Chapter II
Image Features from Morphological Scale–Spaces

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ABSTRACT

Multimedia data mining is a critical problem due to the huge amount of data available. Efficient and reliable data mining solutions require both appropriate features to be extracted from the data and relevant techniques to cluster and index the data. In this chapter, we deal with the first problem which is feature extraction for image representation. A wide range of features have been introduced in the literature, and some attempts have been made to build standards (e.g., MPEG-7). These features are extracted using image processing techniques, and we focus here on a particular image processing toolbox, namely the mathematical morphology, which stays rather unknown from the multimedia mining community, even if it offers some very interesting feature extraction methods. We review here these morphological features; from the basic ones (granulometry or pattern spectrum, differential morphological profile) to more complex ones which manage to gather complementary information.

INTRODUCTION

With the growth of multimedia data available on personal storage or on the Internet, the need for robust and reliable data mining techniques becomes more necessary than ever. In order these techniques to be really useful with multimedia data, the features used for data representation should be chosen attentively and accurately depending on the data considered: images, video sequences, audio files, 3-D models, web pages, etc.

As features are of primary importance in the process of multimedia mining, a wide range of features have been introduced in particular since the last decade. Some attempts have been made to gather the most relevant and robust features into commonly adopted standards, such as MPEG-7 (Manjunath,
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For the description of still images, MPEG-7 contains an heterogeneous but complementary set of descriptors which are related to various properties (e.g. colour, texture, 2-D shape, etc).

In addition to well-known standards such as MPEG-7, local or global descriptions of digital images can be achieved through the use of various toolboxes from the image analysis and processing field. Among these toolboxes, Mathematical Morphology offers a robust theoretical framework and a set of efficient tools to describe and analyse images. We believe it can be a very relevant solution for image representation in the context of multimedia mining. Indeed, its nonlinear behaviour comes with several attractive properties, such as translation invariance (both in spatial and intensity domains) and other properties (e.g. idempotence, extensivity or anti-extensivity, increasingness, connectedness, duality and complementariness, etc), depending on the morphological operator under consideration. Moreover, it allows very easily the construction of image scale-spaces from which can be extracted some robust features.

The goal of this chapter is not to present once again a well-known standard such as MPEG-7 but rather to focus on a specific theory, namely the Mathematical Morphology, and to review how the tools it offers can be used to generate global or local features for image representation. This chapter is organized as follows. First we recall the foundations of Mathematical Morphology and give the necessary definitions and notations. Then we present the morphological one-dimensional features which can be computed from the images either at a local or a global scale but always from a scale-space analysis of the images. In a third section we review several extensions which have been proposed to gather more information than these standard features through multidimensional morphological features. Next we focus on the implementation aspects, and give indications on the available methods for efficient processing, which is needed as soon as these features are used with multimedia indexing. We underline the potential of these features in a following section by giving a brief survey of their use in various application fields. Finally we give some concluding remarks and suggest further readings related to the topic addressed in this chapter.

BASICS OF MATHEMATICAL MORPHOLOGY

Mathematical Morphology is a theory introduced about 50 years ago by Georges Matheron and Jean Serra. Since then, it has been a growing and very active field of research, with its regular International Symposium on Mathematical Morphology (ISMM) taking place every two years and a half, and several recent special issues of journals (Ronse, 2005; Ronse, Najman, & Decencière, 2007).

Theoretical Foundations

Basically, Mathematical Morphology relies on the spatial analysis of images through a pattern called structuring element (SE) and consists in a set of nonlinear operators which are applied on the images considering this SE. Thus it can be seen as a relevant alternative to other image processing techniques such as purely statistical approaches or linear approaches. First works in Mathematical Morphology were related to binary image processing. The theoretical framework involved initially was very logically the set theory. Within this framework, the morphological operators were defined by means of set operators such as inclusion, union, intersection, difference, etc. However, despite initial efforts leading to stack