DEFORMATION STUDIES ON SLOPE AREA USING A DIGITAL CLOSE RANGE PHOTOGRAMMETRY

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DEDICATION

To my beloved father and mother

My husband

My lectures and

My friends

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In the name of Allah S.W.T, the most Beneficent, the most Merciful. I have completed for preparing this thesis and I would like to express thankful to Allah S.W.T as for everything that I being done with HIS blessing.

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ABSTRACT

Most of deformation monitoring for slope instability can be supplied important information about slope behavior that can lead to disaster or collapse. This phenomena always occur when monsoon season where persistent rain triggered landslide or floods and because of thus all human activities and development also deforestation is affected as a result of the disaster. Therefore, for safety and maintenance process, it's important to make sure the stability of the slope area to be monitored. Thus, in order to monitor the movement of slope area, once of the technique are introduced is a Digital Close Range Photogrammetry (CRP) field. The development of photogrammetry nowadays allow to calculate of high accuracy Three-dimensional (3D) coordinates for points on an around the slope area. A side from others technique that was introduces, the CRP technology become getting popular for monitoring slope instability that can lead the disaster. The privilege of using CRP is that no physical contact with the monitoring objects such as slope area body like in conventional land surveying technique. This thesis describes the effectiveness use a digital CRP in deformation studies on slope area. The proposed technique uses a non-metric camera as a tool for capturing slope area images. Before that the camera has been calibrated using calibration sheet provided by PhotoModeler Scanner (PMS) software. The 3D model of slope area has been created using Agisoft software and additional analysis for statistical hypothesis test with Statistical Package for Social Science (SPSS). The selected site has been chosen in Universiti Teknologi Malaysia (UTM) which located at behind the Bioscience and Medical Engineering Faculty building because of there is soil erosion in the area. The Total Station has been used to establish control network points for preliminary results and be continued with Global Positioning Station for the sub control station almost near with slope area. All data processing for CRP image were processed using PMS and Agisoft software. Finally, the 3D digital modelling is presented and the results shows CRP data could be an effective method to monitor deformation studies and capable to achieve a high accuracy compared to others technique.

ABSTRAK

Kebanyakan pengawasan pergerakan bagi ketidakstabilan cerun boleh memberikan maklumat yang penting tentang ciri-ciri keadaan cerun yang boleh membawa bencana alam atau tanah runtuh. Fenomena ini selalu berlaku pada musim tengkujuh di mana hujan berterusan mencetuskan tanah runtuh atau banjir dan kerana keadaan ini menyebabkan semua aktiviti-aktiviti manusia, pembangunan dan penebangan hutan turut terjejas. Oleh itu, keselamatan dan proses penyelenggaraan adalah penting untuk memastikan kestabilan kawasan yang bercerun dipantau. Oleh itu, dalam usaha untuk mengawasi pergerakan kawasan cerun ini, fotogrametri jarak dekat *(CRP)* telah diperkenalkan. Pembangunan bidang fotogrametri masa kini membolehkan ketepatan pengiraan koordinat Tiga dimensi *(3D)* bagi kawasan cerun adalah tinggi. Selain daripada teknik yang telah diperkenalkan, teknologi *CRP* semakin popular bagi kerja-kerja pengawasan kestabilan kawasan cerun yang boleh membawa bencana. Keistimewaan menggunakan *CRP* adalah tiada hubungan fizikal dengan objek yang diawasi seperti dalam teknik pengukuran tanah secara konvensional. Kertas kerja ini menerangkan tentang keberkesanan menggunakan kaedah digital *CRP* dalam kajian deformasi ke atas kawasan yang bercerun. Teknik yang digunakan adalah dengan menggunakan kamera bukan metrik sebagai alat untuk mengambil imej kawasan bercerun. Sebelum itu kamera dikalibrasi dengan menggunakan lembaran yang telah sediakan oleh perisian Pengimbas Photomodeler *(PMS)*. Model *3D* kawasan yang bercerun akan dibina dengan menggunakan perisian Agisoft PhotoScan dan analisis tambahan untuk ujian hipotesis statistik adalah dengan Pakej Statistik untuk Sains Sosial *(SPSS)*. Kawasan tapak kajian yang dipilih adalah di belakang bangunan Biosains dan Kejuruteraan Fakulti Perubatan Universiti Teknologi Malaysia (UTM) kerana wujudnya hakisan tanah berhampiran dengan kawasan tersebut. Alat Total Station digunakan bagi mewujudkan rangkaian titik kawalan untuk mendapatkan keputusan awal dan diteruskan dengan Sistem Kedudukan Global *(GPS)* untuk sub stesen kawalan yang berhampiran dengan kawasan bercerun. Semua pemprosesan data bagi imej *CRP* telah diproses dengan menggunakan perisian *PMS* dan Agisoft PhotoScan. Akhirnya, permukaan *3D* model dapat dimodelkan dan keputusan menunjukkan bahawa data *CRP* boleh menjadi salah satu kaedah yang berkesan dalam kajian mengawasi deformasi kawasan yang bercerun dan mampu untuk mencapai ketepatan yang tinggi berbanding teknik lain.

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LIST OF ABBREVIATIONS

CRP	-	Close Range Photogrammetry
3D	-	Three Dimensional
2D	-	Two Dimensional
TLS	-	Terrestrial Laser Scanning
UAV	-	Unmanned Aerial Vehicle
InSAR	-	Interferometry Synthetic Aperture Radar
mm	-	millimeter
JMG	-	Geology Survey Department of Malaysia
JKR	-	Department of Public Worker
IKRAM	-	Malaysia Public Worker Institutes
PMS	-	PhotoModeler Scanner
DEM	-	Digital Elevation Model
GIS	-	Geographical Information System
SLR	-	Single Lens Reflex
IO	-	Interior Orientation
RBM	-	Range Based Modeling
cm	-	Centimeter
EO	-	Exterior Orientation
GCP	-	Ground Control Points
PM	-	PhotoModeler
DSM	-	Dense Surface Modeling
GPS	-	Global Positioning System

PMV	-	PhotoModeler Video
RMS	-	Root Mean Square
eE	-	Easting of Error
eN	-	Northing of Error
DEM	-	Digital Elevation Model
SPSS	-	Statistical Package Science Social

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CHAPTER 1

INTRODUCTION

1.1 Background of the problem

Malaysia is country located in tropical regions where have an extremely high annual rainfall which frequently triggered debris on slope area known as landslide (Jamaludin *et al.*, 2013). Because of that, more catastrophe frequently occurred likes flooding and landslide especially on high risk slope area. Landslide can occur anywhere in Malaysia without any warning (Talib & Taha, 2005). The Malaysia Government has decided to include a lot of millions of Ringgit Malaysia in national budget to be presented in Parliament each year merely for manage landslide prone areas. The way to monitor or detected the movement of slope area is deformation survey. Various studies have been conducted to monitor landslide activities such as conventional, geotechnical and geodetic techniques.

Each of method contained their advantages and limitation during monitoring movement on slope areas. Therefore this study focus on the effective methods of a digital Close Range Photogrammetry (CRP) and data processing technique to evaluate observation data collecting by a digital CRP due monitoring slope displacement and to generate a standard ground profiling which consists cross and long section as well. This technique is preferred due to its reasonable of costing and it's allowed measuring inaccessible and risky areas. This chapter briefly introduces the background of the research followed by problems statements, objectives and the scopes statement of the research.

Photogrammetry is one method of image measurement and interpretation that abstract the shape and location of an object capturing on earth surface from one or more aerial images of that object. The principle of photogrammetry method can be implement for any situation or purposes where the object to be measured can be recorded directly. The primary of photogrammetry role is reconstruct of three-dimensional (3D) data comes from object acquired by any sources as well as digital images, drawings, map and others. The reconstruct of an object from images or photograph can be describe by the optical process which an image created using all elements that involve to this process such as light sources, properties of the surface object, the medium through which light travel, sensor, camera technology, image processing, film development and further processing as shown on Figure 1.1.

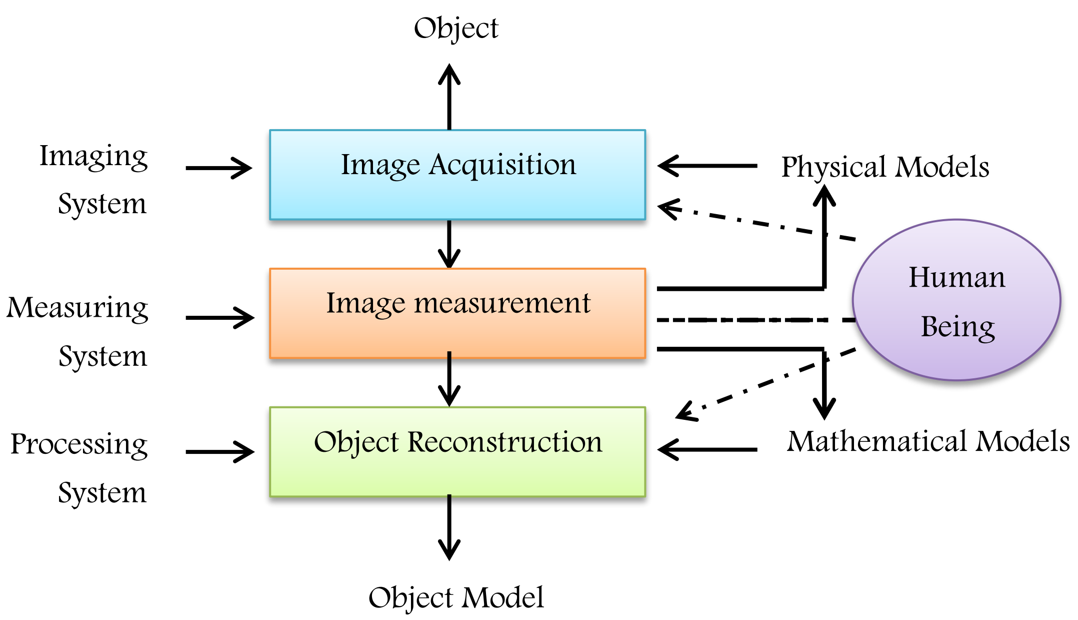

Figure 1.1: The photogrammetry process: From object to model (Luhmann *et al.*, 2006)

Because of wide varied application in photogrammetry field, exist one of new discipline field known as CRP. A CRP nowadays is towards the integration of photogrammetry components in oriented hybrid application system. The integration includes links to such as 3D AutoCAD system, database and information system, quality analysis and control system for production, navigation system for autonomous robot and vehicles, 3D visualization system, internet application, 3D animation and virtual reality. So that, this techniques capable for 3D measuring measurement because of its continued development long into the future. The CRP has become effectively as a tool for monitoring actively landslide and determines ground displacement over a long period of time by comparing of epoch data (Savvaidis, 2003).

This technique requires because of acquisition apparatus with high technology has been developed continuously and rapidly. Therefore, a real time observation data can be fully used with digital image technique rapidly and as a result, the stability and maintenance techniques for monitoring deformation on slope area can be easier, faster, save time and cost as well. Therefore, mostly new photogrammetry application increasingly to industrial metrology, quality control, monitoring, deformation survey which links have been created in other directions.

Latest techniques and methods lately increasing rapidly from day to day especially on technology development in surveying field which can be used in solving problems related to landslide monitoring as well as modern GPS positioning (eg: RTK network), robotic total station, laser scanning, imaging station and others. The capability for mapping application has already proven by Photogrammetry field including the production of orthophoto, cartographic maps, Digital Elevation Model (DEM) and so on. Because of that, the main focus is to access the effectiveness of CRP method for monitoring any displacement on slope area.

1.2 Problem Statement

Nowadays, many displacement monitoring points are usually set to obtain the displacement data to ensure slope stability. These data are typical nonlinear time series and it has high value about how to make use of displacement monitoring data to do the next step forecast analysis. Because of that, the suitable technique must be selected to monitor the slope displacement without directly measurement so that the real time data can be achieved. Photogrammetry has been used since long time to periodically control the evolution landslides either from aerial images (Casson *et al.,* 2003) well as from ground (Cardenal *et al.,* 2008) which combine with Global Positioning System (GPS) on the landslide body (Mora *et al.,* 2003). For accurate landslide inventory and analysis of landslide properties the integration between information on landslide with other information such as aerial photo, geotechnical data and geodetic results are important because in-situ observation are needed to obtain detailed information on geological and mechanical properties of landslide.

The improvement of tools nowadays especially on monitoring and analyzing the instability of slope area will helps us to resolve a certain activity areas. The traditional measuring apparatus to check the stability of civil engineering structures and maintenance have being implement a long time because the result are applied for deformation and stability analysis of that structures. Junggeun Han concluded by the time, precision and micro measuring instrument has grown rapidly along with the advancement of technology today which changed from manual system to automatic. For example one of conventional and manual measuring method known as total station is transferred to digital photogrammetry with high technology development.

The changes occurred because with traditional measurement techniques will do according to a periodic schedule, requirement to have an unobstructed line of sight between the target and instrument. Thus, will reducing the ability to appropriately model to observe phenomena but on site instruments possibly will safety hazards to personnel re-entering potentially hazardous areas (Savvaidis, 2003).This method only handle discrete point measurements and refer to Hei Ling

Chau as a typhoon shelter monitoring project, the survey division of Civil Engineering Department, Hong Kong Special Administrative Region has employed photogrammetric techniques to detect surface deformation of the rubble mound breakwater

Ground based or satellite based Interferometry Synthetic Aperture Radar (InSAR) (Leva *et al.*, 2003; Colesanti and Wasimski, 2006) is also being used to monitor landslide which provide the kind of terrain allows for food coherence between multi temporal images and the main displacement component is along the line sight. Unfortunately, for a ground based needed a fixed and stable installation and monitoring so that the costing are relevant. However, the system is quite efficient and provides almost continuous monitoring over a large area with millimeter (mm) sensitivity.

This kind of technology especially on CRP was introduced in Malaysia but the use and effectiveness in certain application not be applied. The use of CRP in other countries has been growing rapidly in all fields of surveying and engineering work including in the field of medicine, mobile, criminals and also deformation survey that unreachable or too dangerous place to reach can be performed by this technology because unlimited number of points can be monitored. In general, the lack of exposure in the application of non-metric camera or metric camera in deformation studies on slope area in Malaysia due to obstruction that occurred among of them as well as investigation for monitoring only carried immediately after the incident by the government sectors such as Mineral and Geology Survey Department of Malaysia (JMG), Department of Public Worker (JKR) and other private sectors as well as Malaysia Public Worker Institutes (IKRAM). The approach which always used among them is geological and geotechnical method such as inclinometer instrument on the landslide area where it is hard to access especially to the prone area.

Conventional technique as well as aerial photogrammetric mapping needed a good arrangement and planning for collecting data at field. So, time consuming very limited because of data collection took a long time and work to be completed as soon as possible. Thus, the selected technique bounded in CRP condition with the accuracy be assigned is more than adequate to evaluate slope displacement as well as quick enough in term of time limitation and not expensive. Besides that, today there is several low cost software’s that available on market that could be used in CRP application such as to calibrate the sensor, produce accurate measurement, generate 3D model and apply texture to the model. Rieke *et al.*, (2009) reported that the latest digital camera types have included some features such as sensor vibration for removal of dust particles and sensor movement to reduce the effect of camera shaking during the image acquisition. Actually, these features could be possible caused instability of sensor position that not being allowed in photogrammetry field.

1.3 Objectives of Study

The aim of the study is to determine the effectiveness of digital CRP techniques to monitor slope displacement which causing landslide. Therefore, the following objectives are presented to achieve the aim:

a) To evaluate the effectiveness of a digital CRP in monitoring of the movement on slope area

b) To study the deformation characteristics in term of slope area using a digital close range and performed ground profiling which is cross section as well

c) To generate 3D modeling of deformation on slope area using Agisoft PhotoScan software

1.4 Scope of Study

Monitoring of displacement for slope area is a crucial tool for the prevention of hazards. The choice of selecting an adequate monitoring system actually depends on the range of observed velocity, requires acquisition frequency, the desired accuracy and the financial constraint. Thus, the scopes of this study only focuses on deformation studies on slope area using a digital CRP and the details are described as follow:

a) In-Situ Data Observation

In this research, images are taken from different epoch by using a digital CRP to produce 3D image due to reasonable of costing and its suitability for measuring inaccessible and risky areas

b) Equipment

In this study, a non- metric camera Sony Cyber Shot DSC F828is selected to capture the slope area images by convergent technique retrieval image. The data from CRP has been used in this study because the accuracy of this technology is also acceptable for slope deformation monitoring.

c) Process

i. Camera Calibration

Camera calibration is the process of finding the true parameters of the camera parameters which consist a focal length (c), format size, principal point (X_p, Y_p) and radial lens distortion (K_1, K_2, and K_3). The calibration must be carried out for a project to be accurate so that the camera parameters well known.

ii. Software

Photo Modeler Scanner software is the special software that will be used in this study to undergo the process of calibration and other processing related to generate coordinate meanwhile Agisoft software being used for creating 3D model.

iii. 3D Modeling

The process of producing 3D image is undergoing after the calibration process is done. The parameter of the results will be used. The special software will be used to do the 3D image.

1.5 Significant of Study

The establishment of the CRP in deformation survey in real world of deformation survey is new and be able nation from its uses. Thus, there are several essential purposes of the study:

i. From the research, the effectiveness and useful of the digital CRP were determined and exposed especially on deformation studies of slope area.

ii. An alternative of low cost technique and tools for deformation studies on slope area and also to acquire digital images of a simulated model landslide.

iii. Will benefit future researchers that who are interested in knowing more about the potential of CRP role in monitoring civil engineering structure as well as deformation

iv. The suitability and effectiveness a digital CRP technique are utilize in deformation detection especially on monitoring slope movement also could be used for academic and scientific study especially for higher learning institution.

v. Implementation of non-metric camera in deformation studies also the use of PhotoModeler Scanner software as processing images could be used voted guideline for potential in the geological photogrammetry field.

1.6 Chronology of Study

The operational framework is portrayed in four phases and detailed of the tasks are described shortly as Figure 1.2. The operational framework design is illustrated in Figure 1.3.

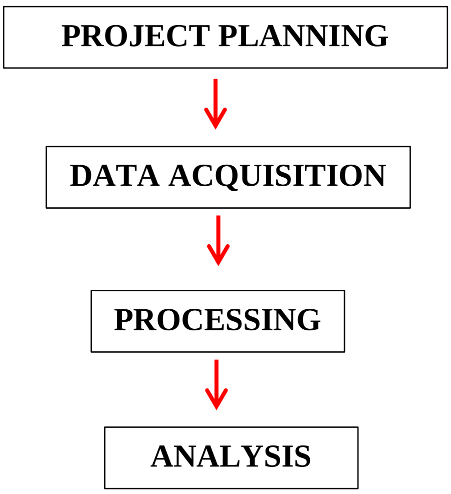

Figure 1.2: The four phase's operational framework

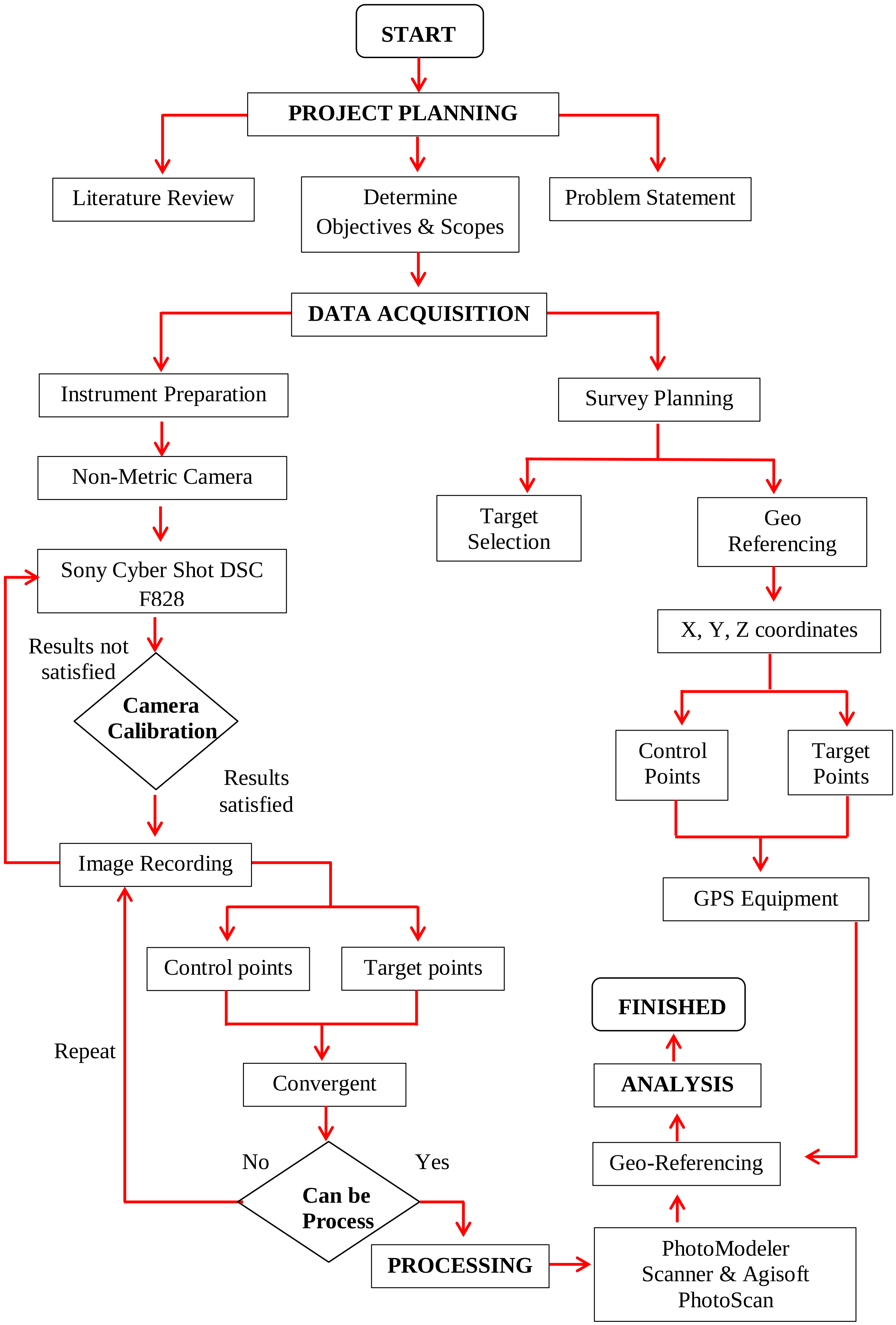

Figure 1.3: The Operational Framework design

1.7 Thesis Outline

The thesis consists of five chapters and is describe briefly as follows:

Chapter 1:

This study is emphasizing of the deformation studies on slope area using a digital CRP. The natural disaster as well as landslide is an inevitable phenomenon in Malaysia. Therefore, this section has stated the introduction of this study including background of study, it objective in order to overcome the problem and discuss concisely about the study significant and the chronology of the operational framework.

Chapter 2:

This Chapter discusses about the overview of Deformation studies on slope area and the CRP techniques as a main issued according to study on the movements occurred at particular area. Then, discussion about the concepts used for detection of deformation on slope area. Since CRP is the main issue in this study, thus, this topic converse more in it including its parameter and survey application. Moreover, this topic confer the performance of CRP and processing workstation too.

Chapter 3:

On this chapter briefly discuss in depth the details of observation procedure and research methodology in using a digital CRP for monitoring deformation studies on slope area that being used in this study. A detailed explanation of both techniques is discussed. This include a discussion reviewing the collection of observation data with different epoch, the calibration for both technique, processing differenced data using appropriate software package and error sources involved in using CRP data. The network design and designation of the monitoring points also cover in this section. This chapter also presents the observation procedure and analyses of processing CRP and ground profiling data for deformation studies on slope area phenomena using a non-metric camera Sony F2F 8, Photo Modeler Scanner software, Agisoft software and Statistical Package Social Science (SPSS).

Chapter 4:

These sections explain the analysis and discussion the work accomplished. The analysis consists of calibration results for CRP, elevation interpolation error, result for volume obtained by this technique, deformation studies detection of different epoch data and ground control profiling consist cross and long section for slope area

Chapter 5:

Finally, conclusion and recommendations made with some suggestions to improve this study. Throughout this study, the performance of effectiveness CRP has been analyzed by modeling process. As a conclusion, the development of CRP in terms of deformation studies detection in this study is expected to work well in order to help many sectors only to development of the country but also for authority well-being and academic purposes.

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