

Chapter 3.9

Machine Learning in Morphological Segmentation

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ABSTRACT

The segmentation of microscopic images is a challenging application that can have numerous applications ranging from prognosis to diagnosis. Mathematical morphology is a very well established theory to process images. Segmentation by morphological means is based on watershed that considers an image as a topographic surface. Watershed requires input and marker image. The user can provide the latter but far more relevant results can be obtained for watershed segmentation if marker extraction relies on prior knowledge. Parameters governing marker extraction varying from image to image, machine learning approaches are of interest for robust extraction of markers.

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We review different strategies for extracting markers by machine learning: single classifier, multiple classifier, single classifier optimized by model selection.

INTRODUCTION

The visual evaluation of microscopic slides is a tedious task, which requires hard concentration of the pathologist screening the specimen under study. With the advent of image processing as an efficient way to extract objects of interest in images, the automatic analysis of images acquired from light microscopes has become an emerging and challenging image analysis application. Microscopic image analysis schemes are usually threefold: image segmentation, objects features

computation, objects classification. We propose to focus on the first part of this scheme for the segmentation of microscopic images of bronchial cytology stained by the international coloration standard of Papanicolaou and acquired in light microscopy. The aim of the segmentation is to extract cells in images; cells being composed of a nucleus and a cytoplasm. Segmentation being in general a difficult task, machine learning has emerged as a key component of intelligent computer vision programs when adaptation is needed (Arif, 2007). In this Chapter, we consider the segmentation of microscopic images by morphological methods and show how to integrate machine learning into a morphological segmentation scheme.

BACKGROUND

Mathematical Morphology is a very well established theory to process images (Serra, 1988). The watershed is the basic tool of Mathematical Morphology for segmentation. It has proved to be a powerful tool and it is used in a large number of applications, such as, medicine, remote sensing, robotics, and multimedia (Meyer, 2001). The parameters for a watershed are marker and input images (Soille, 2004). The watershed grows the markers based on a flooding simulation process by considering the input image as a topographic surface. The problem is to produce the divide-line image on this surface (Roerdink, 2000). Each marker is associated to a color. The topography is flooded from below by letting colored water rise from the holes with its associated color, at an uniform rate across the entire image. When the rising water of distinct colors would merge, a dam is built to prevent the merging. Figure 1 illustrates such a process on a color hematology image with two different sets of markers (provided by the user or by a machine learning algorithm). The most difficult problem when using watershed is of course the definition of appropriate markers with minimal efforts (Rivest,

1992; Meyer, 2001). User provided markers can be attractive for interactive segmentation but for automatic segmentation other techniques have to be considered. An accurate extraction of reliable markers requires prior knowledge on the latter (color, texture, shape, etc.). To incorporate such prior knowledge for the automatic extraction of markers, machine-learning techniques (Derivaux, 2007; Lezoray, 2002; Levner 2007) are the most natural candidates. Figure 2 provides a schematic view of all components involved in the design of a morphological segmentation scheme relying on machine learning algorithms for marker extraction. To perform morphological color image segmentation, a machine learning based classification of pixel feature vectors is done. The result is labeled in connected components and refined by a color watershed. To infer a proper machine learning based pixel classifier, an image database with an associated ground truth is constructed and pixel feature vectors are shared among classes as a basis for supervised learning. In the following Sections, conceiving of each one of these components is described.

MACHINE LEARNING IN MORPHOLOGICAL SEGMENTATION OF MICROSCOPIC IMAGES

Machine Learning

Far more relevant results can be obtained for watershed segmentation if marker extraction relies on prior knowledge. Parameters governing marker extraction varying from image to image, machine learning approaches are of interest for robust extraction of markers. However, with the use of machine learning algorithms for the extraction of seeds, one can consider either unsupervised or supervised learning approaches. Unsupervised approaches do not make use of any learning step and supervised methods do need a learning step to infer an appropriate model of the data. The two

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