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LiDAR point classification based on sparse representation

Nan Li (1,2), Norbert Pfeifer (1), and Chun Liu (2)

(1) Vienna University of Technology, Department of Geodesy and Geoinformation, Wien, Austria (linan89123@hotmail.com), (2) Tongji University,College of Survey and Geoinformation, Shanghai, China

In order to combine the initial spatial structure and features of LiDAR data for accurate classification. The LiDAR data is represented as a 4-order tensor. Sparse representation for classification(SRC) method is used for LiDAR tensor classification. It turns out SRC need only a few of training samples from each class, meanwhile can achieve good classification result.

Multiple features are extracted from raw LiDAR points to generate a high-dimensional vector at each point. Then the LiDAR tensor is built by the spatial distribution and feature vectors of the point neighborhood. The entries of LiDAR tensor are accessed via four indexes. Each index is called mode: three spatial modes in direction X ,Y ,Z and one feature mode.

Sparse representation for classification(SRC) method is proposed in this paper. The sparsity algorithm is to find the best represent the test sample by sparse linear combination of training samples from a dictionary. To explore the sparsity of LiDAR tensor, the tucker decomposition is used. It decomposes a tensor into a core tensor multiplied by a matrix along each mode. Those matrices could be considered as the principal components in each mode. The entries of core tensor show the level of interaction between the different components. Therefore, the LiDAR tensor can be approximately represented by a sparse tensor multiplied by a matrix selected from a dictionary along each mode. The matrices decomposed from training samples are arranged as initial elements in the dictionary. By dictionary learning, a reconstructive and discriminative structure dictionary along each mode is built. The overall structure dictionary composes of class-specified sub-dictionaries. Then the sparse core tensor is calculated by tensor OMP(Orthogonal Matching Pursuit) method based on dictionaries along each mode. It is expected that original tensor should be well recovered by sub-dictionary associated with relevant class, while entries in the sparse tensor associated with other classed should be nearly zero. Therefore, SRC use the reconstruction error associated with each class to do data classification.

A section of airborne LiDAR points of Vienna city is used and classified into 6classes: ground, roofs, vegetation, covered ground, walls and other points. Only 6 training samples from each class are taken. For the final classification result, ground and covered ground are merged into one same class(ground). The classification accuracy for ground is 94.60%, roof is 95.47%, vegetation is 85.55%, wall is 76.17%, other object is 20.39%.