TOPOGRAPHIC/HIGHWAY SURVEY: A COMPARISON BETWEEN EDM VS PHOTOGRAMMETRY

EVELYN CHONG TZE YEH

FACULTY OF ENGINEERING

UNIVERSITI MALAYSIA SABAH

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EVELYN CHONG TZE YEH

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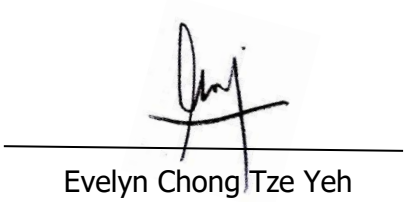

01 July 2022

Evelyn Chong Tze Yeh
BK18110090

CERTIFICATION

NAME : **EVELYN CHONG TZE YEH**

MATRIC NO. : **BK18110090**

TITLE : **TOPOGRAPHIC/HIGHWAY SURVEY: A COMPARISON BETWEEN EDM VS PHOTOGRAMMETRY**

DEGREE : **BACHELOR DEGREE OF CIVIL ENGINEERING**

FIELD : **CIVIL ENGINEERING**

VIVA DATE : **18 JULY 2022**

CERTIFIED BY;

Signature

SINGLE SUPERVISION

SUPERVISOR
Mr. Lim Chung Han

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ABSTRACT

In transportation networks development, the need for accurate record of the existing land conditions is emphasised. Numerous methods can be used to produce these records such as topographical highway survey by using photogrammetry and total station. Most of the land surveys mostly used Unmanned Aerial Vehicles for several applications especially for those kinds of road projects. Thus, for the purpose of this study, GPS was used to establish ground control points for aerial photogrammetry survey. A selected road within the area of University Malaysia Sabah (UMS) is chosen to carry out the two techniques of topographic/highway survey. These techniques could be used in topographic surveys, but their accuracy differs from one another, hence in this project, the main objectives is to extract a procedure utilizing photogrammetry survey on the study area and compare traditional survey technique (total station) and photogrammetric survey technique (UAV) to perform comparison analysis. Then, the RMSE result obtained from the photogrammetry method will be compared with acceptable industry standards to ensure the correct accuracy of detail on the road features, which are surveyed.

ABSTRAK

TINJAUAN TOPOGRAFI/LEBUH RAYA: PERBANDINGAN ANTARA EDM VS FOTOGRAMETRI

Dalam pembangunan rangkaian pengangkutan, keperluan untuk merekodkan mengenai keadaan tanah yang sedia akan ditekankan. Pelbagai kaedah boleh digunakan untuk menghasilkan rekod-rekod ini seperti kaji selidik lebuh raya topografi dengan menggunakan fotogrametri dan total station. Kebanyakan tinjauan tanah menggunakan Kenderaan Udara Tanpa Pemandu untuk beberapa aplikasi terutamanya untuk projek-projek jalan raya. Oleh itu, untuk tujuan kajian ini, GPS digunakan untuk menubuhkan titik kawalan tanah untuk kaji selidik fotogrametri udara. Jalan raya dalam kawasan Universiti Malaysia Sabah (UMS) telah dipilih untuk menjalankan dua teknik kajian topografi/lebuh raya. Teknik-teknik ini boleh digunakan dalam kaji selidik topografi, tetapi ketepatan mereka berbeza antara satu sama lain, oleh itu dalam projek ini, objektif utama adalah untuk mengekstrak prosedur menggunakan kaji selidik fotogrametri di kawasan kajian dan membandingkan teknik tinjauan tradisional (total station) dan teknik kaji selidik fotogrammetrik (UAV) untuk melakukan analisis perbandingan. Kemudian itu, hasil RMSE yang diperoleh daripada kaedah fotogrametri akan dibandingkan dengan piawaian industri yang boleh diterima untuk memastikan ketepatan terperinci yang betul mengenai ciri-ciri jalan raya, yang ditinjau.

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LIST OF SYMBOLS

mm	-	Millimetre
km	-	Kilometre
m	-	Metre
cm	-	Centimetre
°C	-	Degree Celsius
%	-	Percentage
Δ	-	Residual
σ	-	Sigma
μ	-	Mean Residual
N	-	Number of GCPs
Σ	-	Total

LIST OF ABBREVIATION

2D	-	2-dimensional
4D	-	Four-dimensional
3D	-	Three-dimensional
BC	-	Before Christ
BIM	-	Building Information Modelling
CAD	-	Computer-Aided Design
CIM	-	Civil Information Modelling
DEM	-	Digital Elevation Model
EDM	-	Electronic Distance Measurement
GCP	-	Ground Control Point
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
LiDAR	-	Light Detection and Ranging
RICS	-	Royal Institution of Chartered Surveyors
RMSE	-	Root Mean Square Errors
PC	-	Personal Computer
PWD	-	Public Work Department
UTM	-	Universal Transverse Mercator
UAV	-	Unmanned Aerial Vehicle
UMS	-	University Malaysia Sabah
US	-	United States

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CHAPTER 1

INTRODUCTION

1.1 Background of study

1.1.1 History of Survey

The first land surveyors in the history of surveying are the ancient Egyptians, who used land surveying to measure distances in the creation of pyramids in 1,400 BC. "Rope stretchers" is defined as Egyptian surveyors using plumb bobs, measuring ropes and levelling tools with their accurate survey techniques that had built the Great Pyramid of Giza in 2,700 BC. One of the early surveying instruments is the Groma, came from Mesopotamia, which was used by the Romans and Greeks. It is quite useful to establish land surveying as a profession in the early 400 BC. During the Quin dynasty in China, the magnetic compass was introduced in 221 to 206 BC, invented using an iron oxide mineral to design their fortune telling boards by the Chinese. Jumping forward to the year of 1086, William I or known as William the Conqueror ordered a Domesday Book, a record of landowners in England and their plots they had occupied. It placed a greater importance on specific information of the land's quality and content (CourthouseDirect team, 2018).

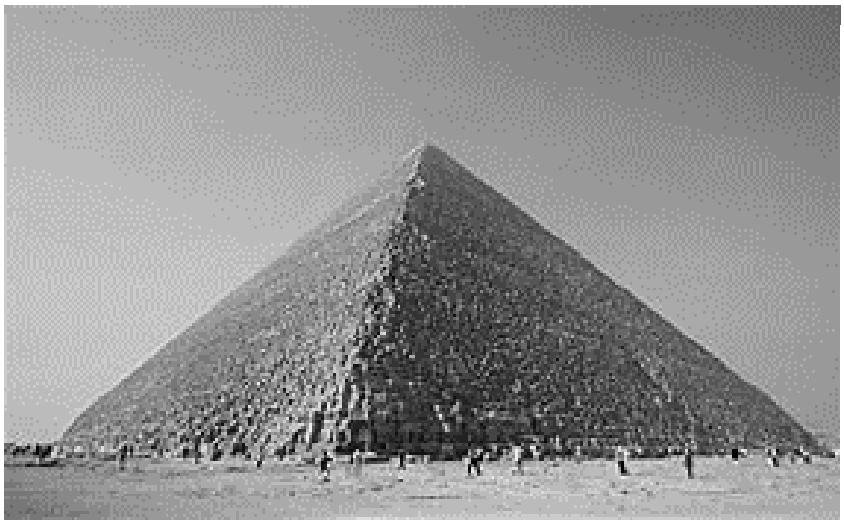

Figure 1.1: Great Pyramid of Giza and Groma

Source: CourthouseDirect team (2018)

In the history of creating New Land Surveying Tools, Joshua Habermel was the first to create theodolite, a precise equipment for land surveying by using compass and tripod to create boundary lines in 1571. Land surveying then became an official profession in the early 1800s with more development of surveying tools. Geodimeter introduced EDM equipment that saved the time for chain measurement in the late 1950s. Total station first appeared to measure both angle and distance combined which brought improvement in survey accuracy in the 1970s. In 1978, the US Air Force launched the first prototype satellites of Global Positioning System (GPS) to provide more accuracy. During the 21st century, development of survey technologies such as terrestrial scanning, remote sensing and 3D scanning using Unmanned Aerial Vehicles (UAV) has made land surveying more accurate and easier (Wikipedia, 2021).

1.1.2 Topography Documentation and Survey

Topography documentation as part of surveying comprises all methods available to record the geometry of objects and/or topography of a specific place. Hence, photogrammetry will often be a top choice as topographic survey method, but a final decision of surveying methods should be considered depending on the specific project. Topography defined as the distribution of features that deals with the study of the Earth's surface. The study of topography involved people of different fields to understand the condition of the land/soil and take actions on it for the sake of creating topographic maps. Civil engineers mostly use topographic maps to examine the land surface and natural features such as drainage, roads, and buildings, to build a specific construction project.

Topographic surveys are classified into two techniques to gather information about a particular land which is indirect survey and direct survey. Indirect topographic survey gains data through satellite images, images taken from the drone or radar images, and it is a preferable technique due to its profitability and convenient to use. On the other hand, direct topographic survey is time-consuming, and the instruments needed for this technique required a qualified surveyor to use theodolite, levels, clinometers, and other instruments to survey the land. Most surveyors will make and record 200 to 275 or more measurements per day by using manual total station in topographic survey (Broome, 1999).

1.1.3 Classification of survey

Surveying is a very important branch for civil engineering as it depends on the types of surveying involved to meet the client's requirements. Hence, surveying is classified into two groups namely plane surveying and geodetic surveying. Plane surveying assumes the surface of the Earth is plane and its curvature is neglected and used to survey smaller areas. On the other hand, Geodetic surveying considers the curvature of the Earth and deals with vast areas.

a) Levelling

Levelling is one of the types of survey used to determine the relative height of the different points below, above, and on the surface of the ground. It is the determination of the elevation of a point or difference between points references to Geocentric Datum for Malaysia (GDM2000). There are a total of three methods used to measure differences in vertical elevation are trigonometric levelling, differential levelling, and direct vertical measurement.

b) As-built Survey

This survey is to document the actual condition of completed projects, which is done for the payment and record purposes. It is regularly completed to check the route survey projects (e.g., railroad, highway, or watercourse relocation projects) against specifications and plans (Broome, 1999).

c) Boundary Survey

The purpose of a boundary survey is to recover or/and establish the property boundary and define the limits of the property accurately. This survey is mostly used for commercial, industrial, and residential purposes to investigate the location of boundary, fencing and improvements occupations relative to the boundary. The prices of boundary surveys are dependent on the property's size and complexities of the site.

d) Foundation Survey

It is a survey done to make sure that the foundation was constructed in the correct elevation and location in accordance with the site plan and subdivision plan. It is aimed to collect the positional data on a foundation which has been completely poured and cured. It is much easier to fix a non-compliant foundation before resumes construction (Mcsteen Team, 2021).

Figure 1.2: Foundation Survey

Source: Mcsteen Team (2021)

e) Chain Survey

No angular measurements are made, and only linear measurements are taken in the field in the chain survey, which is the simplest method of surveying. However, this type of survey is only suitable for small areas with simple details, where the area is split into several small triangles or known as triangulation. Furthermore, at least two surveyors are required for chain surveying.

f) Plane Table Survey

Plane Table Survey was first created by the Egyptians to make large-scale survey maps accurately to illustrate the natural features and man-made structures. Most surveyors recorded the field observations and plotting on a paper, which is fixed on a calibrated plane table to prepare the map. Eventually, this survey is suited for irregular topography existing in natural features, but for most purposes, it has been replaced by total stations and photogrammetry (Broome, 1999).

Figure 1.3: Plane Table mapping of Alaska

Source: Johnston K. (2014)

g) Topographical Survey

It locates all topographical features and improvements by determining the elevation of points on a specific piece of land and plot them into contour lines. Contour lines are likely drawn on a topographic map to indicate the ground elevation that shows the valleys and peaks of that particular land. It brings greater accuracy to any site development by reducing the risk of costly errors to give a clear understanding of how an existing land is arranged.

h) Electronic Total Station Survey

This survey combines the functions of EDM, electronic transit theodolite and software to collect all survey measurements quickly. There is software that can be used for plotting contours at a specified contour interval to form a map. Total station can collect and process data that can be downloaded to PC/computer for further analysis and processing.

i) Photogrammetric Survey

Maps are prepared from the images taken from UAV/drone with photogrammetric techniques. High-speed imaging from photogrammetry can measure, record, and detect the complexity of 2D/3D motion landscapes and obtain the exact positions of surface points. This type of survey is widely used to obtain measurement of Earth's features.

Additionally, photogrammetric surveys can be done by either terrestrial photographs or aerial photographs. Terrestrial photographs were taken from a fixed position or on the ground while aerial photographs were taken from aerial vehicles as shown in Figure 1.4.

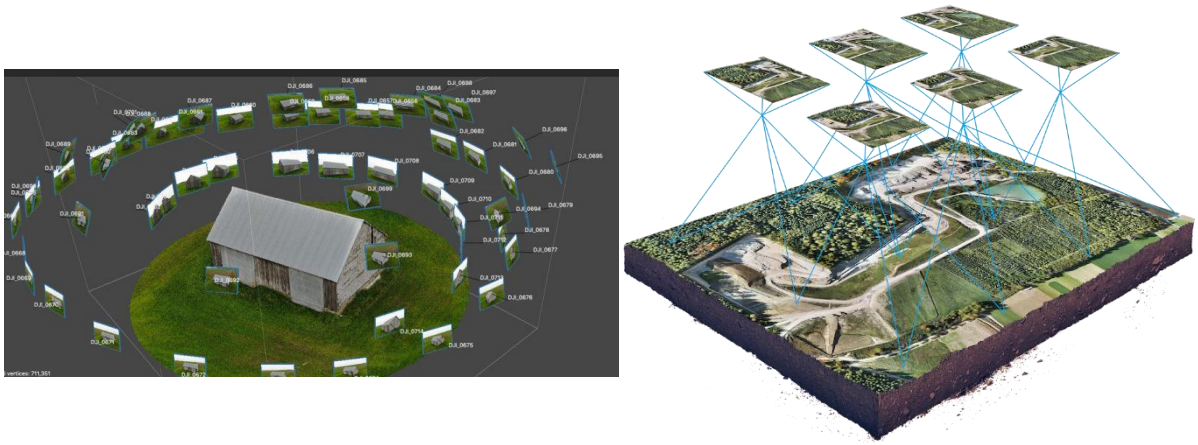

Figure 1.4: Example of Terrestrial and Aerial Photographs

1.1.4 Photogrammetry

a) History and Evolution of Photogrammetry

The definition of photogrammetry is the use of photography in surveying to obtain measurements of an object or structure from different angles and points indirectly. The origin theory of photogrammetry was first introduced by Dominique Francois Jean Arago around 1840, and then Ian Dowman proposed digital photogrammetry in 1984 as a way to map the terrain/topography using satellite images (The Center for photogrammetric training, 2008).

Today photogrammetry has evolved to various methods used to process the photographs by using photogrammetry software compared in the past decades. This software helps in calculating the measurements and creating 2D/3D models using the images, which is a great technique accessible to students, beginners, surveyors including professionals to use photogrammetry software programs such as Meshroom, Pix4D, Agisoft Metashape and many more.

b) Advantages and Limitation

James et al. (2017) mentioned that photogrammetry provides a lot of benefits in the development of topographic survey because it is able to offer a flexible workflow for robust automatic photogrammetric orientation of images captured from landscape platforms. In addition, photogrammetry is implemented at a low-cost and user-friendly photogrammetry software that gives fundamental advantages of its approach with highly accurate measurement records that can be relied on for a variety of construction projects. Furthermore, aerial photogrammetry can survey locations that are unable to access large vegetation or obstacles with minimal effort while maintaining high levels of accuracy.

However, one of the main limitations of photogrammetry is that Unmanned aerial vehicles (UAVs) are sensitive to poor weather conditions namely rain, wind, and fog which can affect the image quality. Some areas of buildings and hill/mountain terrains have restricted altitude of flight, hence, high accuracy and image resolution is unable to achieve in these situations. Moreover, overlapping problems may occur if the camera position does not cover the area wider than the one of interest due to the existence of land that was not flat as shown in Figure 1.1 (El Meouche et al., 2016).

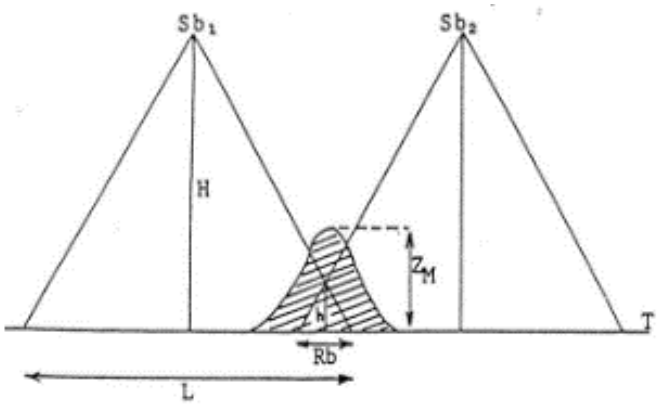

Figure 1.5: Overlapping Problem on non-flat land

Source: El Meouche et al. (2016)

1.1.5 Electronic Distance Measurement (EDM)

a) History and Evolution of EDM

EDM instrument was first developed in Sweden in 1948, then, as decades passed technology has improved drastically. Total station or can be called as electronic tacheometers has appeared in 1971, which has become the primary equipment for surveyors that went from being a team operation into a single surveyor operation with its modernization. These instruments have become increasingly robotized and essential to major construction projects from the 1990s onwards (Hughes. T, 2020).

b) Advantages and Limitations

Total station has greater accuracy in area computation which can measure up to 3 to 5 km of distance. It is able to handle most survey tasks which allows surveyors to handle many construction projects more smoothly. This instrument can measure a distance to a suitable range with an accuracy more than 5 mm and it has features that can eliminate the reading errors and writing errors.