CLASSIFICATION BASED MARKER SELECTION FOR WATERSHED TRANSFORM OF HYPERSPECTRAL IMAGES

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1. INTRODUCTION

Hyperspectral imaging technology, which acquires hundreds of spectral channels, opens new perspectives in classification of remote sensing images. An extensive literature is available on the classification of hyperspectral images, among them pixel-wise processing techniques that work on the spectral information only (one of the most frequently used techniques are Support Vector Machines (SVM) [1]) and spectral-spatial classification techniques that take into consideration both the spectra of the pixels and their spatial context [2].

In previous works, we have proposed to define spatial structures in a hyperspectral image by performing segmentation and considering every region from a segmentation map as an adaptive homogeneous neighborhood for all pixels within this region [3, 4]. In particular, watershed transformation was applied on the gradient image for segmentation [5, 3]. Typically, the result of watershed transform without any pre-processing of a gradient image is a severe oversegmentation (every local *minimum* leads to one region). One of the ways to cope with this problem consists in performing a marker-controlled watershed segmentation [5]. This approach determines markers for each region of interest (each object in the image) and transforms the gradient image in such a way that the local *minima* of the resulting image are only the region markers.

In this paper, we propose to **determine markers for a watershed** on a hyperspectral image by using results of a pixel-wise classification. Thus, a **new segmentation and classification scheme** for hyperspectral data is proposed. The objectives of the proposed method are:

1. To decrease the oversegmentation and thus improve the segmentation results by performing a classification based marker selection.
2. Each marker defined from a pixel-wise classification map is associated with a class label. Therefore, the corresponding class can be assigned to every region in the segmentation map. Consequently, the proposed scheme results in a classification map, obtained by the integration of spatial and spectral information into a classifier.

2. MARKER-CONTROLLED WATERSHED SEGMENTATION AND CLASSIFICATION SCHEME

The proposed method is composed of the following steps (see Figure 1):

1. Perform a pixel-wise classification of the hyperspectral image. We propose to use an SVM classifier for this purpose, which has given good accuracies in classification of hyperspectral data. At the output of this step, we obtain a classification map and a probability map (if a pixel was assigned to the class k, the probability map contains a probability estimate for this pixel to belong to the class k).
2. Select markers by choosing the most reliable classified pixels. We propose the following procedure for this purpose. First, perform a connected components labeling of the pixel-wise classification map. Then, analyze each connected region as follows:
   - If a region is large enough, it should contain a marker. It is determined as the P% of pixels within the connected component with the highest probability estimates.
   - If a region is small, it should lead to a marker only if it is very reliable; potential marker is formed by the pixels with probability estimates higher than a defined threshold.

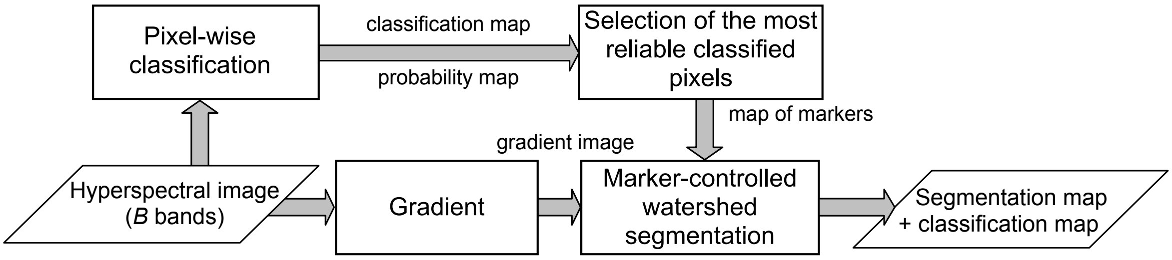

Fig. 1. Flow-chart of the proposed segmentation and classification scheme.

A marker in our study is not necessarily a group of spatially adjacent pixels: it can be a set of pixels that is disconnected in the spatial dimension.

3. Independently of steps 1 and 2, compute the gradient of the hyperspectral image. A one-band gradient is needed as the input for the watershed segmentation. Different approaches to compute a one-band gradient from the hyperspectral image are analyzed in [6].

4. Perform a marker-controlled watershed transformation, using the gradient image and the map of markers obtained in the previous steps. First, apply the minima imposition technique to the gradient image [5]. Then, perform a watershed segmentation of the resulting image. Since a marker can be composed of spatially non-adjacent pixels, it can lead to one or several regions in the segmentation map. Finally, regions belonging to the same marker must be merged together. The result is a segmentation map where each marker results in one region. When for every obtained region, all its pixels are assigned to the class of the marker corresponding to this region, a spectral-spatial classification map is obtained.

3. RESULTS AND CONCLUSIONS

Experimental results are presented on the 200-band AVIRIS image taken over the Northwestern Indiana's Indian Pine site. The segmentation results are compared with those obtained by performing a watershed without markers. The obtained classification results are compared with pixel-wise classification and previous spectral-spatial classification methods which use watershed and an SVM classifier. The oversegmentation is reduced significantly when using the proposed marker-controlled watershed technique. The developed scheme provides classification maps with more homogeneous regions, when compared to pixel-wise classification or other previously proposed spectral-spatial classification methods. The proposed method is especially suitable for images with large spatial structures.

4. REFERENCES

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