Experimental research on urban road extraction from high-resolution RS images using Probabilistic Topic Models

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ABSTRACT

Satellite sensors such as IKONOS, Quickbird and GeoEye can provide us an important data source for urban remote sensing application, for example urban road extraction [1-2] Although there exists a amount of literature about road extraction, most of them focus on rural or forest areas in low and medium resolution images [3]. Therefore, most of them can not be directly used to extract urban road in high-resolution RS images [4]. In this paper, we explored a new algorithm using Probabilistic Topic model to extract road network from high resolution images.

As language models, Probabilistic Topic Models are proposed to analyze the content of documents and the meaning of words[5], for example Probabilistic Latent Semantic Analysis (PLSA) [6] and Latent Driblet Allocation [7]. These probabilistic topic models have been widely used to solve computer vision problem, such as image annotation, object detection, scene classification and so on [9]. In these applications, Probabilistic Topic Model usually clustered low-level visual words (which might be image patches, spatial and temporal interest points or moving pixels) into topics with semantic meanings (which corresponded to objects, parts of objects, human actions or atomic activities) utilizing their co-occurrence information[10] . Probabilistic topic models can describe the neighborhood information in different ways [8] and they could be useful for the road extraction in high resolution images. At the same time, instead of knowing pictures as documents, *a priori*, in solve vision problems using, it is critical to properly design "words" and "documents" when PLSA

and other probabilistic topic models are applied to remote-sensing image processing[11, 12] . In this paper, pixels or a set of pixels are regarded as visual words, and a whole high resolution image is a set of documents. The topics are latent variables and all the words would be clustered into topics. At the same time, different probabilistic topic models consider that a document is a mixture of topics, but they also have slightly different statistical assumptions. If the statistical assumption is complex, parameters are difficult to be estimated. Therefore, it is important to select or design a suitable probabilistic graph model in different applications. By analyzing different models in high resolution remote sensing image processing, one model which can describe the neighborhood information in image documents will be selected. Some documents whose topics contain the topic of road are selected as training data, and all documents will be clustered into different classes and road segments with high accuracy are extracted. The road network will be formed when all road segments are linked together through some algorithm.

The proposed approach is a semi-automated road extraction algorithm. At the very beginning, the high-resolution image is divided into a group of small images and the documents can be overlapped or follow some neighborhood regions generating ways in the software Feature Analyst. Each image patch acts as a document and pixels inside the patch are visual words. Each patch is modeled by using their spectral, textural content and other image features. Then, PLSA, LDA and SLDA models are compared and one best model would be selected to extract road segments. Based on the selected model, we will form a training documents dataset which will express the characteristic differences between road and other land cover. By defining the priori probabilities of sample visual words and documents and learning from samples data, the object-conditional probability distributions can be derived. By comparing every documents formed in the first step, we can get the basic road segments extraction results. If the extraction results are not so well, the result will be added to training dataset and this kind of feedback will improve the results. The feed back will be continued until the extraction result is satisfied. When road segments are extracted, one kind of inspired road linking algorithm will form a final road network. According to preliminary experiments, the road network result of the novel algorithm with Probabilistic Topic Model is not worse than semi-automatic road extraction algorithm in urban area.

In this paper, IKONOS images are used in our experiment. By analyzing the primary experimental results, the road segments and other background targets can be separated clearly using

the proposed algorithm and the proceeding time is limited. There might be some improved researches in the generating methods of image documents for the proposed algorithm. At the same time, the road segments linking algorithm also could be improved.

Keywords: High Resolution Image; Road Extraction; Aspect Model; Probabilistic Topic Model.

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