MULTISCALE STOCHASTIC WATERSHED FOR UNSUPERVISED HYPERSPECTRAL IMAGE SEGMENTATION

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1. INTRODUCTION

Watershed transformation is one of the most powerful tools for image segmentation. Starting from a gradient, the classical paradigm of watershed segmentation consists in determining markers for each region of interest. The markers avoid the over-segmentation (a region is associated to each minimum of the function) and moreover, the watershed is relatively robust to marker position [2]. The segmentation by watershed of hyperspectral images has shown to improve the results of classification in hyper spectral images [7]. To improve some drawbacks of the classical deterministic watershed, the stochastic watershed [1] was recently introduced to detect and to regularize the contours which are robust with respect to variations in the segmentation conditions. The initial framework was then extended to multispectral images [5] and later, a specific methodology of classification-driven stochastic watershed for multivariate images such as multi/hyper-spectral images was proposed [6].

This paper deals with unsupervised segmentation of hyperspectral images, and in particular, various multiscale frameworks for hyperspectral stochastic watershed are introduced. Two multiscale approaches are considered: i) a Gaussian down-sampling pyramid, ii) a morphological scale-space pyramid using levelings [4]. The functions of density of contours associated to the different pyramid levels are combined according to various probabilistic strategies in order to produce a final segmented image. The performance of new introduced methods is studied in comparison with more classical ones using several datasets.

2. BACKGROUND ON STOCHASTIC WATERSHED

The standard stochastic watershed starts from uniform random point markers to flood the norm of a gradient, in order to obtain associated contours to random markers. After repeating the process a large number of times, a probability density function of contours (pdf) is computed by the Parzen kernel method. In the case of multivariate images such as hyperspectral images, a pdf is built for each channel of the image and the flooding function is the weighted sum of the channels pdf. This function is called a weighted marginal probability density function (mpdf). The pdf can be also calculated using the results of a prior classification: after computing a spectral classification of the hyperpspectral image by unsupervised approaches (such as “k-means”), regionalized random balls markers are used to build the pdf. The spatio-spectral pdf is then segmented using the watershed transformation by means of markers extracted from the classification or by fixing the number of regions in hierarchies based on extinction values.

3. MULTISCALE HYPERSPECTRAL APPROACHES

The basic idea of the multiscale stochastic watershed segmentation involves a decomposition of the hyperspectral image in a pyramid of images. Then, a marginal pdf is calculated for each level of the pyramid using uniform random markers or using classification-driven regionalized markers. The various pdf’s can be then combined according to various probabilistic strategies: weighted sum of pdf’s, conditioned pdf of a level using information from lower levels (Bayes law), etc.

Two multiscale approaches are studied in detail. The first one is a classical Gaussian Pyramid, i.e., an algorithm combining a low-pass filter (i.e., convolution with Gaussian) and down-sampling. It results in several images of size reduced by the subsampling factor. Using a constant density of germs for the various levels of the pyramid, the pdf images can be studied under the assumptions of the Boolean model [3].

The second pyramid is based on a morphological scale-space using levelings. A leveling filter has two input images: the reference image and the marker image (which is generally a rough simplification of the reference image), and it simplifies textures and eliminates small details of the reference image according to the marked structures, but preserving the contours of remaining objects. In this case all the levels have the same image size but the details are successively simplified.

4. EXPERIMENTS AND RESULTS

Two remote sensing datasets are used in the examples. The first dataset is the hyperspectral image of the Indian Pines, obtained by the AVIRIS sensor. The other dataset is an airbone image from the ROSIS-3 optical sensor of the University of Pavia. The performance of new multiscale frameworks for hyperspectral stochastic watershed is studied in comparison with more classical unsupervised segmentation methods.

5. REFERENCES

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