

K.N. Toosi University of Technology

Faculty of Geodesy and Geomatics Engineering

Department of Photogrammetry and Remote Sensing

**Doctor of Philosophy (Ph.D) Thesis**

Automatic Registration of Aerial and Terrestrial Point Clouds from Different Sources and Views in Urban Areas

Supervisor

**Prof. Mohammad Javad Valadan Zoej**

Advisor

**Dr. Mehdi Mokhtarzade**

By

**Amin Baghani**

September 2018

**Abstract**

The simultaneous use of point cloud data from the various sources and views as complementary datasets have a high synergy in extracting reliable spatial information. Merging and registering these datasets is a prerequisite for simultaneous use of them. Laser-based and image-based methods are two major sources, and terrestrial and aerial platforms are also two major views for generating of the point clouds. Using airborne platforms in urban environment, top faces are seen abundantly, but still on side faces are lacking. Terrestrial platforms give complete and dense information from side faces. Although the density on side faces is proper, these platforms do not give significant information from top faces (e.g., roofs). The registration aims to yield a complete and dense coverage on both top and side faces in urban areas. The main challenges, however, arise from their heterogeneous views. Most of these challenges include the automatic detection of the common primitives in these datasets. In this thesis, two major approaches have been developed for the automatic registering of the aerial and terrestrial point clouds generated by various methods.

Locating of the local terrestrial scans in global aerial point cloud is the first approach developed in this thesis. In addition to the heterogeneity of aerial and terrestrial views, each of the small-scale terrestrial point clouds is hardly comparable with the overhead and large-scale aerial point cloud. For this purpose, a hierarchical method is proposed. Detecting candidate positions for occupying the virtual scanner in aerial point cloud, structuring the visible points to each of these positions in the form of candidate aerial point clouds, converting the locating problem to a matching between the terrestrial and candidate aerial point clouds, and finally, solving this matching in the form of a classification based on similar characteristics in two aerial and terrestrial views, forms the main steps of the first proposed method. The implementation of the proposed method on several urban datasets, showed a precision of about 5 meters for locating the terrestrial scans in the aerial point cloud, which seems sufficient to enter the registering process.

After the locating the terrestrial point clouds in the aerial point cloud, in the second approach of this thesis, the exact registering of them have been investigated. The proposed method begins by an innovative terrestrial point cloud-sufficient method to solve two rotations of terrestrial point cloud around x- and y-axis. After that, in horizontal registration phase, 2D façade lines were extracted from both datasets; and accordingly a novel polar parameterized mathematical model was extended for simultaneous robust matching and parameter estimation. Finally, vertical registration was done through calculating the dominant vertical shift between the points of the ground planes extracted from both datasets. The evaluation results in two different modes, which were conducted on two different urban datasets, showed the efficiency of the proposed method (RMSE error of 0.21 m/0.12 m in horizontal/vertical direction).