DEVELOPMENT OF LAND BASED MOBILE MAPPING SYSTEM USING GLOBAL POSITIONING SYSTEM AND CLOSE RANGE PHOTOGRAMMETRIC TECHNIQUES

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Geomatic Engineering)

Faculty of Geoinformation Science and Engineering
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JUNE 2006

To my beloved mother and father

ACKNOWLEDGEMENTS

In particular, I wish to express my sincere appreciation to my supervisor, Prof. Dr. Shahrum Ses and co-supervisor Dr. Anuar Ahmad for their encouragement, guidance, and friendship. Without their continue support and interest, this thesis would not have been the same as presented here.

A special thanks to Prof Dr. Halim Setan, for borrowing the digital camera and thanks also to the people from CIMES who help and giving support to my research.

I also wish to express my thankful to the following people whose have assisted me in the implementation of this research, which include Ms Chew May Yeen, Mr. Shu Kian Kok, Mr. Voon Min Hi, Mr. Kee Tuan Chew, Mr. Lim Wen Hong and Mr. Tan Wee Keng.

Last, but not the least, I am also grateful to my family members who give me all the support that I need.

ABSTRACT

The development of Mobile Mapping System (MMS) is still at an initial stage in Malaysia. This research concentrates on georeferencing geographical and topographical features and updating a digital base map using digital cameras and Global Positioning System (GPS). This developed MMS integrates GPS as navigation sensor and Charge Coupled Device (CCD) camera as mapping sensor. The strength of this system is in the ability to georeference mapping sensor (i.e *digital camera*) by GPS. The acquired digital images are processed and referred to a common coordinate system using photogrammetric software known as PhotoModeler. The results from the software are exported to 2D coordinate transformation program to determine the geodetic position of the objects. The final outputs are the position of the topographic features such as road, road sign, bus stop and building. These topographical features are plotted in 1:10,000 scale digital base map.

ABSTRAK

Di Malaysia, pembangunan teknologi Sistem Pemetaan Kenderaan (Mobile Mapping System, MMS) masih berada di peringkat awal. Kajian ini tertumpu kepada 'georeferencing' butiran geografi dan topografi dalam imej digital dan mengemaskinikan peta digital dengan menggunakan kamera digital dan teknik pengukuran GPS. Sistem ini mengintegrasikan peralatan GPS dan kamera CCD (Charge Coupled Device). Keunikan system ini terdapat pada kemampuannya untuk melakukan 'georeference' pada kamera digital dengan GPS. Kedudukan titik-titik dalam imej digital diproses dengan menggunakan perisian photogrametri iaitu Photomodeler kepada sistem koordinat pemetaan yang sama. Hasil dari Photomodeler akan diexport dan diproses dengan menggunakan program transformasi kordinat 2D yang dibangunkan untuk mendapatkan kedudukan geodetic butiran. Kedudukan butiran seperti jalan, tanda jalan, stesen bas, bangunan dapat ditentukan. Butiran ini kemudiannya akan diplot ke peta digital yang berskala 1:10,000.

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LIST OF ABBREVIATIONS

cm	Centimetre
DOP	Dilution of Positioning
DSMM	Department of Survey and Mapping Malaysia
DTM	Digital Terrain Model
GIS	Geographical Information System
GLONASS	Global Satellite Navigation System
GPS	Global Positioning System
Hz	Hertz
Km	Kilometre
m	Metre
mm	Millimetre
OTF	On-the-fly
ppm	Part per million
PPK	Post Processed Kinematic
PRN	Pseudo Random Noise
RMS	Roof Mean Squares
RSO	Rectified Skew Orthomophic
RTK	Real Time Kinematics
TGO	Trimble Geomatics Office
WGS84	World Geodetic System 1984
3D	Three Dimensional
2D	Two Dimensional

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The last two decades have shown an increasing trend in the use of Global Positioning System (GPS) technology in several applications in Malaysia. Such applications include land vehicles and automated car navigation, GPS-equipped KLIA limousines, land deformation monitoring and marine survey job which currently applied both in private and government sector.

The development of Mobile Mapping System (MMS) is still at initial stage in Malaysia. The research in MMS has been carried out since the first prototype introduced by the Center of Mapping at The Ohio State University (Bossler et.al., 1991). This system integrates navigation sensor such as GPS, Inertial Navigation System (INS) and mapping sensor such as Charge Coupled Device (CCD) camera.

The strength of the MMS include its ability to directly georeferenced their mapping sensor (i.e digital camera) by GPS. A mapping sensor is georeferenced to a known mapping coordinate system and can be used to determine the position of external points. Acquired points will then be reference to the digital image in the same mapping coordinate system.

1.2 Problem Statement

The conventional method of mapping such as aerial photography and field survey are coupled with the use of different remote sensing method. Basically, the data are integrated within a Geographic Information System (GIS) environment. Limitation of traditional land-based surveying systems is that each point of interest (i.e control point) needs to be occupied. The analysis of remote sensing data includes both optical and radar images. The processing of these conventional methods is more difficult, time consuming and costly. The use of digital camera is advantageous because it eliminates the requirement to scan photograph and it would substantially reduce the period from raw data collection to extracted data dissemination.

In MMS, direct georeferencing is done by using GPS and INS to locate the camera position and orientation. This is fundamentally different from traditional indirect georeferencing whereby the position and orientation of the platform are determined using measurements made to control points.

The control points are established through a field survey prior to or after data acquisition, and their establishment is typically expensive and time-consuming. Therefore, eliminating such step results in apparent decrease in both the cost and time required for data collection. The task of establishing ground control is much more complicated since its cost and time requirement are basically difficult to estimate. In many terrestrial surveys the establishment of sufficient ground control is virtually impossible, for example to consider the control requirement to map an entire city using close range photogrammetry. The establishment of ground control is not practical unless direct georeferencing is performed.

Figure 1.1 shows some typical mobile mapping system available in the world, which integrates GPS, CCD cameras and mapping vehicles. The positions of the CCD cameras are georeferenced with GPS. The final output of MMS is easily integrated with the GIS.

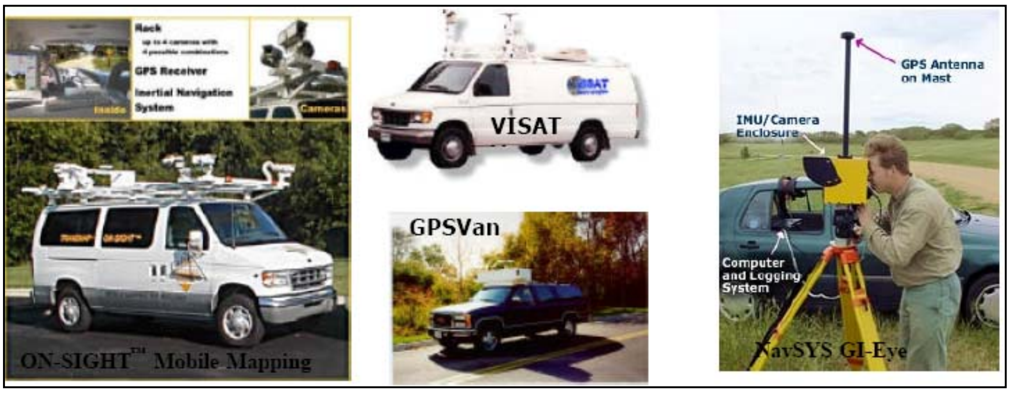

Figure 1.1: Mobile Mapping System (Zhang and Xiao, 2004)

Cartography and GIS have gain increases popularity in modern days. This new situation requires spatial database. Modern data requirements necessitate distinct solutions for acquisition of spatial information. The growing use of GIS technology and the consequent necessity to update information increases the importance of an environment to handle spatial data and information that will be even more demanding. An efficient electronic deposit of a large quantity of road images obtained by the mobile system is envisaged, whereby an image database is required to manage growing volume of data and images (Fernando and Silva, 2003).

1.3 Research Objectives

The objectives of this research include the following:-

i. To geo-referenced the geographical features of the digital image using GPS, digital camera comprise with the usage of a photogrammetric software, known as PhotoModeler.

ii. To evaluate the capability of PhotoModeler software for positioning the planimetric features.

1.4 Research Scopes

The research scopes of this study include the following:-

i. Camera calibration in the laboratory.
ii. Familiar with the Post Process Kinematic GPS technique and close range photogrammetry technique.
iii. Develop a program to integrate between the camera position and GPS coordinates.
iv. Accuracy test on Post Process Kinematic GPS technique.
v. Updating base map from digital image.
vi. Evaluate the effectiveness of integration between digital camera, software and GPS.

1.5 Contribution

The aim of this research is to evaluate the effectiveness of GPS and photogrammetry in developing land-based mobile mapping system. Hopefully the outcome of this research is useful and can be implemented in Malaysia. The MMS is deemed to be more comprehensive and innovative in the future.

1.6 Literature Review

The mobile mapping technology has been developed since 1980's. The development of the mobile mapping system became possible due to the availability of GPS signal for the civilian community.

During the past few years, tremendous advances have taken place in GPS technology especially in the satellite receiver, such as in data collection hardware and field data collection software. The autonomous GPS accuracy has improved data collectors are getting smaller, lighter, and less expensive. The GPS and GIS software has become cheaper and easier to learn. All these advancements have made the GPS/GIS data collection tasks easier, faster and more economical.

Each GPS satellite transmits signal on two frequencies: L1 (1575.42 Mhz) and L2 (1227.60 Mhz). The L1 frequency contains the civilian Coarse Acquisition (C/A) Code as well as the military Precise (P) Code. The L2 frequency contains only P code. The P code is encrypted by the military which are using a technique known as anti-spoofing and is applicable to authorized personnel only. The encrypted P code is referred to as Y code. Civilian GPS receivers use the C/A code on the L1 frequency to compute positions, although high-end survey grade civilian receivers use the L1 and L2 frequencies' carrier waves directly. Military GPS receivers use the P (Y) Code on both L1 and L2 frequencies to compute positions (Rizos,1999).

GPS receivers need at least three satellites to determine its position. Satellites position computation method is called trilateration. Recently, selective availability, an intentional degradation of the satellites signals, has been turned off down to centimeters or less, depending on equipment used and the conditions.

Undeniably, there may have particular uncertainties or errors, inherent in these positions. A number of factors that contribute to these errors include satellite clock drift, atmospheric conditions, measurement noise and multi-path. In addition, due to the satellite geometry, vertical accuracy (i.e elevation) generally can be one and a half to three times worse than horizontal accuracy.

As for close range photogrammetry, photogrammetry in general has received a substantial push forward towards the fully digital domain due to rapid advances in microelectronics and semiconductor technology. The development of new sensors, such as solid-state camera, and more powerful computer hardware has enhanced new technologies and fields of application. Hybrid and fully digital acquisition and processing system have triggered off much interest among photogrammetrist since the 15th International Congress of Photogrammetry and Remote Sensing in Rio de

Janeiro in 1984. Within ten years, digital close range photogrammetry has matured to the extent that it can now serve as a precise and reliable technique for non-contact three-dimensional measurement. The ease and speed of data acquisition, the inherent on-line and even real time capabilities, the high degree of automation and the adaptability to various requests have made it a viable measurement tool for a great number of different applications in science, art and industry (Akinson, 1996).

The position of a point in space is commonly defined by a three dimensional Cartesian coordinate system. The origin, scale and orientation can be arbitrarily defined. It is often necessary to convert between coordinates in systems having different origins, orientations and possibly scale (Akinson, 1996). In other words, it is required to define coordinated points with reference to a coordinate datum related to features on the object itself. Subsequently it may be required to define the points to a new datum.

Mobile Mapping System (MMS) is capable of observing objects at closer range, thus providing greater details. Land-based MMS uses digital camera as imaging sensor. This was possible because of the much smaller camera-to-object distance in land-based MMS when compared to air-borne systems. The poor resolution of CCD chips revealed that they could not be used in aerial applications without noticeable accuracy degradation (El-Sheimy, 1996). The use of digital camera is an advantageous because it eliminates the requirement to scan photographs. Consequently they substantially reduce the period from raw data collection to data dissemination.

MMS integrates navigation sensors and algorithms with sensors that can be used to determine the positions of points remotely. Sensors are rigidly mounted together on a platform. The navigation sensors are used to determine the position and orientation of the platform and the algorithms determine the position of external points to the platform. The sensors that are used for remote positioning are predominantly photographic sensors and thus referred to as imaging sensor (El-Shemy, 1996).

The strength of MMS lays on the ability of georeferencing the mapping sensors. A mapping sensor is georeferenced when its position and orientation relative to mapping coordinate system is known. Once georeferenced, the mapping sensor can be used to determine the position of external points to the platform in the same mapping coordinate system. MMS differ from the traditional georeferencing where the position and orientation of the platform are determined using measurements made to control points. Establishment of control points are time consuming and labour intensive.

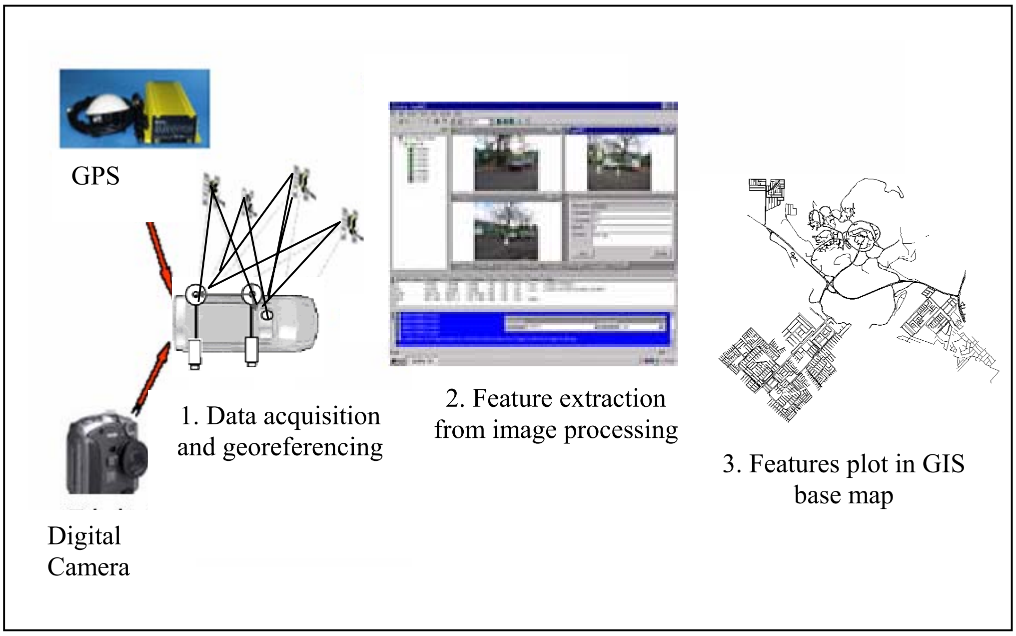

Figure 1.2: Basic Concept of Mobile Mapping System

Figure 1.2 shows the basic concept of MMS. The system operation can be divided into three components: raw data acquisition and georeferencing of the digital images, 3D feature extraction and plotting in GIS base map. Data acquisition begins by supplying power to the system while it is stationary. The Inertial Measurement Units (IMU) uses this time to “warm up”, while the GPS receiver utilises this time to resolve integer ambiguities. After the warm up period, which eventually lasts for several minutes execution of the task can be carried out which involve capturing of images. Care must be taken to ensure the entity of interest is captured in at least two frames.

Completion of data acquisition, the images and navigation data from the INS and GPS sensor are downloaded to a personal computer. INS and GPS data are processed couple with digital images towards georeferenced with the aid of appropriate software. Finally, using photogrammetric principles, two or more georeferenced digital images, 2D and 3D positions of any point or object that is visible in the two or more images can be depicted.

1.7 The appliances

Figure 1.3 shows the instrumentation that used in this research. Instrumentation used includes digital cameras (Kodak DC290 and Canon S400) and GPS receivers (Trimble and Leica). Image processing is carried out using photogrammetry software known as PhotoModeler. On the other hand, Matlab are used for programming purpose.

Figure 1.3: Photomodeler, Digital Camera, GPS Receiver and Matlab

1.7.1 Mapping sensor

For mapping sensor, Kodak DC290 and Canon S400 zoom digital camera are used in this research. The specifications of the camera are shown in Appendix A.

1.7.2 GPS Receiver

Positions of the mapping vehicle and cameras are determined using GPS Trimble 4800 and Leica GPS System 500. The specification of the GPS receivers are shown in Appendix B. Post Pocessing Kinematic (PPK) technique is adopted to optimise the field task. Processing of the GPS data are carried out using Trimble GPS processing software known as Trimble Geomatic Office (TGO).

1.7.3 PhotoModeler

PhotoModeler is a close range photogrammetric software developed by EOS System. It is windows based which is capable of extracting measurements and constructing 3D models from digital images (EOS, 2006).

1.7.4 Matlab

MATLAB is a high-level technical computing language with the ability of interactive environment for algorithm development, data visualization, data analysis, and numerical computation. The outputs of the program are object coordinates.

1.8 Research Methodology

Figure 1.4 shows the research methodology. Research methodology includes the followings:

i. Literature Review

The literature review is the backbone of the research. Information about Global Positioning System, close range photogrammetry, mobile mapping system and GIS are reviewed.

ii. System Design

The instruments that include in this research are GPS, CCD cameras, car and processing software, Photogrammetry.

iii. Instrumentation Test

Instrumentation test is carried out to make sure the instruments can applied effectively to the system. The tests are includes accuracy test on Post Process Kinematic GPS technique, camera calibration, software consideration and developed a 2D coordinate transformation program.

iv. Data Acquisition

The topographical features of study area are captured with the developed mobile mapping system.

v. Image Processing

The digital images are processed using Photomodeler and developed program. The features are plotted in digital base map.

vi. Analysis and Conclusion

At this stage, the anticipated finding will be derived from the analysis of the research. The conclusion is based on findings and experienced gain.

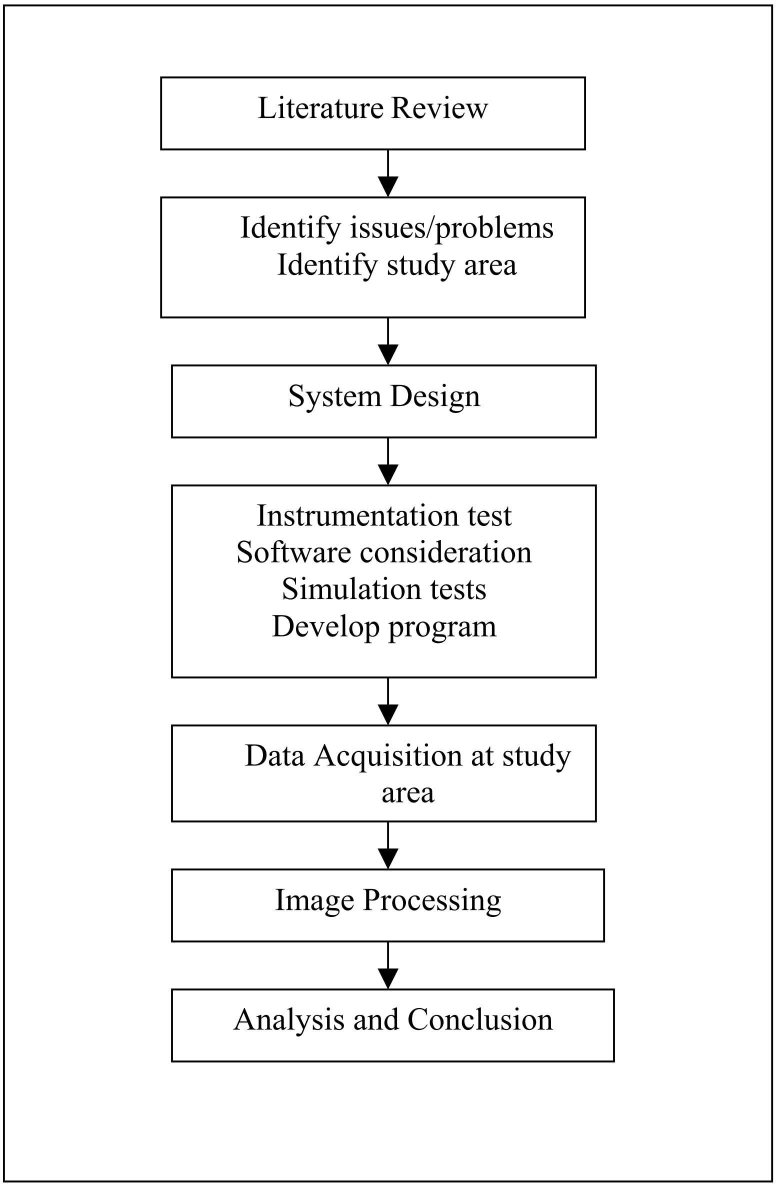

Figure 1.4: Flow Chart of Research Methodology

1.9 Thesis Outline

This thesis is divided into six chapters:-

i. Chapter 1: Introduction

This chapter discussed on the topic being studied such as issues and problems, research objectives, scope of study, significance of study, and research methodology.

ii. Chapter 2: Concept And Theory

The related theories are briefly discussed in this chapter. The discussion is focus on definition, concept about GPS, close range photogrammetry, GIS, and mobile mapping system.

iii. Chapter 3: System Design, System Calibration and Field Procedure

This chapter discussed on instruments calibration, system design and field procedures.

iv. Chapter 4: Software and Image Pocessing

This chapter deals with the processing software used, developed program and data processing of the topographic details gathered from the study area.

v. Chapter 5: Results and Analysis

Analysis on the accuracy of the topographic details and the evaluation of the mapping devices are discussed in this chapter.

vi. Chapter 6: Conclusions and Recommendations

Conclusion and recommendation for further research are discussed in this chapter.

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