3D SEMANTIC LABELLING OF URBAN LIDAR POINT CLOUD AND MULTISPECTRAL DATA

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by

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ABSTRACT

LiDAR (Light Detection And Ranging) is one of the most unprecedented geospatial technologies introduced in the last decade for direct and accurate measurement of elevation of a point on the earth surface. The geocoded LiDAR data enable extraction of various 3D urban objects true to geometrical measurements which can be directly used for creating 3D models. However, due to the unstructured nature of the data and its high volume, localizing and extracting various urban objects in 3D perspective from the LiDAR data, generally known as point cloud, remains a challenge. Semantic labelling establishes geometrical-structural relationship in the point cloud and is very critical for exploiting the rich point cloud for various applications such as infrastructure mapping, disaster management, virtual reality, utility management.

The overall aim of this thesis is to develop an efficient and reliable algorithmic framework for semantically labelling 3D coloured LiDAR point cloud (point cloud with spectral data integrated) acquired over an urban environment using computer vision techniques in an open source prototype system.

Within this overall aim, the objective of this thesis is two fold. The first objective is to develop a novel 3D object-based framework for semantically labelling the 3D coloured LiDAR point cloud obtained by integrating LiDAR point cloud and multispectral imagery. Segmentation is an important stage in object-based labelling framework. In this thesis, initially color-based region growing segmentation algorithm has been used to create 3D segments. Further, to improve the efficiency of the algorithm while processing highly dense point cloud, a computationally efficient supervoxels-based LCCP (Local Cloud Connectivity Patches) segmentation approach has been adapted and extended for creating meaningful segments from the point cloud. The segments are classified using various machine learning techniques into multiple urban classes based on the spectral and geometric features extracted from the segments.

The methodological framework developed has been implemented on different airborne Li-

DAR and multispectral images captured at multiple sites assessing the generalization capability of the methodological framework developed. The validity and the accuracy of the labelled point cloud has been independently validated against the ground truth by International Society of Photogrammetry and Remote Sensing (ISPRS). Results appear promising and the labelled 3D points can be directly used for 3D surface reconstruction of various man-made and natural urban objects.

The second objective is to critically assess the role of spectral and geometrical information in the various stages of object-based point cloud labelling, namely, segmentation, feature extraction, and classification. Results indicate that both the spectral, and geometrical information is critical for semantic labelling of low point density LiDAR point cloud (point density < 5 points/m^2), whereas the geometrical information alone is sufficient for LiDAR point cloud with higher point density. It is also evident that the supervoxels-based LCCP segmentation is computationally efficient and offer superior labelling accuracy while processing high point density LiDAR point cloud.

The methodological studies carried out in this thesis make a significant contribution to the current suite of approaches used for 3D semantic labelling of LiDAR point cloud. As the methodologies presented in this work is an object-based approach with further flexibility of its implementation on an open source platform, it has promising application in labelling high density point cloud. The labelled point cloud will be an asset to the data users and decision makers who can easily segregate and visualize objects of interest and for further reconstruction of measurable 3D models.