# Three Dimensional Modelling Using Terrestrial Laser Scanner Data, with Applications on Water Structures


Prepared by

**Eng. Huda Abd El.fattah Abd El.salam Amer**

Assistant researcher at National Water Research Center

Faculty of Engineering, Ain Shams University


In partial fulfillment of the Requirements for the Degree of

**Doctor OF Philosophy**

In

**PUBLIC WORKS**

Under the Supervision of


**Prof. Dr.Ibrahim Fathy Shaker**

Professor of Surveying and Photogrammetry

Public works Department- Faculty of engineering

Ain Shams University, Cairo, EGYPT

**Prof. Dr. Ayman Fouad Ragab**

Professor of Surveying and Photogrammetry

Public Work Department-Faculty of Engineering

Ain Shams University, Cairo, EGYPT

**Prof. Dr.Ahmed Khedr Abel-Gawad**

Professor of Civil Engineering

Civil Engineering Department - Engineering Research Division

National Research Centre, Cairo, EGYPT

**Dr. Yasser Mostafa Megahd**

Associate Professor of Surveying and Geodesy

Public Work Department-Faculty of Engineering

Ain Shams University, Cairo, EGYPT



CAIRO – EGYPT

2020


# Three Dimensional Modelling Using Terrestrial Laser Scanner Data, with Applications on Water Structures

A Thesis
Submitted to Faculty of Engineering
Ain Shams University in Fulfillment of the Requirement for Ph.D. Degree in Civil Engineering
(Surveying)

**Prepared by**

**Eng. Huda Abd El.fattah Abd El.salam Amer**

M.Sc. in Civil Engineering, May 2010
Faculty of Engineering, Cairo University

## THESIS APPROVAL

| EXAMINERS COMMITTEE | SIGNATURE |
|---|---|
| **Prof. Dr. Saad Mohamed Bolbol**<br>Professor of Surveying and Geodesy<br>Faculty of Engineering-Shoubra-Benha University | . . . . . |
| **Prof.Dr. Maarouf Ahmed Diefallah**<br>Professor of Surveying and Photogrammetry<br>Faculty of engineering- Ain Shams University | . . . . . |
| **Prof. Dr. Ibrahim Fathy Shaker**<br>Professor of Surveying and Photogrammetry<br>Faculty of engineering- Ain Shams University | . . . . . |

**Date:** …../……/ 2020

# DEDICATION

*To the one who may be absent in body, but present in all our spirits. To the one who gifted me knowledge and integrity. To the one whose legacy is an overflow of virtuous deeds, to my root and stem,* ***my father****; may god rest his soul in piece.*

*To* ***my beloved mother****, the river of warmth and care, the cradle of life, the start, and end point of our lives, to the one who gifted me love, life, hope.*

*To* ***my dear sisters****, Hagar and Sarah*

*To* ***my dear brothers****, Wael, Mohamed, Hesham, and Sameh*

*To* ***my angels****, Ahmed, Hala, Malik, and Layla*

*I present you this simple, humble work.*

Ain Shams University - Faculty of Engineering

Public Works department

# Researcher data

| | |
|---|---|
| **Name:** | Huda Abd El.fattah Abd El.salam Amer |
| **Date of Birth:** | 30/11/1979 |
| **Place of Birth:** | United Kingdom |
| **Academic Degree:** | M.Sc. in Civil Engineering |
| **Field of Specialization:** | Public works department – (Surveying) |
| **University Issued the Degree:** | Cairo University |
| **Date Issued the Degree:** | May, 2010 |
| **Current Job:** | Assistant Researcher at National Water Research Center |

**Date:** …../……/ 2020

# Statement

The dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Civil Engineering.

The work included in this thesis was carried out by the author in the Department of Public Works Ain Shams University from June 2012 to April 2020.

No part of this thesis has been submitted for a degree or a qualification of any other University Institution.

**Date:** / /2020

**Name:** Huda Abd El.fattah Abd El.salam Amer

**Signature:**

# Abstract

At the last decade, the terrestrial laser scanning technique became a suitable alternative to create a 3D model for any object instead of the (image-based technique). This suitability is related to different factors; simplicity, high progress of data acquisition, and direct recovering of interest points on the object without more measurements or processing. Although the TLS is recommended as a highly accurate instrument which is adequate for various applications, maintaining high accuracy of acquired huge data in the presence of some errors (instrumental, object-related, environmental, methodological, and scanning geometry) is a major challenge.

Therefore, the **main objective** of this research work is the investigation of the sources which could be controlled, these sources are;

- Scanning geometry which is the orientation (angle and range) of the object related to the scanner.
- Methodological errors which includes; the chosen registration or geo-referencing techniques, survey method, used soft wares and user experience.

The applied **work methodology** was depending on; the accuracy assessments of the output product whether they are point clouds or models to fulfil the required objective. In this context; two experiments (Outdoor and Indoor) were implemented using two designed calibrated targets to evaluate the geometric accuracy of the distances on the scanned targets under different geometric conditions. On the other side, the registration and geo-

referencing techniques, surveying planning, choices of the suitable programs and the user experience was investigated through two different 3D modelling applications (small statue and large water structure).

The **concluded results** show that; the orientation of the object is not affecting the accuracy of the output point clouds measurements with in 7m range. All the RMSE are ranging from 0.8mm to 2mm with orientation angles from 0˚ to 50 ˚. For the long distances, the results were different. The scanning accuracy is directly decreased with the increase of used orientation angle; the RMSE value was nearly 10mm. Through the implementation of two different applications, different techniques of registration and geo-referencing were applied and various programs were used. For both applications, the Trimple Realworks adopted better result than the Scene software from the point of view of accuracy, simplicity, and organization. The Geomagic software was preferable than the Trimple Realworks based on the specialized modelling capabilities for the modelling of Three-dimensional irregular objects (small statue). The Trimple Realworks is suitable for the modelling of the systematic engineering applications (barrage). The accuracy assessment of the created 3D model of the Indoor application (small statue) obtained a result of (1.2 mm) total RMSE. On the other side, the accuracy assessment of the created 3D model of the Barrage obtained a result of 10.94mm total RMSE.

---

Keywords: TLS - Scanning geometry - Methodological sources - RMSE

# Acknowledgements

Foremost, all praise goes to the almighty **Allah**, the sustainer who has been showering His endless blessings on me throughout my life.

First of all, I would like to express my sincere thanks and special gratitude to **Prof. Dr Ibrahim F.M.Shaker** for his supervision, continuous encouragement, and valuable advice during all stages of this research; for the many hours of his valuable time which he spent on aiding me.

I also wish to express my deepest appreciation and grateful thanks to **Prof. Dr Ayman Fouad Ragab** for his kind supervision and careful guidance, and his unlimited help and support throughout the whole study period.

My deepest and unlimited gratitude to my supervisor **Prof. Dr Ahmed Khedr Abel-Gawad** for his continuous encouragement and immediate solutions to any of the complicated problems related to this research . As well as providing his valuable time spent in revising the manuscript of this thesis.

My special thanks are also extended to **Dr Yasser M. Megahd** for his continuous help, assistance, encouragement, and advice throughout my studies.

Furthermore, Advice given by **Prof Dr. Shaban Abou-Hussein**, National Research Centre, has been a great help in the preparation and publication of the research papers.

The technical information of the used Instrument and programs provided by **Eng. Ahmed H. Ibrahim** the senior sales engineer at Zamil Steel & Owner of CSS contracting was greatly appreciated.

I am particularly grateful for the technical writing assistance and technical problems solving given by **Eng.Hesham A. Amer** the senior civil engineer at Khatib & Alami.

I would like to offer my special thanks to **Mr Ahmed Elwahsh** for his valuable assistance in the lingual aspect of the research.

I am greatly indebted to **Eng. A. Abdelmaabod and Eng.Moaman** , Demonstrators at Faculty of Engineering, Ain Shams University for their appreciated help and support during the research period.

# Table of Contents