ROAD CONDITIONAL MAPPING USING TERRESTRIAL LASER SCANNING METHOD

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This thesis is dedicated to Allah (SWA) for his infinite mercies and blessings upon me throughout the period of my study.

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ABSTRACT

Road transportation plays a vigorous part in the lives of people worldwide, because it bond people for commercial activities or pleasure by connecting small and large cities, urban and rural areas as well as connecting a country with its neighbour. To support the safe movement of people, goods and services, road and their features are carefully designed and constructed to increase road traffic safety, improve the efficient use of the overall network and reduce the harm such as death, injuries and property damage. Crack is the common surface distress of asphalt pavements it is necessary to detect the crack as early as possible to reduce maintenance cost. Terrestrial laser scanning is one of the most capable remote sensing techniques, which can be used to detect and analyse road distress at all levels The main objectives of this research were to acquire the road data using terrestrial laser scanning and close-range photogrammetry method, measure the width, length and area affected by the crack from point cloud data and also to verify the result using close-range photogrammetry and manual method. Ten lengths of the crack ware measured, ten width and area affected by the crack was also measured from point cloud data. The results obtained from point cloud data was verified using close-range photogrammetry and manual measurements. The results shows the potential of terrestrial laser scanning to detect, measure and analyse the road crack with root mean square error of the measured lengths between terrestrial laser scanning and close-range photogrammetry 0.015m and that of terrestrial laser scanning and manual method was 0.018m while the root mean square error of the measured widths between terrestrial laser scanning and close-range photogrammetry 0.001m and that of terrestrial laser scanning and manual method was 0.001m.

ABSTRAK

Pengangkutan jalan raya memainkan peranan yang penting dalam kehidupan manusia di seluruh dunia, kerana ia membantu manusia untuk aktiviti komersial atau berseronok dengan menghubungkan bandar-bandar kecil dan besar, kawasan bandar dan luar bandar serta menghubungkan negara dengan jirannya. Bagi menyokong pergerakan manusia, barangan dan perkhidmatan, jalanraya dan ciri-ciri jalanraya direka dengan teliti dan dibina untuk meningkatkan keselamatan, meningkatkan kecekapan penggunaan rangkaian secara keseluruhan dan mengurangkan bahaya seperti kematian, kecederaan dan kerosakan harta benda. Keretakan adalah masalah permukaan biasa dan turapan adalah perlu untuk mengesan keretakkan seawal mungkin untuk mengurangkan kos penyelenggaraan. Pengimbasan laser daratan adalah salah satu teknik penderiaan jauh paling mampu dan boleh digunakan untuk mengesan dan menganalisis kerosakan jalan raya di semua peringkat. Objektif utama kajian ini adalah untuk memperoleh data jalan menggunakan pengimbasan laser daratan dan kaedah fotogrametri jarak dekat dimana ukuran lebar, panjang dan kawasan terjejas akibat keretakan diperolehi daripada data titik awan dan mengesahkan keputusan pengukuran dengan menggunakan fotogrametri jarak dekat dan kaedah manual. Sepuluh panjang keretakan diukur, sepuluh lebar dan kawasan terjejas akibat keretakan juga diukur dari data titik awan. Keputusan yang diperolehi daripada data titik awan telah disahkan menggunakan fotogrametri jarak dekat dan ukuran manual. Keputusan menunjukkan potensi pengimbasan laser daratan untuk mengesan, mengukur dan menganalisis retak jalan raya dengan punca kuasa dua terdikit panjang diukur antara pengimbasan laser daratan dan jarak dekat fotogrametri ialah 0.015m dan unca kuasa dua terdikit pengimbasan laser daratan dan kaedah manual adalah 0.018m manakala punca unca kuasa dua terdikit dua lebar diukur antara pengimbasan laser daratan dan jarak dekat fotogrametri 0.001m dan pengimbasan laser daratan dan kaedah manual adalah 0.001m.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

3D	Three Dimensional
ALS	Airborne Laser Scanning
GIS	Geographic Information System
GPS	Global Positioning System
LiDAR	Light Detection and Ranging
TLS	Terrestrial Laser Scanner
OECD	Organization for Economic Co-operation and Development
MHA	Malaysian Highway Authority
STLS	Stationary Terrestrial Laser Scanning
MTLS	Mobile Terrestrial Laser Scanning
GNSS	Global Navigation Satellite Systems
EDM	Electronic Distance Measuring
DEM	Digital Elevation Model
UV	Ultra-Violent

APIP	Automated Pavement Imaging Program
BPNN	Back Propagation Neural Network
UAV	Unmanned Aviation Vehicle
MLS	Mobile Laser Scanner
GVF	Gradient Vector Flow
GRF	Geo Reference Feature
RMSE	Root Mean Square Error
RMSD	Root Mean Square Deviation

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Road transportation is an important part of human lives across the world. It connects people and links cities for commercial activities and pleasure. Urban and rural areas are also connects to a neighbouring countries through roads. To support the migration of people, industrial products and services, road and other transportation medias are designs and constructs carefully to enhance safe road transportation, and improve the quality of the whole network and reduce the harm such as death, injuries and property damage (Guan et al. 2015) accurate information about the road condition is a key issue for the overall management of transportation infrastructure. The public road networks are corrupting in many places, as necessary investments are postponed or withdrawn. In order to organise available means in a most serviceable way, the evaluation and geo-referenced mapping of the road quality is an essential prerequisite for maintenance management (Miraliakbari et al. 2014).

Three-dimensional data on roads quality records are usually obtained by means of traditional land survey methods. Generally dual categories of information are documented (constructions and road symbols) and situation of road. The field survey techniques make use of GPS and total stations to document the position of numerous properties. GPS can be used to record road equipment like lamp posts, sign boards etc. Although manual survey techniques are very precise in two-dimensional

space, it is tough to acquire the third dimension. These approaches are time consuming and huge as well (Sairam et al. 2016).

It is known that a good road infrastructure of a country is a pre-requisite to the development of a nation (Sufiyan and ir zulakmal, 2009) road surface crack discovery plays significant part in gauging the road condition and deliver the necessary road maintenance. Crack is the common surface distress of asphalt pavements it is necessary to detect the crack as early as possible to reduce maintenance cost (Li et al. 2014) roads are significant artificial infrastructure that show distress because of their continuous usage, therefore it's necessary to maintain them to confirm accurate pavement performance (Henrique, 2009) roads especially bitumen road are important as major transportation and communication ways in recent civilizations. Because of weather condition and loads from vehicles road surface frequently experience distress from time to time (Patrick et al. 2012).

Currently, laser scanning has become a supplementary technique for geodetic applications. The use of laser scanners is constantly growing. There are different laser scanners available from different companies (Schulz et al. 2004) the arrival of a high accuracy terrestrial laser scanner means that the inspector/surveyor can be in a safer location, away from high speed traffic and obtain huge amounts of detailed data rapidly and cost efficiently (Garry, 2007).

1.2 Problem statement

Base on literature review as mentioned earlier in the introduction certain problems need to be addressed.

Road has become a vital facility which required time and man labours for maintaining and surveying. Road information is needed frequently to be restructured and measured for effective maintenance issue such as cracking (Yu, 2005) road

safety problem has been increasing from time to time; due to this reason transportation problem became a research motivation (Danli, 2013) road administrators need additional information about the road network and it's surrounding for several reasons such as urban planning, road network management etc. (Darko et al. 2014).

Ordinarily pavement condition data were collected by human inspectors who travel along the road to measure the distress and come out with a report. This method is time consuming, costly and is not safe (Sufiyan and ir zulakmal, 2009) rehabilitation and road conservations is not only time-consuming, but it also creates traffic instabilities and is also very costly, these have made visual inspection less capable (Patrick et al. 2012) Figure 1.1 shows an example of road crack.

Engineers use visual inspection or other traditional land survey method to measure distress and come out with report, this method is time consuming and is not safe for the surveyor also the result are more general. With TLS thousands of point clouds can be obtain within short period of time and many parameters needed for monitoring the road distress can be obtain from point cloud data, this method is more safer and less time consuming than the older methods.

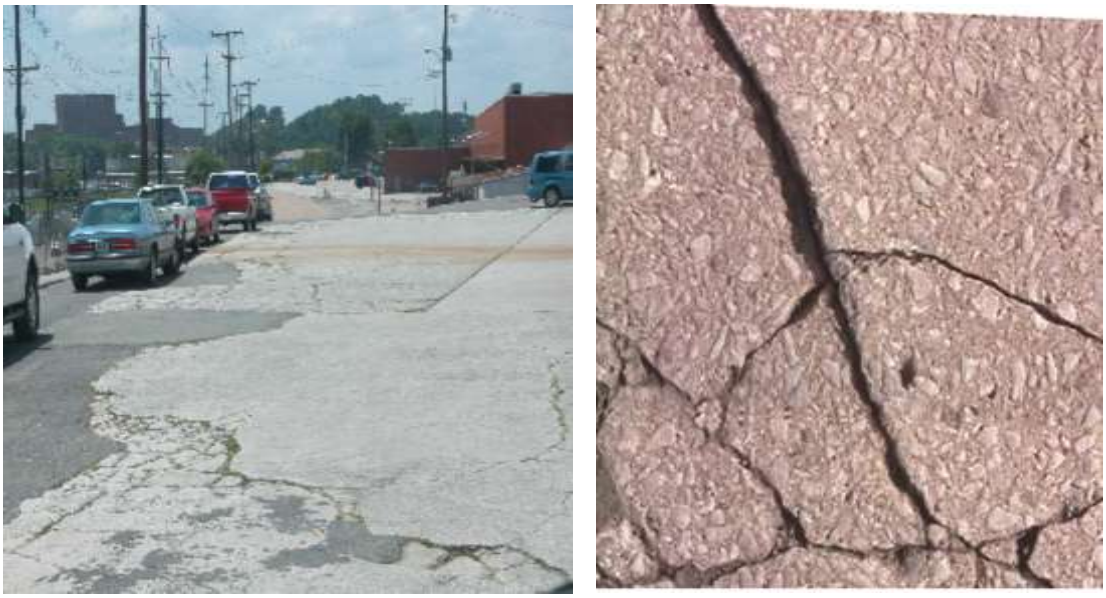

Figure 1.1. Image showing road cracking (Yu et al, 2005).

1.3 Aim of Study

The aim of this study is to investigate the crack measurement performance of TLS to detect, to measure and analyse road crack from point cloud data.

1.4 Objectives of Study

To achieve the aim and purposes of this study, the following objectives have been established:-

i. To acquire the road crack data using TLS and close-range photogrammetry method.

ii. To measure the width, length and area affected by the crack from point cloud data.

iii. To verify the result using close range photogrammetry and manual methods

1.5 Research Question

The following research questions are addressed and have been answered in order to fulfil the research objectives.

Table 1.1: Research Objectives and Research Question

	Research Objectives	**Related Research Question**
1	To acquire the road crack data using TLS and close-range photogrammetry methods.	• What is terrestrial laser scanning (TLS)? • How to acquire the road crack data? • Why terrestrials laser Scanning
2	To measure the width, length and area affected by crack from point cloud data.	• What is road crack? • How to measure the length, width and area of the crack? • What is point cloud?
3	To verify the result using close-range photogrammetry and manual methods.	• What is photogrammetry? • How photogrammetry works? • How to compare the results?

1.6 Scope of Research

The scope of this research is as stated below.

- This research only focused on the alligator crack.
- Data of the crack was collected using TLS Leica Scan Station C10.
- The verification of the result was done using close range photogrammetry and manual methods.

- Cyclone and photoModeler Pro5 software were used to process the data.

1.7 Study Area

This research was carried out at University Teknology Malaysia Skudai Johor Bahru. Figures 1.2 and 1.3 shows the map of University Teknology Malaysia and image of the study area.

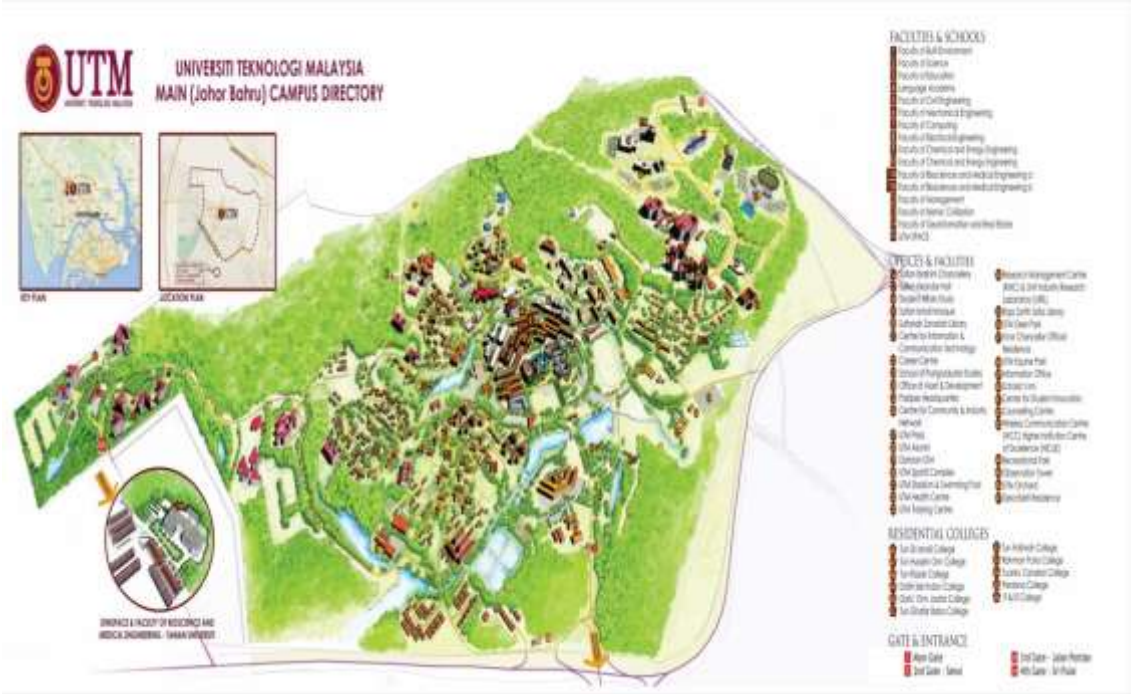

Fig 1.2 Map of University of Teknology Malaysia Skudai Johor Bahru.(Google map, 2016).

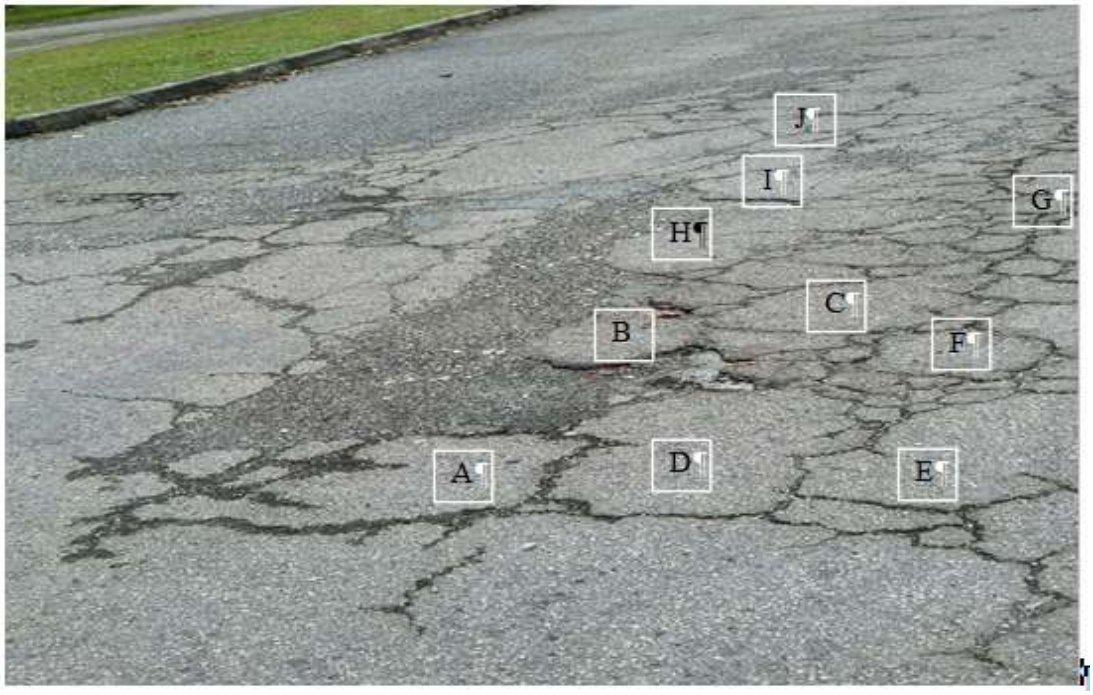

Figure 1.3. Study Area.

1.8 Significant of the Study

The purpose of this study is to detect any trouble (such as road surface crack) at the initial stage so that maintenance can be performed on the right time before the renovation charges become too expensive.

The current road conditional mapping will help management to have additional information about the road condition and it's surrounding for better management.

1.9 Thesis Content

This thesis comprised of five main chapters which are organized as follows:-

Introduction, Literature review, Methodology, Result and analysis, conclusion and recommendation.

Chapter 1 Introduction:- this chapter provides a brief explanation on the overview of the whole research, which includes background of the study, problem statement, aim and objectives, scope of the study , study area and also the significance of the study.

Chapter 2 Literature Review:- this chapter provide literature review on all the suitable information about road condition mapping, terrestrial laser scanning (TLS) , photogrammetry and other related data that was gained from previous studies on paper, book, and internet were discussed in this chapter.

Chapter 3 Methodology: - this chapter explain the methodology and overall work flow of this study. Starting with planning and preliminary study, data acquisition, data processing, and measurement which, were used to map the road crack.

. Chapter 4 Result and Analysis:-this chapter **provides** the results obtained from the point cloud data, photogrammetry and manual and discussions that was carried out in this study.

Chapter 5 Conclusions and Recommendations:- the last but not the least is the summary of the whole study and recommendation for further studies.

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