



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

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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.



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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.

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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 Trimble 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 Trimble Realworks based on the specialized modelling capabilities for the modelling of Three-dimensional irregular objects (small statue). The Trimble 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

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