EFFECT OF LIGHTING DIFFERENCE IN RECONSTRUCTION OF THREE DIMENSIONAL DENSE MODEL USING CLOSE RANGE PHOTOGRAMMETRY

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In the name of God, most Gracious, most Compassionate

I dedicate my project report work to Allah swt, my family and friends. A special feeling of gratitude to my loving parents, Mohamed Fadzel Bin Bien whose words of encouragement and push for tenacity ring in my ears, and Masanah Sa Binti Abdullah my beloved mother always be my side throughout the process and your love. My Brothers, Zulhanan Bin Mohamed Fadzel, Mohd Hadari Bin Mohd Fadzel, my sister, Sakinah Binti Mohamed Fadzel and lastly my youngest brother Muhammad Khairul Ezy Bin Mohamed Fadzel.

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ABSTRACT

Lighting is one of the main elements in photographic process. Adequate source of lighting is required to give enough illumination to the object. Close Range Photogrammetry (CRP) is one of the technique and it has been used in variety of fields for example forensic, traffic management, archeology, medical, construction and else. These kinds of fields have different condition and environment for instance in term of source of lighting. The lack of illumination on the object can cause many problems, for example the quality of images, the accuracy of the project and more. Therefore, in this study, consumer grade digital camera is used to capture the image of an object and reconstruct the three dimensional (3D) model, under the different of intensity of light. The images were processed by using PhotoModeler Scanner and irfanView software. This software is help to generate the 3D model and histogram graph for analysis and result. For geometry evaluation, the model comparison is conducted between the model from CRP approach and laser scanning method. Lastly, the models constructed give different result depending on the intensity of light used.

ABSTRAK

Pencahayaan adalah salah satu element di dalam proses fotogrametri. Sumber pencahayaan yang mencukupi diperlukan untuk memberi pencahayaan kepada objek. Fotogrametri Jarak Dekat (CRP) adalah salah satu teknik dan ianya telah digunapakai dalam pelbagai bidang seperti forensik,pengurusan trafik, arkeologi, perubatan, pembinaan dan sebagainya. Bidang ini memiliki pelbagai jenis keadaan dan persekitaran yang berlainan sebagai contoh sumber pencahayaan. Pencahayaan yang tidak mencukupi boleh menyebabkan pelbagai masalah seperti kualiti gambar, ketepatan projek dan banyak lagi. Oleh itu, di dalan tesis ini,camera jenis pengguna akan digunakan untuk mengambil gambar objek dan membina model tiga dimensi di bawah cahaya yang berbeza. Gambar yang ditangkap telah diproses dengan mengunaakan perisian PhotoModeler Scanner dan IrfanView. Perisian ini membantu dalam menghasilkan model 3D dan graf histogram untuk dianalisa dan keputusan. Bagi penilaian geometri, perbezaan antara model telah dilakukan antara model daripada teknik CRP dan imbasan laser teknik. Akhir sekali, model yang dihasilkan memberi keputusan yang berbeza bergantung kepada pencahayaan yang telah digunakan.

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LIST OF ABBREVIATIONS

CRP	Close Range Photogrammetry
CCD	Charge coupled deviced
CMOS	Complementary metal oxide semiconductor
RAD	Ringed Automatically Detection
UAV	Unmanned Aerial Vehicle
DSM	Dense Surface Model
DSLR	Digital Single Lens Reflex
SNR	Signal and Noise Ratio
ISO	International Standard Organization
CFA	Color Filter Array
CFM	Color Filter Mosaic
RGBE	Red, Green, Blue and Emerald
EMCCD	Electron Multiplied Charge Coupled Device
ICCD	Intensified Charge Coupled Device
PET	Polygonal Editing Tool

LIST OF SYMBOLS

µ	-	Micro

CHAPTER 1

INTRODUCTION

1.1 Introduction

Photogrammetry is a combination of three Greek's words "*photos"* or "*phot"* which means light, "*gramma"* (letter or something drawn) and "*matrein"* (the noun of measure) (Schenk, 2005). In other words, it is science of measurement and interpretation of surfaces and objects from two or multiple overlapping images and without physical contact with the object. This technique primarily aims to construct three-dimensional (3D) model of an object either in the digital form or graphical form by using specific mathematical algorithm to obtain the information from the photographs (Luhmann *et al*, 2006). Apparently, most of photogrametry people was choosing digital camera instead of film camera for capturing the image of objects or scenes. This is because the digital camera was equipped with high technology and sensor, which provide advantages in recording high quality of images compare with film-based camera. Techniques in photogrammetry can be grouped into terrestrial photogrammetry and aerial photogrammetry. These techniques can be distinguished by looking at the procedure of data acquisition, processing and objective of task. Moreover, photogrammetry has been

used in variety type of industries for example in archeology which used to modeling the pottery, artifacts of culture heritage, statue and building (Kadobayashi *et al*, 2004). Furthermore, in movie industry, these techniques are quite popular for instance, constructing 3D model of character of animation and real motion picture. Last but not least, this techniques is also used in medical industry, architecture industry and engineering as well (Yilmaz *et al*., 2008).

The development of science and technology in world of photogrammetry served lots of advantages to the photogrammetry people. The improvement can be seen in form of instrumentation, methodology and processing software and hardware. They have tried to create new approach to resolve the problems faced by photogrammetry people. This phenomenon are due to the demand of high data quality, accuracy and precision and also reduce human interfere during the processing. The quality of data is most critical aspect in surveying and in photogrammetry as well. The data recorded is processed to generate 3D model by using 3D modeling software, and then documentation process for all the information, data and result. In archeology industry, all types of data collected related to the artifact must be put in one document for further analysis and interpretation (Barsanti *et al*, 2014).

Apparently, there are multiple different of techniques and equipments that have been used in the measurement of objects for example 3D laser scanner, theodolite and total station, Close Range Photogrammetry (CRP), Coordinate Measurement Machine (CMM), structure light system and direct method. These techniques and equipments can differentiate in term of cost, size and weight of measurement, the object complexity and processing time (Ordonez *et al*, 2009). Therefore, some company cannot afford great investment on expensive instrument like laser scanner and the weight of the instrument is count in selecting the best techniques and equipment in project as well (portability). Moreover, the technique used is depending on the complexity of object because if the object is simple and less complex, it is better to use CRP method instead of using laser scanning technique. Meanwhile, if accuracy is highly concern in a project then laser scanner is the best equipment to use.

Camera has been used so many years as one of the equipment in recording scenes, surfaces or objects. Before the digital camera has been introduced in public, the photographer were used conventional camera which depends entirely on chemical and mechanical process and do not use electricity to operate. The new technology was totally changed how the visual information is recorded. Nowadays, digital camera is widely used by photogrammetry people. It is consists of build-in computer and records the images in an electronic form or digitally. Moreover, digital camera consists of sensor that converts light into electrical charge. The light is reflected on the surfaces of the objects before reach to the digital camera's sensor (Karim *et al*, 2004). There are multiple types of sensors for example Couple Charge Device (CCD), Complementary Metal Oxide Semiconductor (CMOS) and more. These sensors consist of tiny light-sensitive diode known as photosites. For example, a 2.1 megapixel camera has approximately 2 100 000 photosite on the CCD. In other hand, resolution is the amount of detail that the camera can capture and it is measured in pixel. So, the more pixel camera has, the more detail and clear of image can be. The example of digital cameras available in the market are Sony Alpha 7 II, Richo EG-30, Leica x(Type 113), Canon PowerShot SX60 HS, Nikon D750, Panasonic Lumix DMC-LX100, Samsung NX1 and more.

1.2 Problem Background

Photosite is used to convert light into electrical charge. The light that released or transmitted from the source is reflected by the surfaces before reached to photosite. The accumulated charge is shifted vertically into serial output register and shift it again horizontally to readout each individual pixel. Certain sensors are able to work efficiency in different illumination. Basically, the charge of a pixel is reflex on the amount of light received by a photsite. In other hand, it is important to select the types of lighting to ensure the high quality of images can be produced, because low quality of images can

affect the geometry and radiometric information and also causing some problems during the processing phase (Blizard, 2013). Therefore, he was suggested to provide an adequate of illumination exposed surrounding the object during capturing the images activity, so the high-detail, sharp and flat imagery can be produced.

In addition, one of the steps in 3D model reconstruction process is locating the image target point or reference. The sharp and clear images are help to locate the target point accurately. Therefore, high resolution camera allows sharper and more detail of the images, which improves the resolvability of the target point. Besides, external light source is used to provide enough illumination of the object (Jack, 2003). Indoor and outdoor activities are also can affect the result and images quality because of the different in source of lighting.

Outdoor activity is depends on the sun light. The sunlight might produce shadows and different brightness between the images. The formation of shadows are due to when the sun is not on top of the object and the brightness is different because of the cloud is covering the sky during the capturing image. Meanwhile, indoor activity is using artificial source of lighting for examples bulb, fluorescent and others. The number of bulb and the distance between the object provides difference illumination to the object. It is important to ensure all the images have similar brightness and shadows. Otherwise, overlapping the texture process can generate inconsistent texture on the model (Radoservic, 2010).

1.3 Problem statements

The study and research were carried out and identified some of problems in previous study. The problem statements are:

1. Lighting is one of the factors that affecting the quality of images and it is used in reconstruction 3D dense model. In order to simulate the illumination and brightness at the real cases, the difference of lighting models is used. Then, multiple overlapping images of an irregular artificial object are captured by using consumer grade digital camera at different position. Does 3D dense surface can be established from these images?
2. Quality of images is important in image interpretation and measurement process which to be identified from its form, brightness or color distribution for every image point, values in the form of radiometric information and geometric information (position in image) can be obtained. This requires measurement systems with appropriate geometric and optical quality. So, what are the relationship and effects to the radiometric and geometric information of images and output (model) when differences of lightning are used?
3. New methods and equipments have been introduced with high technology implied to fulfill the demand for high precision and accuracy of the output. For example, laser scanning technique, this technique is provided more accurate result compare with conventional method in reconstruction of 3D model (Kadobayashi *et al.*, 2004). Therefore, which 3D models are more accurate by comparing the 3D model obtained by laser scanning technique?

1.4 Objectives of study

There are three objectives for this study and they are:

1. To reconstruct 3D dense models from difference source of illumination.
2. To study the accuracy of 3D models formed by using difference source of illumination
3. To evaluate the 3D models in term of geometry and radiometry.

1.5 Scope of Study

This study is covered only small irregular artificial object and size which is to simulate the small artifact goods such as poetry, human footprint, tombs and more. The approximate object's dimension used in this study is 27 cm width, 36 cm long and 10 cm height and the size is easy to handle. It is because the object is move from one place to another place. Moreover, to make sure the object use is similar throughout the study, the object was made up from less fragile medium and fix shape such as cement. Cement is one of the suitable medium to create artificial object because, the object would not able to change whatever condition and place.

The process of data collection was planned to do at two different places; indoor and outdoor space at near to Faculty Geoinformation and Real Estate, Universiti Teknologi Malaysia, Skudai Johor Baharu, Malaysia (1°33'37.1"N 103°38'13.5"E). Based on article from Malaysia Meteorological Department website, on the average, Malaysia received about six hours of sunshine per day. Therefore, the light intensity is different at different country and continent based on the latitude and longitude but this is not the only factor that affecting the light intensity (Paul Burgess, 2009). The data collection for outdoor activity is collected within that period of time. Meanwhile, indoor activity is fully dependant on the artificial lighting and it is explained in chapter 3 in this thesis.

So, this study would not touch any big scale of object in reconstructing 3D model. The processing software used is the PhotoModeler Scanner software which less expensive and low system requirement, instead of using expensive sotware such as Softimage Face Robot software, Autodesk Maya, Autocad and other 3D modeling and graphical software. Photomodeler scanner is capable to processing both types of data/techniques; image-based and range-based technique in creating 3D model. In other hand, the expensive software requires high system requirements either in processing and also storage. Lack of experience of using the expensive software is one of the factors of selecting the PhotoModeler scanner.

1.6 A Brief Note on the Methodology

In surface, this study is aims to manipulate the condition surrounding the object especially the lighting. The differences of illumination either indoor or outdoor would give effect on the reconstruction of 3D model, radiometric information and geometry. Therefore, the irregular artificial object is converted into 3D model by using CRP procedure. Multiple of images are captured surrounding the object at different camera position to ensure 60 % overlapping or more of images can be achieved.

The software used to create 3D dense model is PhotoModeler scanner Software. This software is able to determine root mean square error, total error, residual and precision values of projects. In order to determine the accuracy of the project, laser scanning technique is used and apply on the similar object before 3D model can be obtained. And then, the analysis of the model is made to identify the accuracy of the project. Last but not least, the geometrical assessment is performed by comparing the 3D model from CRP method, laser scanning method and direct method.

In this research, it is begin with project planning where all the information related with project are collected to understanding which suitable instrument, techniques and procedure to be used. Afterthat, all the output from project planning is implemented in data collection activities. Capturing the images of the object using the CRP technique and scanned by laser scanner as well is a part of activities in data collection phase. Since, the camera used in this project is non metric camera, it is compulsory to do camera calibration first in order to identify the camera parameters to be inserted in processing software. These materials or images are processed by using PhotoModeler software in reconstruct the 3D dense model. The measurement, analysis of the model and the error are able to compute by using the software. Lastly, the comparison between all models and the accuracy is performed during the project analysis and finding phase. And also give the solution of problem statements of the study.

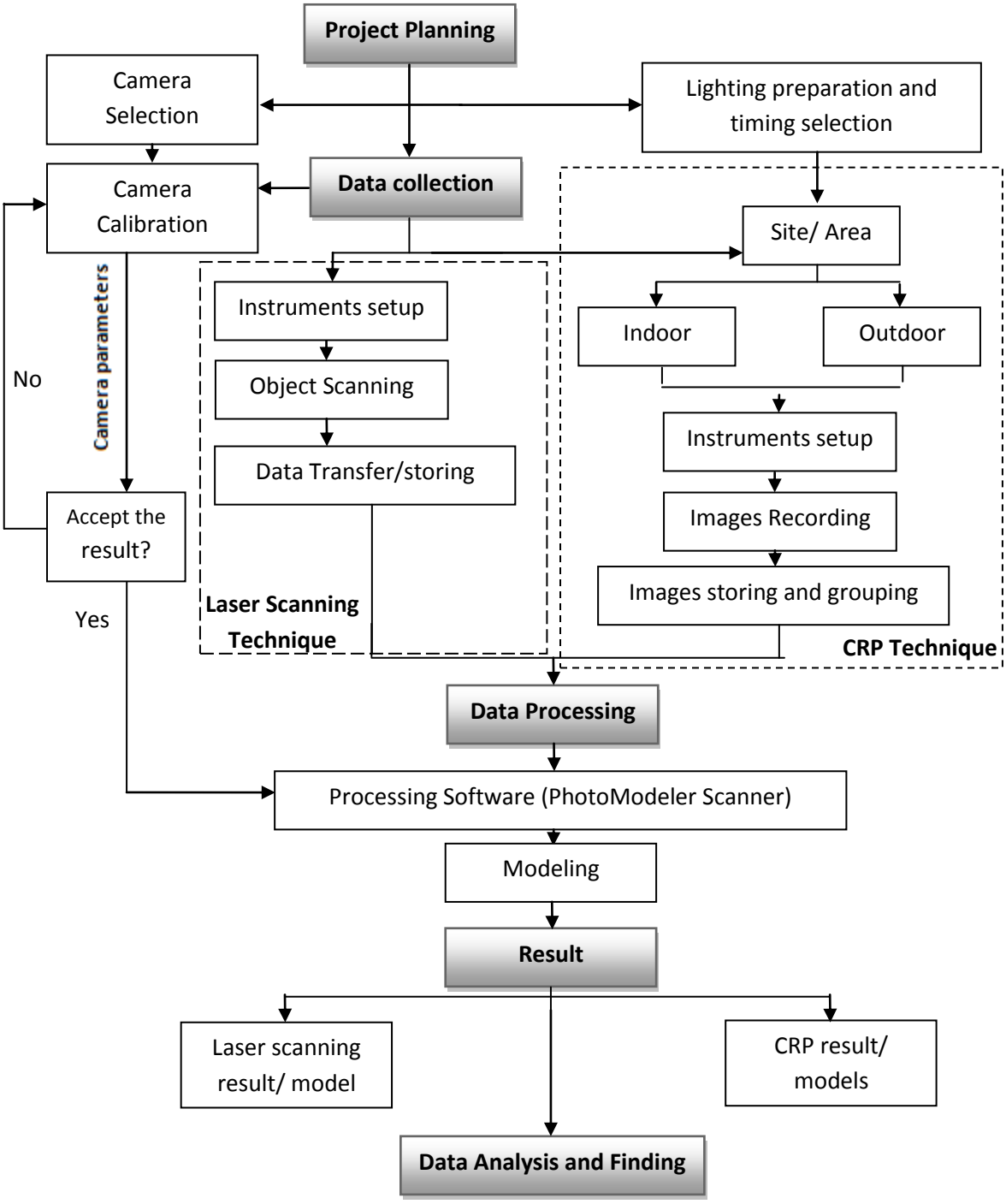

Figure 1.1: Research Methodology Workflow

1.7 Significant of Study

This research is trying to investigate the effect of lighting towards the radiometric information and geometric of 3D model by using CRP technique. Since, the photogrammetry has been used in multiple types of industries, so the environment might be different from one another. What I mean, the brightness and illumination of site area where the image-based photogrammetric technique is applied. Moreover, this research is trying to give idea on lighting selection and suitable period where the sun light position and then it may reduce the shadow and brightness to get the good quality of images.

A part from that, this study is applied laser scanning technique and creates the 3D model. Most of researcher did mention the advantages of laser scanning technique in creating 3D model. Therefore, in this study, this technique is set as a benchmark of the result obtained from CRP method to see which models created is most accurate, and then identify which lighting model gives better result/illumination to the object.

Last but not least, the images captured with different of lights produce different of intensity value on the images. Therefore, by using luminosity histogram analysis illustrated the relation between intensity value and images of different exposure. Moreover, another aspect is evaluated such as luminosity histogram, the image analysis and the relationship between the number of image and point cloud generated.

1.8 Thesis Outline

This thesis consists of five chapters. Chapter 1 explains the introduction of this study, background of problems, problems statements, objective and scope of the study, brief note on the methodology and significant of the study.

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