High-Dimensional Object Feature Spaces for Spatio-Spectral Classification

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For urban remote sensing applications, the spectral classification of multispectral satellite imagery is quite limited due to small object sizes, complex illumination conditions and the wide range of urban surface materials. Spectral classification assumes image pixels to be independent and identically distributed which is in fact not the case. This suggests the use of spatial descriptors. Segmentation provides means to extract spatial descriptors, namely object features, which can be concatenated at pixel level to the spectral signature vector. It is shown in this presentation that the pixel and the object domain can be effectively combined for spatio-spectral classification. Moreover, it is suggested that instead of preselecting object features (and necessarily segmentation parameters to create the objects) a large set of uninspected object features from iteratively increased segmentation scales can be used in order to reduce efforts for manual feature selection and segmentation parameterization. It is argued that the feature (and scale) selection process can be handed over to a machine learner because – for complex classification problems – the relationship between segmentation parameters, object size/shape, object goodness and finally feature goodness is not trivial. Moreover, for the human analyst the interaction of features (correlation or dependency) is hard to grasp and pattern in potentially high-dimensional feature spaces remain ‘hidden’.

As an application, several meter to submeter satellite images (WorldView-2) of urban areas are classified to extract basic land cover classes or specific target objects. The random forest learning technique is applied and compared to other classifiers, such as support vector machines, simple (CART-like) decision trees and nearest neighbor algorithms.

The findings and statements of this work are: random forests can deal with high-dimensional, uninspected feature spaces which also contain correlated or unpredictive features. For machine learning applications, accessing object features on pixel level entails advantages as the sampling/processing units are of uniform size and – even more important – do not depend on the segmentation quality. Furthermore, it is shown that the random forest prediction accuracy is highest when complementing pixel (spectral signature) and object features.