TWO DIMENSIONAL NETWORK ADJUSTMENT AND DEFORMATION ANALYSIS VIA MATLAB

Roya Olyazadeh

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Faculty of Geoinformation Science and Engineering

Universiti Teknologi Malaysia

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To my beloved mother and father

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ABSTRACT

Network adjustment and deformation monitoring are one of the main activities of engineering surveying. Geodetic networks are estimated by the method of least-squares estimation (LSE) adjustment and the 'goodness' of the network is measured by a precision analysis based upon the covariance matrix of the estimated parameters. When such a network is designed, global test and local test are assessed to test compatibility of variance factor via two-tailed chi-square distribution and residual of measurements to detect gross error by using a technique pioneered by the geodesist Baarda. The second step is Deformation detection. Generally, the deformation computations can be divided into geotechnical and geodetic methods. There are two types of geodetic networks, namely the absolute and relative networks. In the absolute network, some of the points are assumed to be located out of the deformable body. However, in a relative network, all points are assumed to be located on the deformable body. This study focuses on two dimension (2-D) absolute geodetic deformation detection via MATLAB7. Deformation analysis can be handled by several techniques such as Robust (IWST and LAS), Congruency, Bayesian method and etc. This study presents a deformation analysis procedure via geodetic methods that consists of LSE of individual epochs, trend analysis of the displacement field and the deformation detection by IWST between epochs. This research focuses on the development of two programs in MATLAB7 for network adjustment (distance, angle and azimuth observation respectively) and deformation detection between two epochs. In this project, first LSE adjustment is done for each epoch and creates the appropriate input files for deformation program. Next, deformation program reads them and creates an output file and displays a graphic consists of error ellipse for each stations and displacement vector for moved stations. There are three data sets to run these two programs. For adjustment part the results are compared with STARNET results and for deformation part the results are compared with previous works by Caspary (1987), Ranjit(1999) and Khairulnizam(2004).The results show that these two programs work and there are not significant difference between these results and results from other works.

ABSTRAK

Pelarasan jaringan dan pengawasan deformasi merupakan salah satu kegiatan utama dalam ukur kejuruteraan. Jaringan geodetik dianggarkan dengan kaedah pelarasan kuasa dua terkecil (LSE) dan kualiti jaringan diterbitkan berdasarkan analisis daripada matriks kovarians bagi setiap parameter terlaras. Apabila jaringan tersebut direka, ujian global dan ujian lokal dijalankan untuk menguji keserasian faktor varians melalui taburan dua hujung khi kuasa dua dan sisa pengukuran untuk mengesan selisih kasar dengan menggunakan teknik yang dipelopori oleh penyelidik Baarda. Langkah kedua adalah pengesanan deformasi. Secara umum, perhitungan deformasi boleh dibahagikan kepada kaedah geoteknik dan geodetik. Terdapat dua jenis jaringan geodetik iaitu jaringan absolut dan relatif. Dalam jaringan absolut, beberapa titik kawalan diandaikan terletak diluar jasad tercanggakan. Namun, dalam jaringan relatif, semua titik kawalan diandaikan terletak dalam jasad tercanggakan. Kajian ini menumpu pada pengesanan deformasi dua dimensi (2D) geodetik absolut melalui MATLAB7. Analisa deformasi dapat diterbitkan oleh beberapa teknik seperti kaedah Robust (IWST dan LAS), Congruency, Bayesian dan lain-lain. Kajian ini menbentangkan prosidur analisis deformasi melalui kaedah geodetik yang terdiri daripada LSE bagi setiap epok, analisis trens tentang magnitud anjakan dan pengesanan deformasi oleh IWST antara epok. Kajian ini berfokus pada pembangunan dua program dalam MATLAB7 untuk pelarasan jaringan (cerapan jarak, sudut dan azimut masing-masing) dan pengesanan deformasi antara dua epok. Dalam projek ini, pelarasan LSE dilakukan terlebih dahulu untuk setiap epok dan menerbitkan fail input yang sesuai untuk program deformasi. Selanjutnya, program deformasi membaca fail input yang diterbitkan dan menghasilkan output fail serta memaparkan grafik yang terdiri daripada selisih elips bagi setiap stesen dan vektor anjakan bagi stesen yang telah berganjak. Terdapat tiga dataset dihitung dengan kedua-dua program tersebut. Untuk bahagian pelarasan, hasil dibandingkan dengan keputusan STARNET dan untuk bahagian deformasi pula hasil dibandingkan dengan kerja sebelumnya oleh Caspary (1987), Ranjit (1999) dan Khairulnizam (2004). Kesimpulannya, kajian ini menunjukkan bahawa kedua-dua program berfungsi dan hasil yang didapati tidak banyak perbezaan berbanding dengan kerja sebelumnya.

CHAPTER ONE

INTRODUCTION

1.1 Background

Deformation measurements are one of the most important activities of engineering surveying. Deformation analysis is one of the main research fields in geodesy and geomatic. Deformation analysis process comprises of measurement and analysis phases. Measurements can be collected using several techniques such as Total station, GPS, Laser scanner, Photogrammetry or combined techniques. The output of the evaluation of the measurements is mainly point positions. In the deformation analysis phase, the coordinate changes in the point positions are investigated.

Generally, the deformation measurement techniques can be divided into geotechnical, structural and geodetic methods. In the geodetic method there are two basic types of geodetic monitoring networks; namely the reference (absolute) and relative networks (*Chrzanowski et al.,* 1986). In a reference network, some of the points or stations are assumed to be located outside of the deformable body or object, thus serving as reference points for the determination of the absolute displacements of the object points. However, in a relative network, all surveyed points are assumed

to be located on the deformable body (Setan and Singh, 2001). In this study 2D absolute geodetic deformation is considered.

1.2 Problem Statement

The results of deformation measurements are related to direct safety of engineering structures and human life. To avoid a wrong interpretation of displacements, an appropriate deformation monitoring network must be established and the data obtained from deformation monitoring network must be carefully evaluated. Deformation measurements and analysis require the use of very accurate surveying equipment and analysis methods (Setan and Singh, 1999). Therefore, deformation detection and network analysis is very important to represent movement of subjects.

There are several known adjustment and deformation system software packages, from different university research group like ADJUST4.6 (Ghilani, 2006), also commercial software like STARNET (Starplus Software, 2000), GEOLAB (Micro Search, 1985) and PANDA (GeoTec GmbH, 2004). Specialized computer programming is required because most commercial software like STARNET does not provide the required data for deformation detection. And some of them are not easy to use. This research focuses on the development of a program via MATLAB7. MATLAB is a mathematical computer programming that covers all mathematical functions are required in surveying and this special subject, deformation. So in this work MATLAB programming is developed for network adjustment and (distance, angle and azimuth observation respectively) deformation detection where Adjustment program can create required data for deformation detection. These programs are not as powerful as other software and especially commercial software.

1.3 Aim and objective of the study

The purpose of this work is to monitor and analyze the displacements of deformation for 2D network IWST (Iterative Weighted Similarity Transformation) robust method after network adjustment. Robust method is used when there is no previous information about the movement of points within the network (Singh & Setan 1999). IWST, developed by Chen (1983) in the New Brunswick University, is known as the robust method.

The secondary goal is to program via MATLAB and determine whether this program can be converted to executable (EXE) file by using MATLAB compiler. Consequently the specific purposes of this work are:

1. Network Adjustment
2. Deformation Analysis
3. MATLAB Programming

1.4 Significance of the study

The results of deformation measurements are related to direct safety of engineering structures and Human life. To avoid a wrong interpretation of displacements, an appropriate deformation monitoring network must be established and the data obtained from deformation monitoring network must be carefully evaluated. Deformation measurements and analysis require the use of very accurate surveying equipment and analysis methods. This project is only limited to 2D network adjustment and 2D deformation detection for distance, angle and azimuth observations.

1.5 Research Scope

The research scope covers the limits of the research. In this project the limits are as follows;

The research area covers a real network with 6 stations and 4 stable stations. For network adjustment and deformation detection, MATLAB programming is carried out, while this program is objected to do all 2D network adjustments and deformations with distance and angle and azimuth. Another example have been used to test, is a known data of a dam monitoring network, taken from *Caspary* (1987) with 12 stations and 7 stable stations. The third data set is 12 stations with distance and azimuth observation (Setan, Abidin Md Som and M.Idris, 2003).

1.6 Research Methodology

Several methods or approaches can be employed for deformation analysis like The robust analysis of deformation (Caspary, 1987) ,The Generalized approach (Chen UNB, 1986) , The integrated analysis (Teskey, 1988) ,The Grey theory (Chen HK) ,The robustness analysis (Vanicek).This study will be focused on robust method (IWST) via MATLAB. Robust method was made using both an Iterative Weighted Similarity Transformation (IWST) and the Least Absolute Sum (LAS) method.

The commonly adopted methods for monitoring deformation by geodetic methods are based on the repeated observation of a survey monitoring network at difference epochs (Caspary, 1987), followed by two-step analysis (i.e. independent least squares estimation (LSE) or adjustment of single epoch, and deformation detection between epochs). The detection of deformation uses two-epoch analysis, an absolute monitoring network and a static model to compare the coordinate between the epochs (Setan, 1997).

Deformation analysis using the geodetic method mainly consists of these steps analysis (Setan and Singh, 2001):

1. pre-analysis
2. data acquisition
3. The network least squares adjustment
4. Trend analysis
5. Deformation analysis

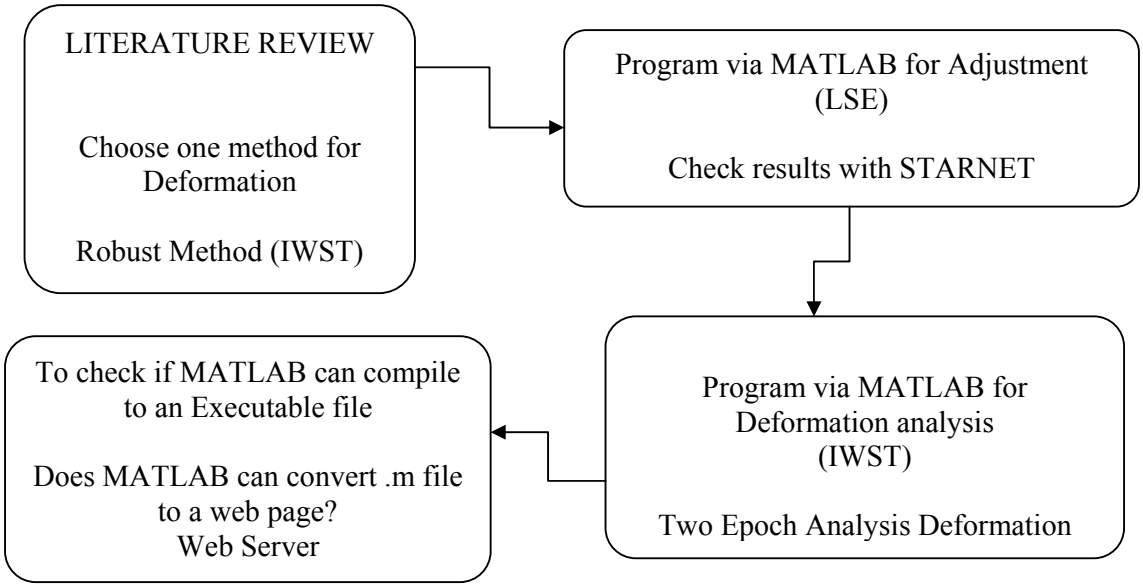

Figure 1.1 Flowchart of the research methodology

1. Literature review stage

The literature review is to explore the 2D network adjustment computation and deformation analysis methodology referring to Internet, books or journal paper.

2. Planning stage

The planning stage is where preparation is done prior to research implementation. This stage consists of selection for deformation detection methodology as well as adjustment computation, MATLAB programming practice and learning how to use compiler in MATLAB and to launch program in a web server by learning Java or .Net.

3. Implementation stage

This stage involves what is done in order to obtain the final output for deformation detection. The process is; Input data, processing via MATLAB and output file for deformation and adjustment and graphic display.

First input data (approximate coordinates and observation) can be read by MATLAB, and then programming for this network is performed. Finally results are saved in text file and graphics display in a plot.

4. Results and analysis stage

After implementation stage, the final results are produced from adjustment program and deformation program which analysis is made for further decisions and conclusion as well as future work.

5. Conclusion and recommendation stage

The final outcome of the entire process in this thesis is concluded, from which necessary recommendations are made based on the outcome.

1.7 Thesis Outline

The thesis is in six chapters as detailed below:

Chapter one: Introduce the research topic, the background of the study, problem statement, research objective, scope and methodology.

Chapter two: This chapter covers literature review which is to explore methodology for adjustment and deformation and software packages that can perform these analyses.

Chapter three: This chapter provides the methodology of this study. The steps include; data input, processing stage and output.

Chapter four: This chapter discusses implementations of this research. The steps include; how text file can be read by MATLAB, processing and iterations, M file to function and how to make an executable file by compiler and launch it to web server.

Chapter five: This chapter discusses the results and analysis of this study from which necessary conclusion and recommendation will be made.

Chapter six: In this chapter, conclusions and recommendation for future study are discussed.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES