COMPARATIVE STUDY OF GEOREFERENCE TECHNIQUE USING PHOTOGRAMMETRIC AND GEOGRAPHICAL INFORMATION SYSTEM SOFTWARES

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DEDICATION

To my beloved mother and father,
my wife Aisha,
my beloved Ibrahim and Yomna,
my brothers and sisters,
all my beloved friends.

AKNOWLEDGMENT

All praises and thanks are due to God Almighty Allah for seeing me through and for His abundant mercies, guidance and protection on me. I wish to express my sincere gratitude and appreciation to my supervisors, Associate Prof Dr. Anuar Ahmad and thank you for the tremendous support and guidance you provide me and above all for the knowledge you imparted in me.

Also my deepest gratitude goes to all staff and students of the faculty of Geoinformation and Real Estate. My heartfelt thanks goes to all my friends at beloved PALESTINE.

ABSTRACT

In photogrammetry, georeference is a process to determine ground coordinate based on measurement of photo coordinate. In digital photogrammetry, georeference process can be carried out using many softwares which are widely available. Georeference is important in photogrammetry. There are many techniques of georeference such as rectification and orthorectification. The accuracy of georeference is very critical because it depends on the capability of the software to produce good accuracy. Today there are many software available for digital photogrammetry but each software may use different algorithm. The aim of this study is to make comparison of accuracy between three softwares ERDAS IMAGINE 2011, ArcGIS 9.3 and Global Mapper 13 using different georeference techniques. In this study, four aerial photos, acquired from Department of Survey and Mapping Malaysia and 11 GCPs and 21 CPs were established using rapid static technique of Global Positioning System (GPS) and secondary data were used to perform georeference process. Georeference process was performed using the three softwares and these comparison was made based on Root Mean Square Error (RMSE). Also digitizing is carried out from the rectified and orthorectified photos in the three softwares. The distance measurements was also compared with distance measured on the ground. The RMSE based on point measurement, distance measurement and other factors such as time taken for processing was compared for the three softwares. In this study the results showed that orthorectification technique in ERDAS IMAGINE 2011 software produces better accuracy (±0.333m) compared to rectification technique in ArcGIS 9.3 (±0.879m) and Global Mapper 13 (±1.367m). As conclusion, Global Mapper13 and ArcGIS9.3 can generate rectified photo with reasonable accuracy but both softwares could not produced block triangulation and orthophoto. However, ArcGIS9.3 and Global Mapper13 softwares are much more user friendly compared to ERDAS IMAGINE 2011 software.

ABSTRAK

Dalam fotogrametri *georeference* adalah satu proses penentuan koordinat bumi berdasarkan pengukuran koordinat foto. Dalam fotogrammetri digital, proses *georeferen*ce dapat dilakukan dengan menggunakan pelbagai perisian yang terdapat di pasaran. *Georeference* adalah sangat penting dalam fotogrammetri. Terdapat pelbagai teknik dalam penggunaan *georeference* contohnya rektifikasi dan ortorektifikasi. Ketepatan *georeference* adalah kritikal kerana ianya bergantung kepada kemampuan perisian tersebut untuk menghasilkan ketepatan yang baik. Pada masa kini, terdapat pelbagai perisian untuk fotogrammetri digital tetapi setiap perisian menggunakan algorithma yang berlainan. Tujuan kajian ini adalah untuk membuat perbandingan ketepatan diantara tiga perisian iaitu *ERDAS IMAGINE 2011, ArcGIS 9.3* dan *Global Mapper 13* dengan menggunakan teknik *georeference* yang berbeza. Dalam kajian ini, empat foto udara yang diperolehi dari Jabatan Ukur dan Pemetaan Malaysia dan 11 titik kawalan bumi serta 21 titik semakan digunakan untuk melaksanakan proses *georeference*. Proses *georeference* dilakukan dengan mengaplikasikan tiga perisian tersebut dan seterusnya perbandingan dibuat berdasarkan kepada *Root Mean Square Error* (RMSE). Proses pendigitan juga dilakukan pada foto yang telah direktifikasi dan diortorektifikasi pada ketiga-tiga perisian tersebut. Pengukuran jarak juga dibandingkan dengan jarak sebenar di atas tanah. Perbandingan RMSE adalah berdasarkan titik pengukuran, pengukuran jarak dan beberapa faktor lain termasuk waktu yang diperlukan untuk pemprosesan bagi ketiga-tiga perisian turut dilakukan. Dalam kajian ini, hasil kajian menunjukkan teknik ortorektifikasi dalam perisian *ERDAS IMAGINE 2011* menghasilkan ketepatan yang lebih baik (±0.330m) berbanding perisian *ArcGIS 9.3* (±0.879m) dan *Global Mapper 13* (±1.367m). Kesimpulannya, perisian *ArcGIS 9.3* dan *Global Mapper 13* boleh menghasilkan foto rektifikasi dengan ketepatan yang baik, namun kedua-dua perisian tersebut masih tidak dapat menghasilkan penyegitigaan udara dan ortofoto. Walaubagaimanapun, perisian *ArcGIS 9.3* dan *Global Mapper 13* adalah perisian mesra pengguna jika berbanding dengan perisian *ERDAS IMAGINE 2011*.

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LIST OF DEFINITIONS

Check point (CP): An additional ground point used to independently verify the degree of accuracy of a triangulation.

Digitizing: Any process that converts non digital data into numeric data, usually to be stored on a computer. In ERDAS IMAGINE, digitizing refers to the creation of vector data from hardcopy materials or raster images. The data are traced using a digitizer keypad on a digitizing tablet, or a mouse on a display device.

Fiducials: Four or eight reference markers fixed on the frame of an aerial metric camera and visible in each exposure. Fiducials are used to compute the transformation from pixel.

Omega, Phi, Kappa: A rotation system that defines the orientation of a camera/sensor as it acquired an image. Omega, Phi, Kappa is used most commonly, where Omega is positive rotation around the X-axis, Phi is a positive rotation around the Y-axis, and Kappa is a positive rotation around the Z-axis. This rotation system follows the right-hand rule.

Stereopair: A set of two remotely-sensed images that overlap, providing a 3D view of the terrain in the overlap area.

Tie point: A point; its ground coordinates are not known, but can be recognized visually in the overlap or side-lap area between two images.

Orthophoto: An aerial photo or satellite scene that has been transformed by the orthogonal projection, yielding a map that is free of most significant geometric distortions.

Interior orientation: Describes the internal geometry of a camera such as the focal length, principal point, lens distortion, and fiducial mark coordinates for aerial photographs.

Ground control point (GCP): An easily identifiable point for which the ground coordinates of the map coordinate system are known.

LIST OF ABBREVIATIONS

AT	Aerial Triangulation.
DEM	Digital Elevation Model.
DTM	Digital Terrain Model.
GCP	Ground Control Point.
GIS	Geographic Information System.
GPS	Global Positioning System.
RMSE	Root Mean Square Error.
TIN	Triangulated Irregular Network.

CHAPTER 1

INTRODUCTION

1.1 Background

Photogrammetry can be defined as the art, science and technology of obtaining reliable information about physical objects and the environment, through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena. As given by the (American Society for Photogrammetry and Remote Sensing,1980). Photogrammetry was invented in 1851 by Colonel Aimé Laussedat, and has continued to develop over the last 150 years. Over time, the development of photogrammetry has passed through the phases of plane table photogrammetry, analog photogrammetry, analytical photogrammetry, and has now entered the phase of digital photogrammetry (Konecny, 1994).

Photogrammetry allows for the extraction of three-dimensional features from remotely sensed data (close-range, aerial, orbital, etc.). When dealing with aerial photography or satellite imagery, there is a method for geometrically "adjusting" spatial data that is relatively simple (e.g. rubber sheeting). Although this method plays an important role for GIS users, it does not create a suitable product for making accurate geometric measurements. The photogrammetric process is needed to

confront the systematic and non-systematic errors introduced when an image is captured or made digital such as terrain relief, camera orientation, lens/sensor distortion, and scanner distortion. It is only after solutions are found for these errors that accurate topographic and planimetric information can be extracted from a digital image (Anuar,2008).

All air-photos contain systematic distortions caused by camera angle, distance, and surface elevation. An orthophoto is a digital image that has been processed to correct for distortions of camera perspective and surface elevation, and the products is a geometrically correct images of orthophotography (Feng, 2000). Figure 1.1 shows the perspective and orthographic image geometry.

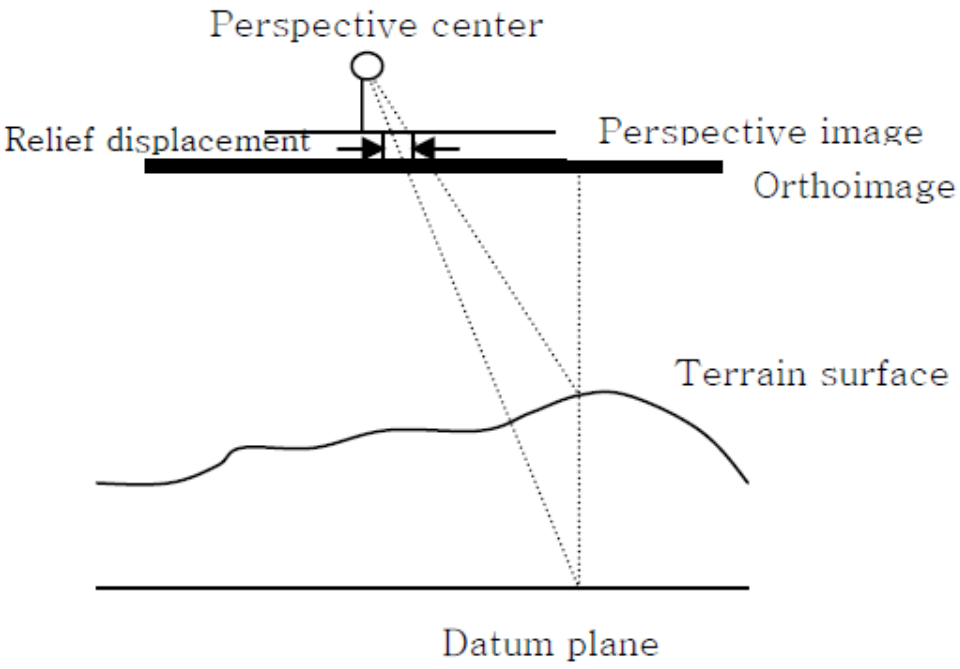

Figure 1.1: Perspective and Orthographic Image Geometry

The fundamental step in the automatic generation of DEM is the process of image matching by which conjugate points are identified in the two images. Conjugate points are points in two different images with the same ground location. The identification of conjugate points can be carried out using an area or a based

feature approach. Based area matching, matches small area as or patches in each digital image using correlation techniques, based feature matching identifies objects such as the edges of buildings, or roads, which are visible in both images (Gooh and Chandler, 1999).

Georeferencing involves assigning real-world coordinates to a number of reference points on the image. Also it is the first step when making analogue data digital. Raster data is commonly obtained by scanning maps or collecting aerial photographs and satellite images. Scanned map datasets do not normally contain spatial reference information. With aerial photography and satellite imagery, sometimes the locational information delivered with them is inadequate, and the data does not align properly with other data. Thus, in order to use some raster datasets in conjunction with other spatial data, user often need to align it, or georeference it, to a map coordinate system. A map coordinate system is defined using a map projection (a method by which the curved surface of the earth is portrayed on a flat surface). To make georeference raster dataset, user must defined its location using map coordinates and assign a coordinate system. Georeferencing raster data allows it to be viewed, queried, and analyzed with other geographic data.

1.2 Problem Statement

Due to the large geometric distortion associated with raw aerial photography and satellite imagery, measurements made on data sources that have not been rectified for the purpose of collecting geographic information are not reliable. Generally, the geometric distortion is used by various systematic and non systematic errors such as camera and sensor orientation, terrain relief, Earth curvature, film and scanning distortion, and measurement errors (Wolf 1983,Konecny and Lehmann 1984).

In geoinformation, spatial data are divided mainly into vector data and raster data. Raster data can be collected using different ways. For example aerial photos,

close range photogrammetry technique, satellite image and scanned maps. One way to get the data is from aerial photos. Aerial photos can provide extra details than some other source. Aerial photos based on films can be scanned and converted into a digital TIFF or JPG file. Scanned photos do not usually contain information as to where the area represented on the map fits on the surface of the earth. Thus, in order to use these types of information in conjunction with other spatial data, it need to be georeferenced to a map coordinate system.

Remote sensing images and aerial photographs give information about objects and natural features on the surface of the earth. These objects and features are located in specific geographic positions and they correlated with each others with spatial relations. Raw images contain distortion, which makes image does not represent correctly the geographic area that has been captured. Therefore the images must be georeferenced before using it. There are many methods and softwares that can manipulate the georeference process. This study uses several softwares and different methods in performing georeference technique.

1.3 Aim of Study

Since aerial photos and satellite images are considered the basis to produce topographic maps, georeference the data is essential before using it for any application. Therefore the aim of this study to make comparison of different georeferencing technique using various softwares.

1.4 Objectives of Study

The aim of this study could be achieved by performing several objectives .The objectives are as follow:

i. To perform georeference techniques using three different georeference softwares (ERDAS IMAGINE 2011, ArcGIS 9.3 and Global Mapper 13)
ii. To determine the accuracy of georeferencing process biased on different georeference software .
iii. To analyse the results of the three softwares in teem of positional accuracy and image visualization.

1.5 Scope of Study

In this study, three main field of geoinformation are used which include photogrammetry, engineering survey and GIS. Four aerial photographs are used to perform georeferencing techniques. For engineering surveying the ground control points (GCPs) and check points (CPs) is established by using rapid static techniques of Global Positioning System (GPS) and secondary data were used with accuracy in centimetres . Additional, observations is collected for checking and accuracy assessment. Different digital photogrammetric software is used to implement georeference techniques and make comparison. All data are exported to GIS. Finally, the accuracy of the rectification and orthorectification is assessed by using Root Mean Square Error (RMSE) calculations. Different georeference softwares used are ERDAS IMAGINE 2011, ArcGIS 9.3 and Global Mapper 13.

1.6 Study Area

The study area is located in Universiti Teknologi Malaysia (UTM), Skudai, Johor , Malaysia. There are some aerial photographs and satellite image related to this area are available in the Faculty of Geoinformation and Real Estate, UTM. This

study area is chosen because it's easy to access and then collect data from the field. The photographs are acquired from the Department of Surveying and Mapping Malaysia (DSMM) in February 2005 at the scale of 1:10,000. Figure 1.2 shows the study area.

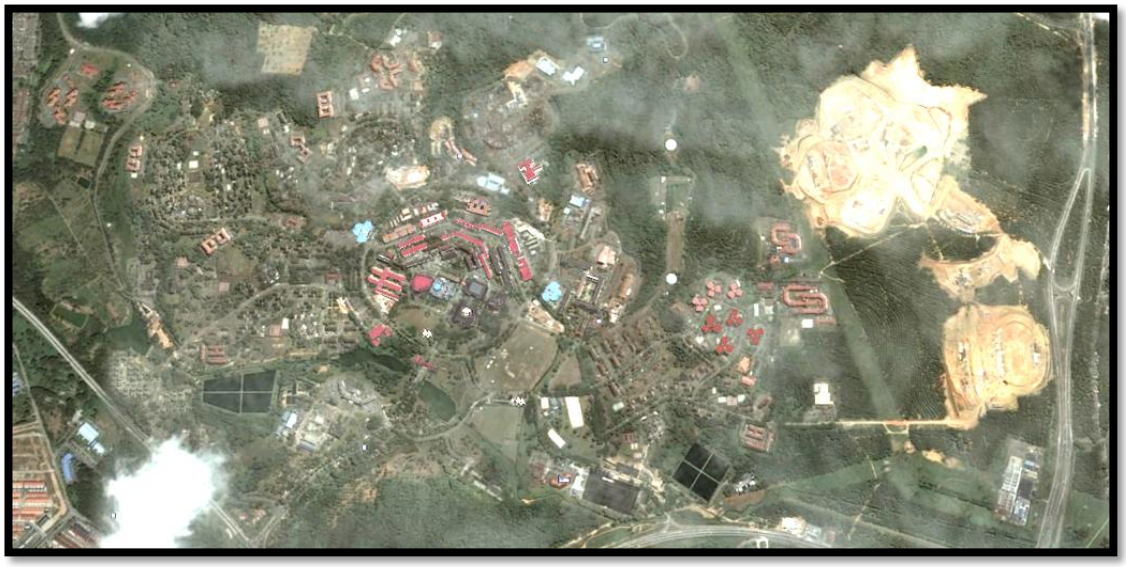

Figure 1.2: The Study Area in UTM, Skudai, Johor Bahru ,Malaysia

1.7 Significant of Study

The aerial photographs and satellite images are considered as main data set in preparation of topographic maps. The significant of this study is to highlight the importance of georeferencing techniques. Georeferencing is crucial to aerial and satellite imagery. When data from different sources need to be combined and then used in GIS application, it becomes essential to have a common referencing system. Also in change detection of multi-temporal images. Moreover, to make mosaic images: individual images are often mosaicked together to cover the complete geographic area of interest. For these images to align correctly, they must have geometric distortions corrected and be georeferenced to a compatible, consistent coordinate system.

Before making any measurements such as, direction and distance, the raw image data must be processed to remove geometric errors and to georeference the image to a real-world (map) coordinate system. For these measurements to be accurate the geometric distortion and scale must be corrected.

1.8 Thesis outline

The study consists of several stages which include planning, implementation, analysis, conclusion and recommendation. Figure 1.3 shows the flowchart of the study.

Chapter 1 : Introduction which discusses, the background of the study, problem statement, aim, objectives, significant of study, study area , scope of the study and research methodology.

Chapter 2 : Literature review. This chapter covers the related topics with georeference techniques and software packages used to perform it.

Chapter 3: This chapter provides the research methodology of this study. The steps included data collection , data input and processing stage .

Chapter 4: This chapter discusses the results and analysis of this study from

which necessary conclusion and recommendation will be made.

Chapter 5: In this chapter, conclusions and recommendation for future study .

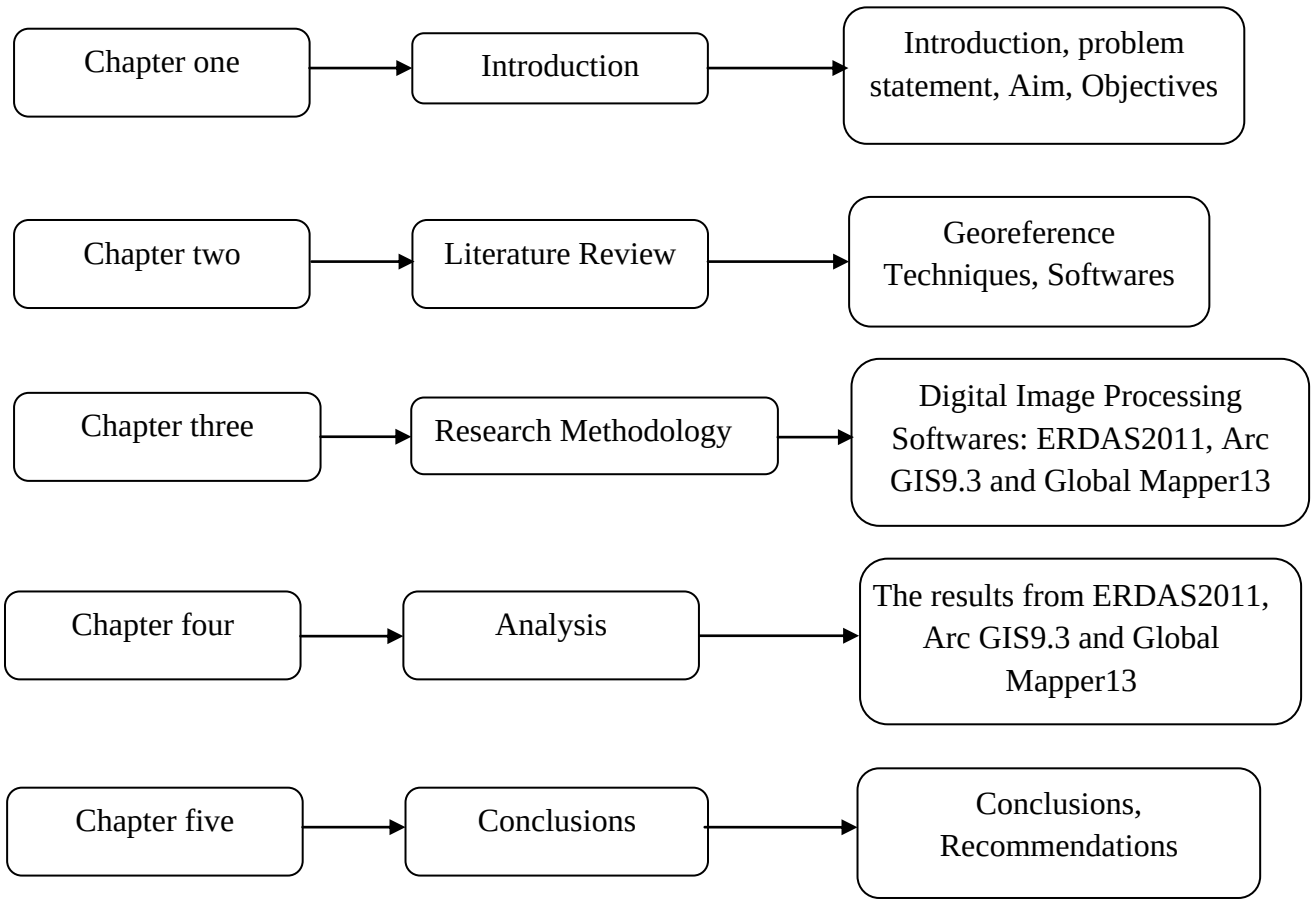

Figure1.3: Overview of chapters in the study

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