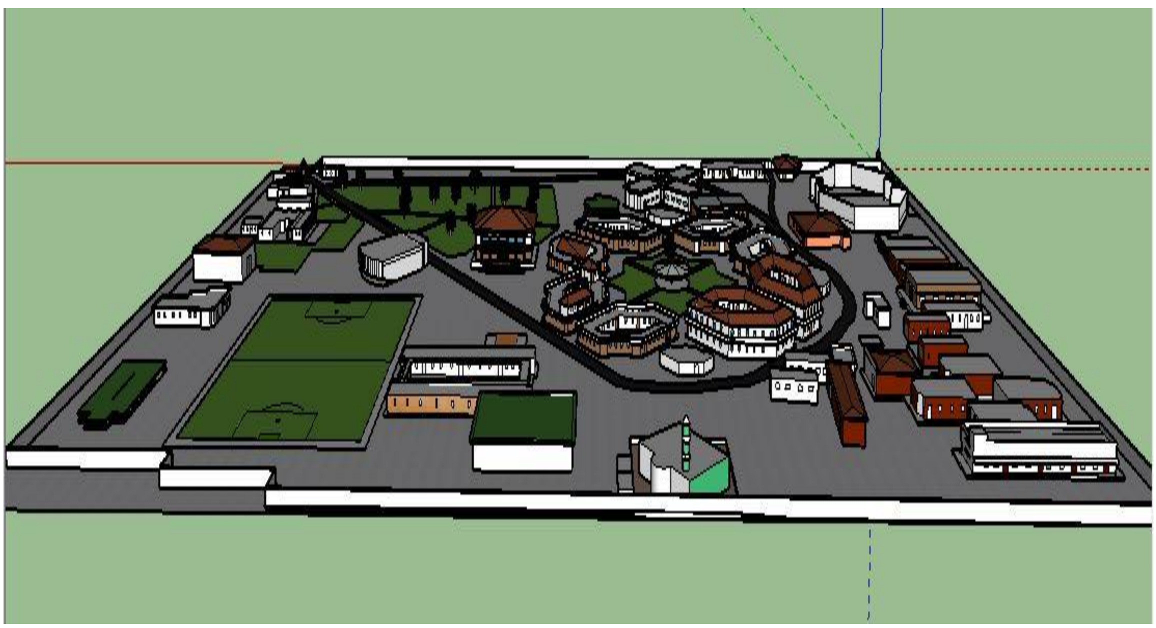
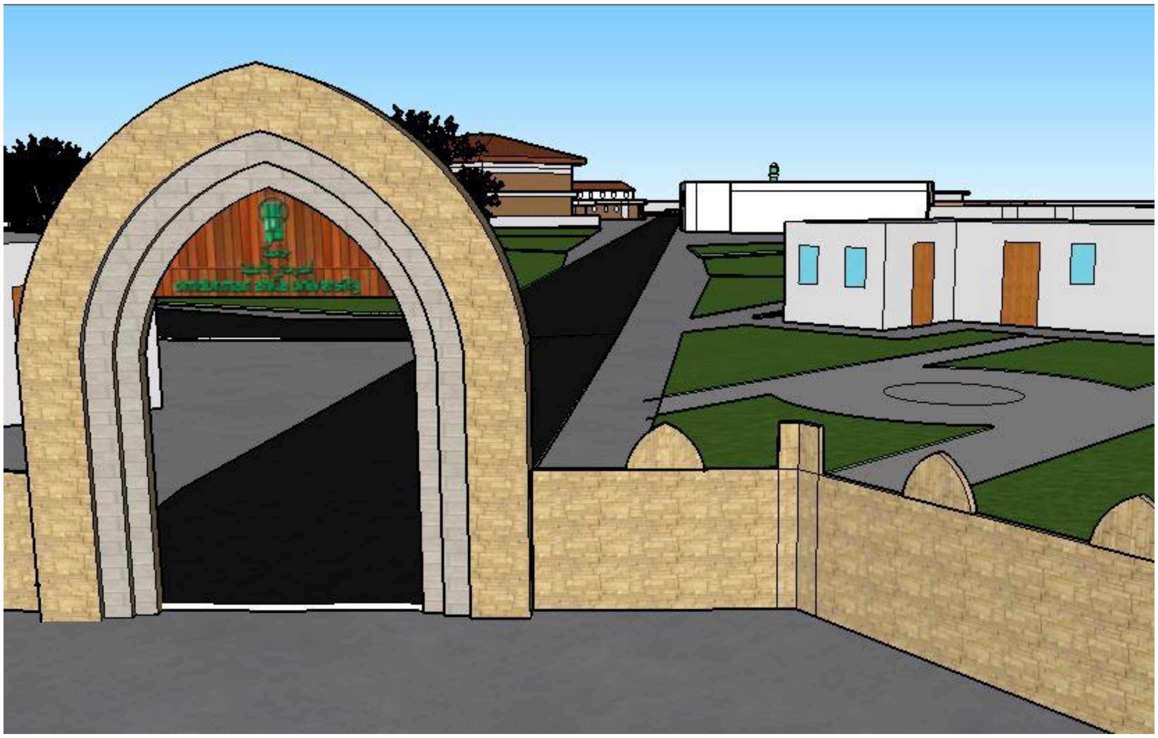


(C)

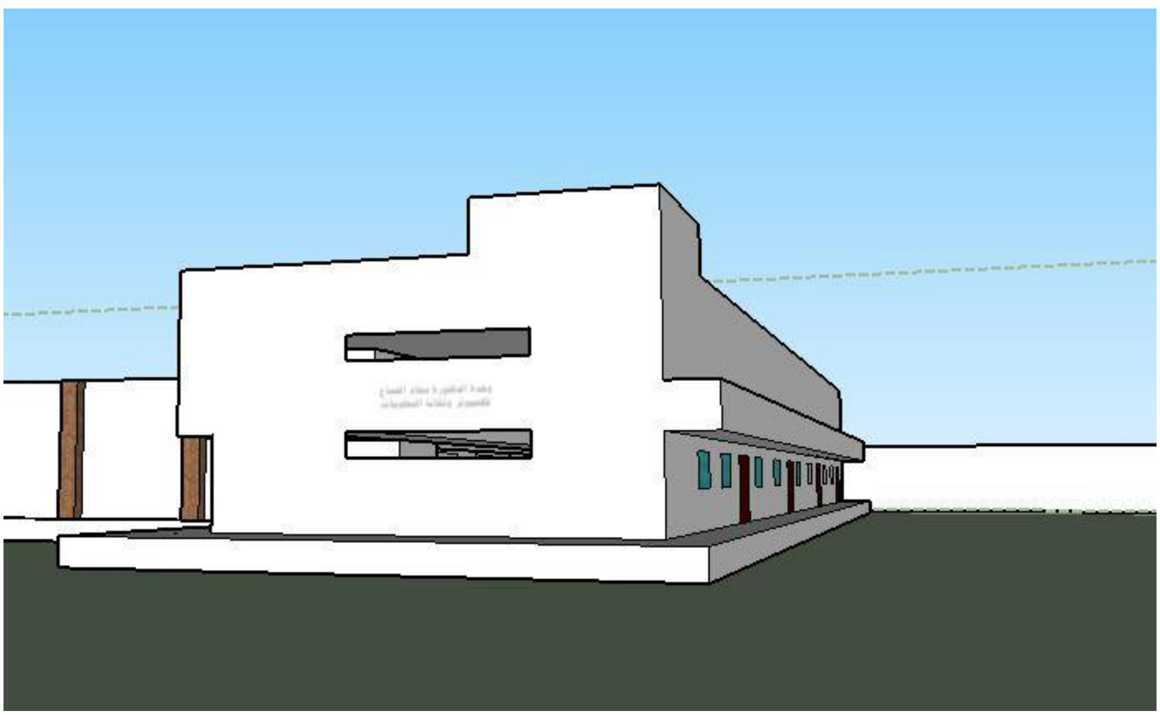



*(D)*

*(E)*

*(F)*

*(G)*



*(H)*

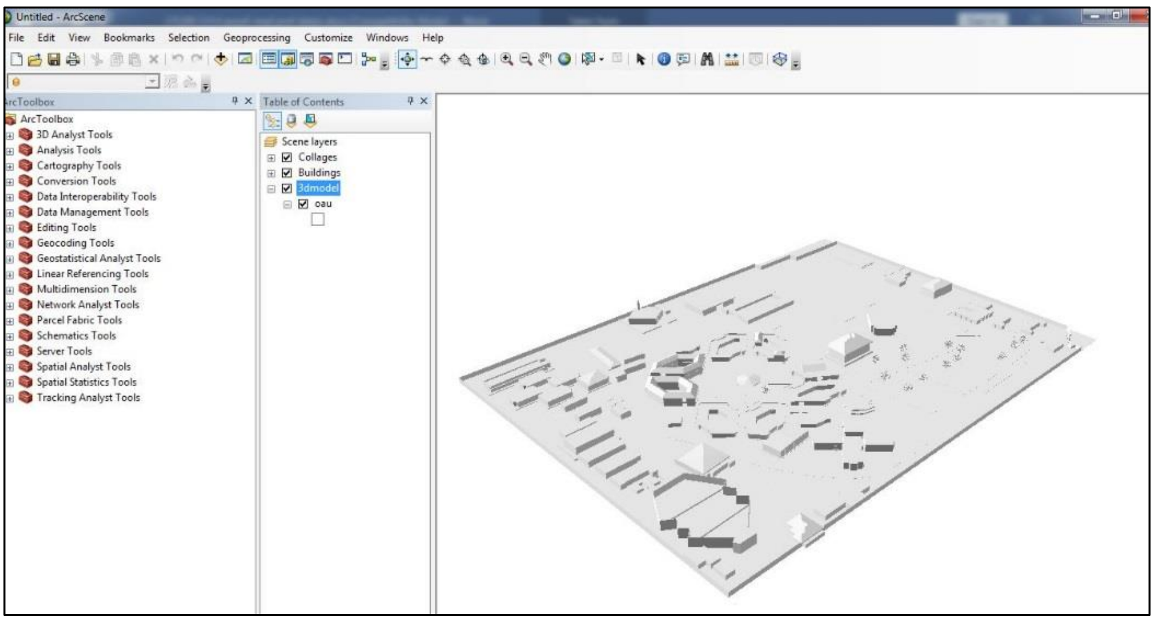
*Fig. 5.5 (A, B, C, D, E, F, G and H) Sample of Colleges and in Camps of Omdurman Ahlia University from different views*

### 5.2.2 ArcGIS

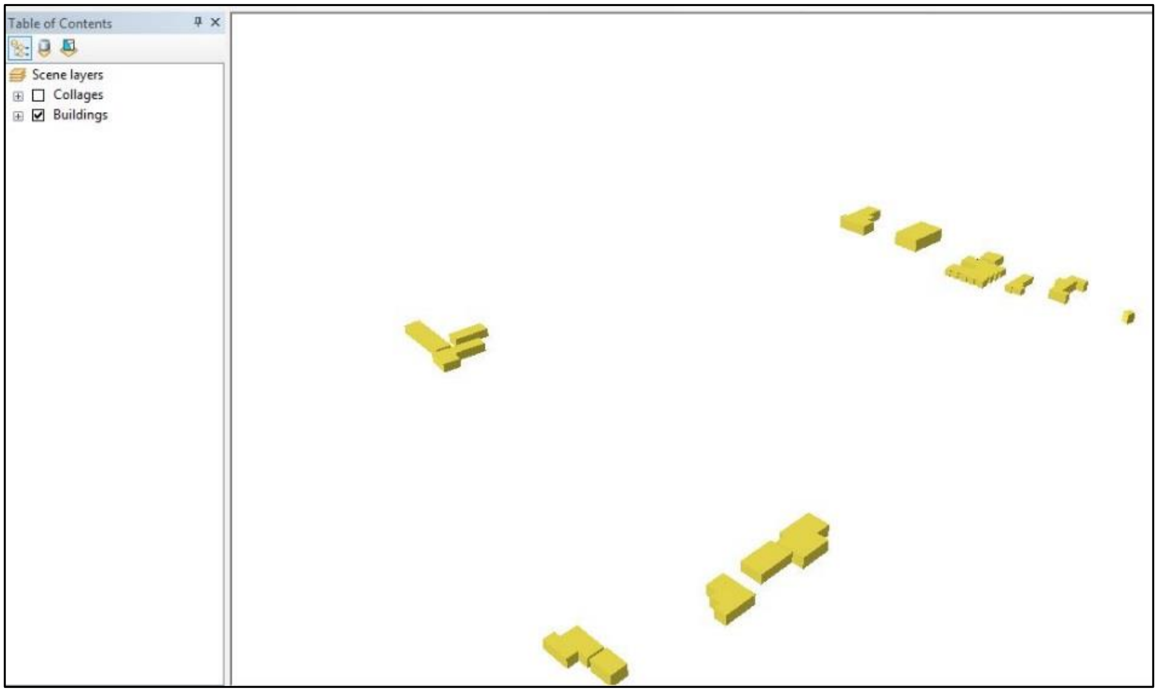
ArcGIS is one of Commercial off-the-shelf (COTS) software's, that allow for emitting reality and building 3D geometric, vector and raster layers, and to provide geo-referencing. Optional analyses help in decision making, In this step, the source file from the SketchUp to convert it into the 3D GIS model after adding geographic references and linking it to the metadata database to facilitate the process of analysis and query.

First of all, the 3D buildings and the Colleges layer are processed, as shown in Fig 5.6 Here a suitable coordinate system has to be chosen (vertical and horizontal), The world geodetic system was chosen is WGS 1984 UTM Zone (36, 35) N, because it covering Sudan.

Finally, the layers had to be converted to shape files as illustrated in Fig 5.7




*(A)*

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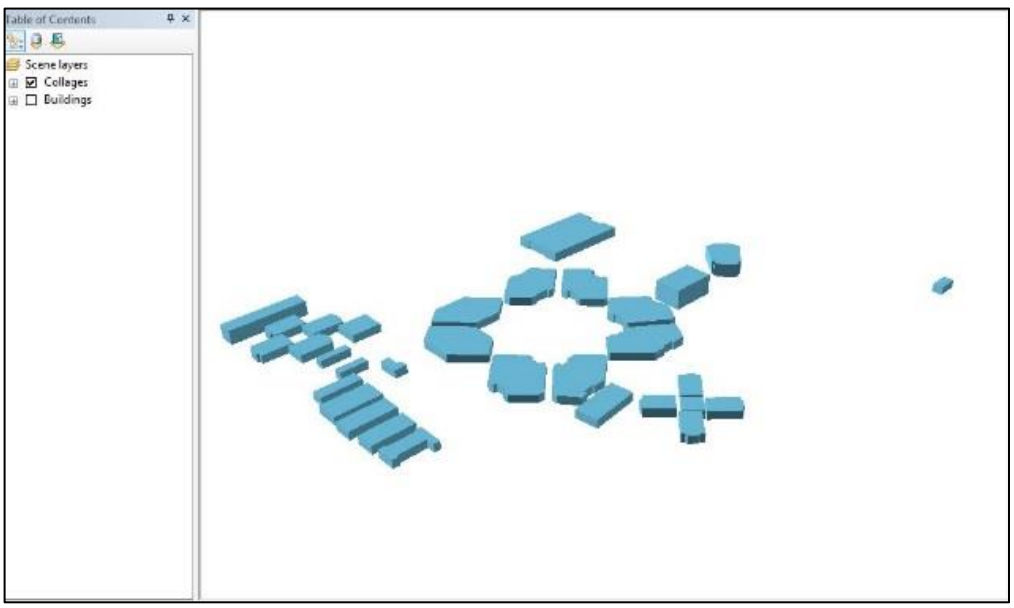



*(C)*

*Fig. (5.6) The main model layers (A) 3D layer (B) Buildings layer (C) Colleges layer*

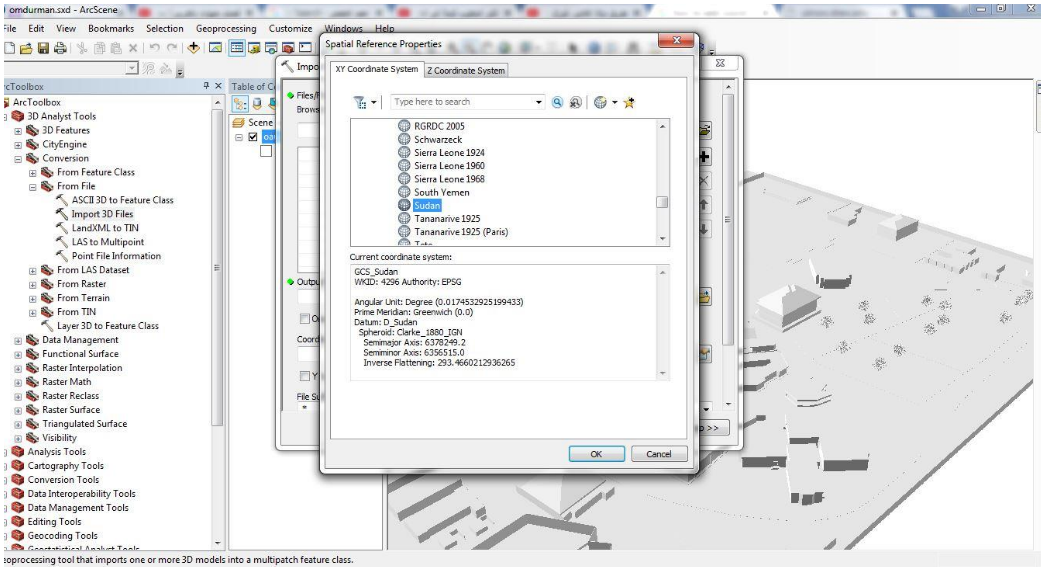



*Fig. (5.7) Coordinate System Specification.*

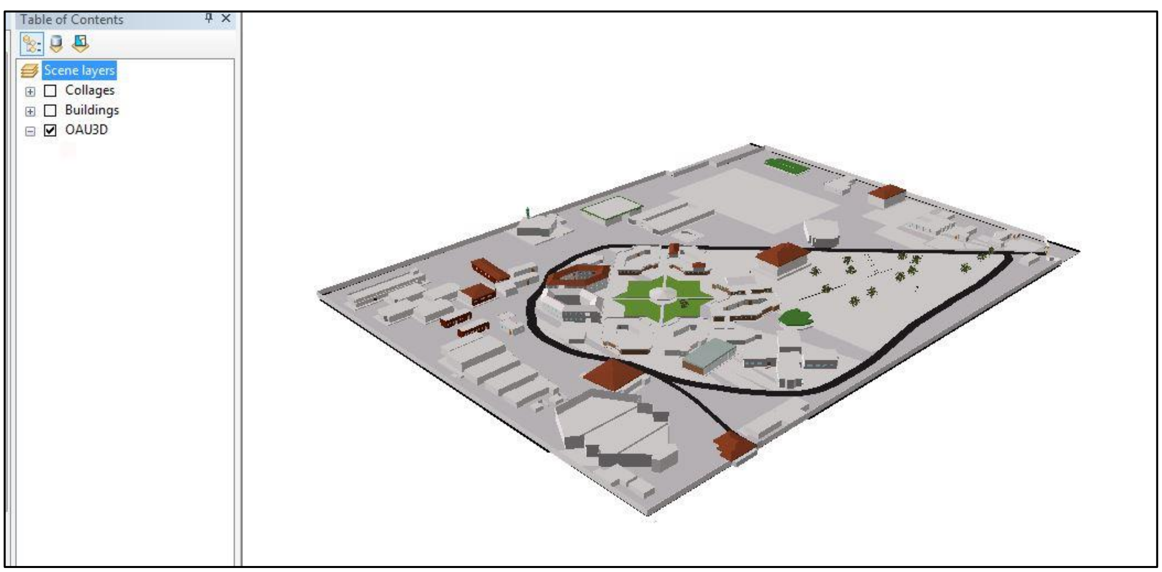
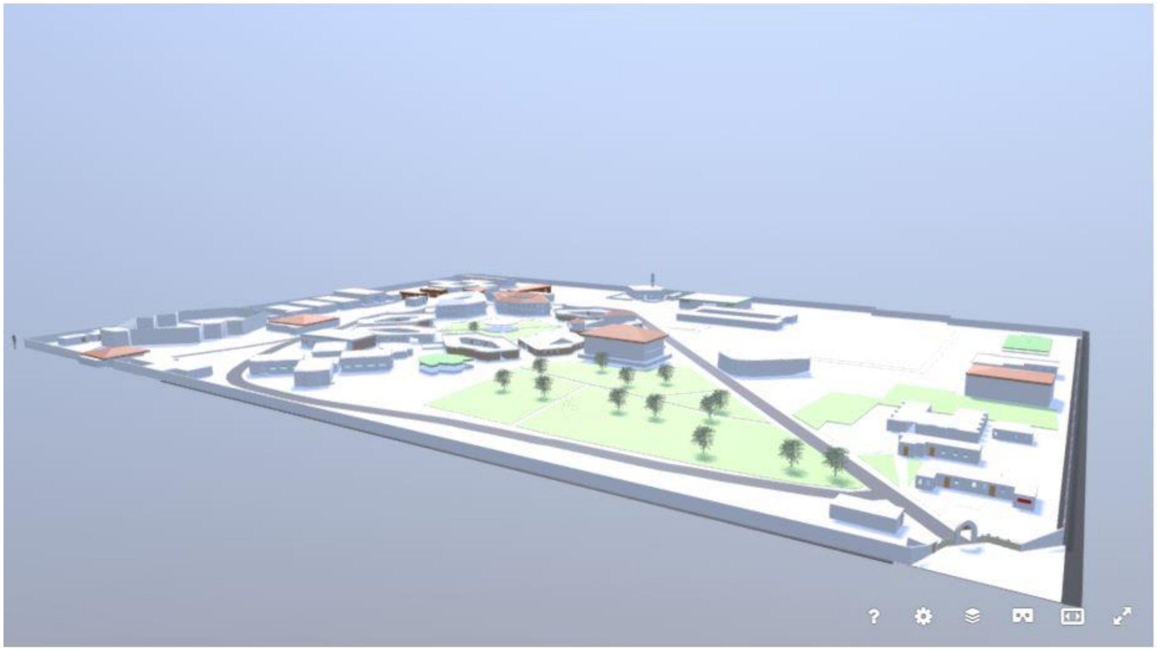
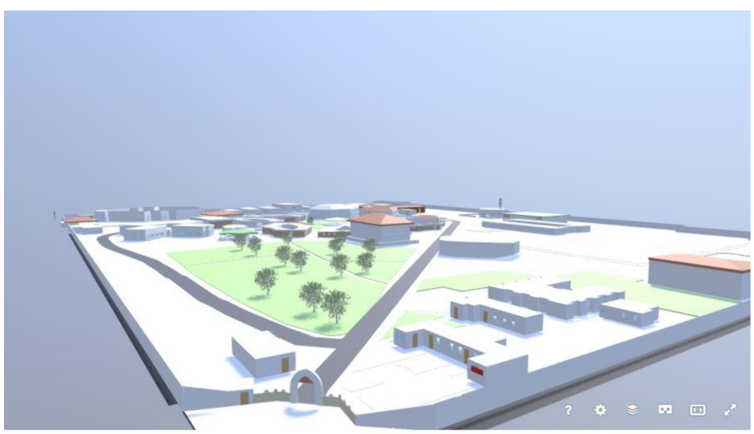



*Fig. (5.8) Virtual reality model of Omdurman Ahlia University Camps*

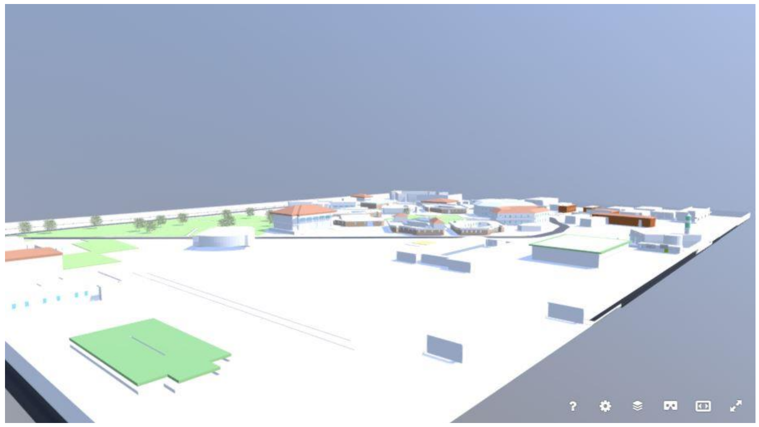
The final result from above illustrated phases is an OAU2 3D GIS model, was started from exporting point clouds and shapefiles to finally extracted VR file (see Fig5.9). more pictures in appendix D.



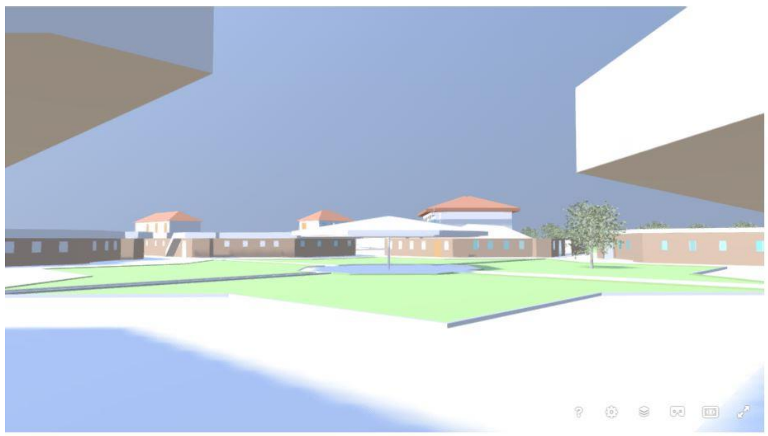
*(A)*



*(B)*



*(C)*



*(D)*

*Fig. (5.9) (A, B, C and D) VR view in sketchfab. [19]*

# CHAPTER SIX

## Conclusions and Outlook

### 6.1 Recommendations

### 6.2 Conclusions

# CHAPTER SIX

# Conclusions and Outlook

## 6.1 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 OAU campus 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 Omdurman Ahlia University campus 3D model directly with the web site, Android application or web services 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.
- ArcGIS Server is used for creating and managing GIS Web services, applications, and data.
- Using ArcGIS Pro program can be done without several programs.

## 6.2 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 OAU main campus environments to offer a three-dimensional model with texture mapping that allows for virtual reality visualizations, orientations and navigations around campus 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 new students, teachers, administrators and visitors in their navigations without wasting time and efforts.

It provides information about all resources inside the OAU campus, when new students and visitors make location queries and guides them to the right direction, especially there who are coming for the first time haven't to ask every time when they want to reach a particular place within campus. Moreover, it supports any restructuring of the OAU campus.

still do not allow Sudan to have an original copy of its programs, which makes users inside Sudan going to (cracked programs) look at appendix E.

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# Appendix

## Appendix A

Most commonly used cameras in photogrammetry are the aerial and terrestrial cameras. Photos taken with these are mostly used for topographic mapping and other surveying or engineering applications. Cameras used in these applications are termed metric cameras. A metric camera is one in which focal length and internal dimensions are exactly known or can be determined through calibration.
Aerial cameras are highly specialised instruments developed to enable accurate and consistent imagery of the earth to be obtained from an aircraft. They are referred to as "passive sensors" in that they detect and capture the natural light reflected from objects. Over the years a number of different styles and camera formats have been used but the basics of geometry still needed to be adhered to when utilized for ground measurement and mapping.

Early film cameras were hand-held surveillance instruments used by various armies to obtain pictures of the enemy. These rapidly developed into high altitude "fixed to the aircraft" types that held rolls of film enabling many frames of photography to be exposed in single sorties. These frames overlapped each other by 60 per cent which enabled three dimensional models to be created of the earth's surface. These resulting stereo images were the main source of information for mapping and in particular, ground height depiction for many years, Later developments in camera and film technology enabled infrared film to be used for specific imagery capture, but it was the advent of digital technology that enabled capture of not only the visible light spectrum but also radiation at either end of the visible light range.

Digital sensors are used in many platforms including satellite, manned aircraft, unmanned aircraft, land-based vehicles and in static placements. Digital cameras have a further advantage in that their imagery pixels can be used to create point cloud elevation data sets.

There are two major differences, the equipment used and the expected orientations of the cameras. Aerial photogrammetry tends to use large format cameras mounted in aircraft looking straight down. Some highly specialized cameras use multiple lenses to simultaneously collect nadir looking views and obliques surrounding the nadir view. Terrestrial photogrammetry is based on cameras at ground level looking horizontally. The cameras can be special purpose cameras or general-purpose hobby grade cameras. For either application the professional grade cameras will have very rugged and stable construction and orientation of the lens with respect to the image plane. Aerial photogrammetry is a major contributor to topographic mapping and a significant input source for GIS applications. Terrestrial applications are very diverse. They can be architectural facade studies, archeology, medical, industry, forensics, or any task requiring measurement, the differences are in the values of the parameters that are computed (or in the initial estimates used to begin the computations). The aerial case is simpler in that the camera is generally pointed down so the domain of the orientations is smaller than that for the terrestrial case where the camera can literally be pointed in any direction.

## Appendix B

RGB-D cameras are novel sensing systems that capture RGB images along with per-pixel depth information, it's rely on either active stereo or time-of-flight sensing to generate depth estimates at a large number of pixels, RGB-D cameras allow the capture of reasonably accurate mid-resolution depth and appearance information at high data rates.

RGB-D cameras are affordable and provide dense depth estimates at high frame rates. Hence, these sensors are popular for building dense representations of indoor environment. Yet, the sensors often do not provide accurate depth estimates since the generation of depth estimates is mostly a black box which exhibits a sensor-dependent deformation. This bias can decrease the reconstruction quality and reduce the camera pose estimation accuracy, especially when using dense reconstruction frameworks, and may ultimately lead to failure of the tracking process.

The deformation can be present for a number of reasons. Wrong estimates on the calibration parameters for involved cameras can degrade the depth quality especially further away from the principal point. Different exposure and capture times of the cameras add an error depending on the current sensor motion. Another discrepancy exists between depth estimated from the moving RGB camera and IR-based depth estimates. Quality problems during manufacturing like a different housing, temperature changes, mechanical strain, or strong disturbances on the sensor parts also change the intrinsic parameters and depth estimates and may require a recalibration. On the upside, the strength of this deformation mostly depends on the position within the depth image and the range, which allows us to mitigate the effects by a better calibration. In contrast to existing approaches, we do not rely on fitting planes into planar surfaces of dense depth

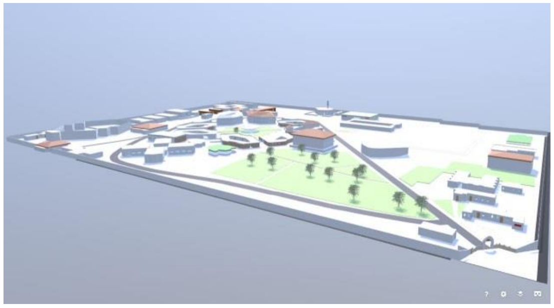
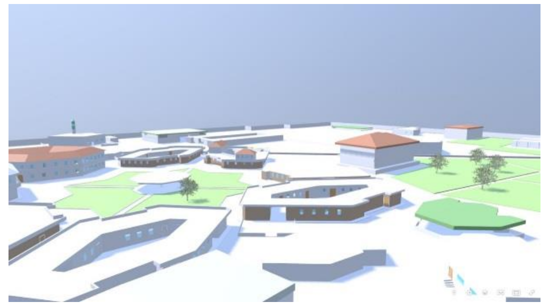
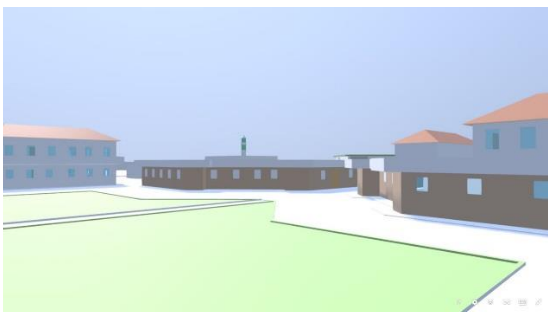
## Appendix C

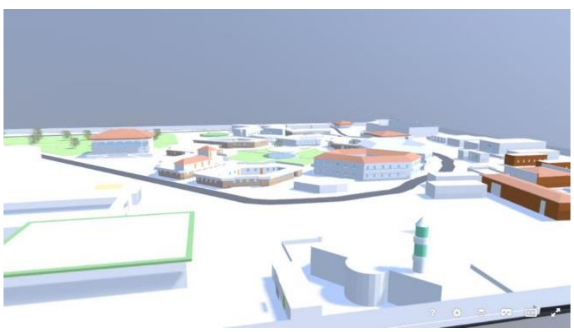
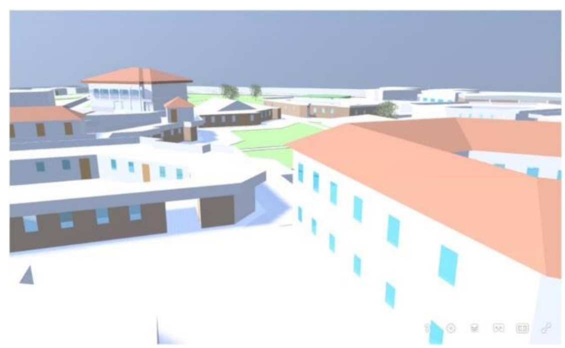
The LAS file is intended to contain LIDAR (or other) point cloud data records. The data will generally be put into this format from software (e.g. provided by LIDAR hardware vendors) which combines GPS, IMU, and laser pulse range data to produce X, Y, and Z point data. The intention of the data format is to provide an open format that allows different LIDAR hardware and software tools to output data in a common format.

LAS File created in the standard LAS format, which was developed by the American Society for Photogrammetry and Remote Sensing (ASPRS); stores Light Detection and Ranging (LIDAR) data that is collected by optical remote sensors; used to exchange LIDAR data between data providers and data consumers.

It's was developed in response to the growing number of proprietary LIDAR file formats. It also was designed to overcome some of the complexities in existing LIDAR data. LAS files are stored in a binary format.

## Appendix D

**Appendix E**

Software cracking (known as "breaking" in the 1980s) is the modification of software to remove or disable features which are considered undesirable by the person cracking the software, especially copy protection features (including protection against the manipulation of software, serial number, hardware key, date checks and disc check) or software annoyances like nag screens and adware.

A crack refers to the means of achieving software cracking, for example a stolen serial number or a tool that performs that act of cracking. Some of these tools are called keygen, patch, or loader. A keygen is a handmade product serial number generator that often offers the ability to generate working serial numbers in your own name. A patch is a small computer program that modifies the machine code of another program. This has the advantage for a cracker to not include a large executable in a release when only a few bytes are changed.

A loader modifies the startup flow of a program and does not remove the protection but circumvents it. A well-known example of a loader is a trainer used to cheat in games.

Fair light pointed out in one of their .info files that these type of cracks are not allowed for warez scene game releases. A nukewar has shown that the protection may not kick in at any point for it to be a valid crack.

The distribution of cracked copies is illegal in most countries. There have been lawsuits over cracking software. It might be legal to use cracked software in certain circumstances, Educational resources for reverse engineering and software cracking are, however, legal and available in the form of Crackme programs.