Image Classification Using Mathematical Morphology

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Abstract. This paper describes an image classification using of the elementary morphological operators. This classification is based on sup-generating operators, by use of morphological operators characterization defined by Gerald J. F. Banon.

Keywords: Image Classification, Mathematical Morphology, Characterization of Morphological Operators.

1 Introduction

In the literature, the image classification problem has been widely studied and several algorithms were proposed [Duda--Hart (1972)]. In the last years, the fuzzy approach has given good results [Kent--Mardia (1988)]. The mathematical morphology approach for these problems produced their first results with the Dougherty's papers [Dougherty--Cheng (1995), Dougherty et al. (1992)] using granulometry, in the sense of the shape recognition. However, in the literature doesn't exist an image classification method totally morphological yet.

This paper shows a new perspective of the problem, inspired by Banon's characterization of morphological operators [Banon (1995)]. In his paper, three different characterizations of the elementary operators, named respectively, characterization by confrontation, by selection and by decomposition are presented. In this paper, we use characterization by selection, which will be recalled in the section 2.

2 Some definitions

We will show briefly the characterization by selection which we will use here and that can be found in [Banon (1995)]. Let K_1 be a bounded chain and let L_2 be a finite lattice. A mapping p from K_1 to L_2 is a erosion iff p is increasing and $p(max\,K_1)=max\,L_2$. It is a anti-dilation iff p is decreasing and $p(min\,K_1)=max\,L_2$. Let W a subset of the Abelian group $(A,+)$, we denote W^t the transpose of W, that is, the subset of A given by: $W^t := \{y \in A : -y \in W\}$. We denote by K^W the set of mappings from W to K (W can have any dimension and to contain any number of points). In the characterization by selection of the translation-invariant window elementary operators (with window W) from K_1^A to K_2^A such operators are characterized in terms of elementary operators from K_1 to $K_2^{W^t}$, which Banon called *impulse response*.

In particular, any translation-invariant and window erosion E from K_1^A to K_2^A can be written:

$$E(f)(x) := \bigcap_{u \in W} e^t((f-x)(u))(u) \quad (f \in K_1^A, x \in A)$$

where e is an erosion from K_1 to $K_2^{W^t}$.

In particular, any translation-invariant and window anti-dilation δ^a from K_1^A to K_2^A can be written:

$$\Delta^a(f)(x) := \bigcap_{u \in W} d^{at}((f-x)(u))(u) \ (f \in K_1^A, x \in A)$$

where d^a is an anti-dilation from K_1 to $K_2^{W^t}$.

The intersection of these operators leads to a new operator λ called sup-generating operator, which is the base for classification process (figure 1). The use of sup-generating for pattern recognition is not new, but its application in image classification doesn't appear in the literature.

3 A classifier using Morphological Operators

An image classifier has two objectives which are: to discriminate n classes in an image and to attribute each pixel of this image in one of these classes. The discriminant part of a classifier can be a statistical, fuzzy or other algorithm. The attribution part consists of deciding which class maximizes the correct classification or minimizes the classification error.

A classifier using mathematical morphology operators is visualized in figure 1. The λ_{ij} (where $i = \{1, \dots, n\}$ and $j \geq 0$) boxes, which correspond to the discriminant part, are the sup-generating operators and the function family from K_1 to $K_2^{W^t}$ can be probability density functions or membership functions. These functions must be unimodals and must comply to the restrictions of the Section 2. However, these functions can be bimodals or multimodals. To treat them, they can be decomposed in parts: increasing and decreasing parts, according to [Banon (1993)]. The increasing parts are erosions and the decreasing parts are anti-dilations (see Section 2). Thus, one class can have more than one sup-generating operator associated. We can see in figure 1 a case when a class is given by a bimodal function. This function is decomposed in two parts to compose λ_{11} and λ_{12}. In the unimodal case the decomposition of the function composes only λ_{n1}.

The class attribution (showed δ in the figure 1) for a pixel x is given by: x in

$$\begin{cases} classe_i, & \text{iff } (\lambda_i(f))(x) = max_{j,k \le n}(\lambda_{kj}(f))(x) > 0 \\ D, & \text{iff } (\lambda_i(f))(x) = max_{j,k \le n}(\lambda_{kj}(f))(x) = 0 \end{cases}$$

where D is a label for dubious

4 Conclusions

This paper shows the possibility to use the elementary morphological operators to make image classification. This classifier can be extended to work with multispectral images and the decision can be made based on a predefined neighbourhood.

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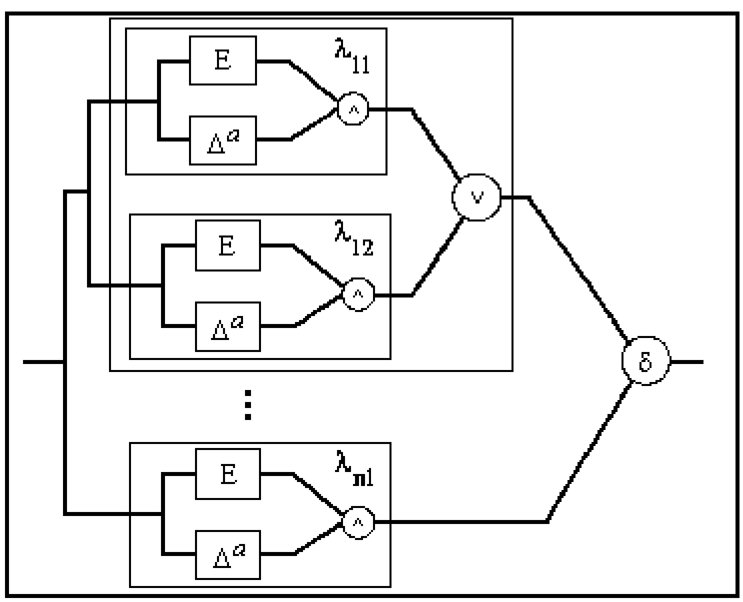

Figure 1. Operators composition for image classification.