

Assoc. Prof. Ph.D Eng. Valeria-Ersilia ONIGA

HABILITATION THESIS

**RESEARCH REGARDING THE CREATION AND
ACCURACY ASSESSEMENT OF 3D MODELS
OBTAINED BY USING DIGITAL IMAGES, TLS
AND ALS POINT CLOUDS**

**CERCETĂRI ASUPRA CREĂRII ȘI EVALUĂRII
PRECIZIEI MODELELOR 3D OBȚINUTE PE
BAZA IMAGINILOR DIGITALE ȘI A NORILOR
DE PUNCTE LST ȘI LSA
-REZUMAT-**

DOMAIN: GEODETIC ENGINEERING

SPECIALIZATION: TERRESTRIAL MEASUREMENTS AND CADASTRE

BUCUREȘTI, 2021

Abstract

The habilitation thesis entitled *“Research regarding the creation and accuracy assesement of 3D models obtained by using digital images, TLS and ALS point clouds”* presents the most relevant results obtained through research, after obtaining the Ph.D in the field of “Civil Engineering”, by order of the Minister of Education, Research and Innovation no. 5581, from 3.12.2013. The post-doctoral research activity is based on the main topic approached in the Ph.D thesis, namely 3D modeling of urban area by photogrammetric and remote sensing methods. Thus, after defending the Ph.D thesis entitled *“Comparative study on methods for 3D modeling of urban area”*, under the coordination of Prof. Ph.D. Eng. Dumitru Onose, research continued on the calibration of digital cameras, as well as on creation and accuracy assesement of 3D buildings models by using digital images, or terrestrial and airborne laser scanner point clouds.

The research activity, carried out within research projects with national and international teams, can be summarized in four main directions:

- theoretical and experimental research on the creation and accuracy improvement of 3D models obtained based on UAS (Unmanned Aerial System) images;
- theoretical and experimental research on the creation and accuracy improvement of 3D models obtained by terrestrial photogrammetry;
- theoretical and experimental research regarding the terrestrial laser scanning technology;
- theoretical and experimental research regarding the airborne laser scanning technology.

The thesis is in the field of Geodetic Engineering and is structured in three sections, as follows:

- scientific, professional and academic achivements;
- contributions made so far in the field of photogrammetry and remote sensing;
- proposals for the future academic, scientific and professional career development.

The first chapter, entitled *“Theoretical and experimental research on the creation and accuracy improvement of 3D models obtained based on UAS (Unmanned Aerial System) images”*, presents the original results obtained in the field of UAS photogrammetry, being structured in three subchapters. Among the original contributions made in this field on international plan, the following can be listed:

- the creation of a 3D calibration field for UAS systems, representing the first national calibration field and the largest international calibration field;
- testing in UAS projects, for the first time nationally and internationally, the parameters obtained by calibration based on the calibration field, using nadiral images and also oblique images, with a very large number of control points (i.e. 100).

For the patenting of the calibration field, there is a patent application entitled “INNOVATIVE CALIBRATION AND TESTING FIELD FOR THE DIGITAL CAMERAS MOUNTED ON UAS (UNMANNED AERIAL SYSTEM)” from 18/10/2017 with no. A / 00834;

- the use of GNSS technology combined with classical geodetic measurements to create a local three-dimensional network, necessary in short-range photogrammetric applications, being the only approach of this type at national and international level. The results obtained for the 3D calibration field certify the applicability of the method in similar situations and provide a rigorous algorithm for determining the spatial position of the detail points with high precision;

- determining the optimum number of Ground Control Points (GCPs) for georeferencing UAS images, representing the only national and international approach carried out on an urban area, containing artificial elements, such as a uniformly textured building covering approximately 15% of the study area and a parking lot;
- conducting an extensive study on the accuracy assesment of a building 3D model with a complex shape, created based on UAS images, being tested the most used commercial and open-source software internationally.

At national level, a book has been published which presents the flight planning mode for an Unmanned Aerial System (UAS) and the processing steps of the UAS image block obtained after the flight, using the “Pix4D Mapper” software, being the only manual of this type in Romania.

The second chapter entitled *“Theoretical and experimental research on the creation and accuracy improvement of 3D models obtained by terrestrial photogrammetry”*, presents the original results obtained in the field of terrestrial photogrammetry, being structured in three subchapters. The main achievements obtained in each subchapter are the following:

- study on the accuracy assesment of the most used methods for digital cameras calibration on international plan, using different types of 3D and 2D calibration targets;
- proposing a new method for 3D model creation of an object, using convergent digital images, taken simultaneously with two digital cameras with the same characteristics, mounted on a tripod. The accuracy of the proposed method satisfies the precision requirements imposed by such projects, namely 1 cm, being determined by comparing the 3D model obtained by the proposed method with the mesh surface, created based on the terrestrial laser scanner point cloud (TLS);

Another direction of the research activity included in the third chapter, was directed towards the *terrestrial laser scanning technology*, being continued the studies within the Ph.D thesis, in which the accuracy of buildings 3D models creation based on TLS point clouds was tested and a new method of buildings 3D models texturing has been proposed.

At the national level, a book of practical works was published, in which were described in detail, with calculation examples, methods and algorithms for point clouds registration, representing the only material of this type in Romania. Through, two workshops organized at the Faculty of “Hydrotechnical Engineering, Geodesy and Environmental Engineering” in Iasi, in 2017 and 2019, respectively, I trained a number of 50 people for the use of the Maptek I-Site 8820 terrestrial laser scanner and for processing cloud points resulting from the scanning process.

The fourth chapter entitled *“Theoretical and experimental research on airborne laser scanning technology”* is structured in three subchapters and presents a series of analyzes using point clouds resulting from airborne laser scanning, both on urban and natural environments.

On international plan, a series of scientific articles have been published presenting personal approaches for filtering, segmentation and point clouds classification for obtaining Digital Terrain Models (DTM) based on Airborne Laser Scanner (ALS) data. Nationwide, a chapter on laser scanner point cloud classification and filtering has been included in the book *“Advanced Photogrammetry”*. Also, for the proposed method of obtaining DTM based on Airborne Laser Scanner (LSA) data, there is a **patent application** entitled ***“Innovative method for filtering, segmenting and classifying point clouds for the derivation of digital terrain models (DTM) based on Airborne Laser Scanner (ALS) data”*** from 21/07/2017 with no. A / 00501.

In the final part of the thesis the plan for the development of academic, scientific and professional career is presented.

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Associate Professor Valeria-Ersilia ONIGA

