Chapter 3
Orthogonal Image Moment Invariants:
Highly Discriminative Features for Pattern Recognition Applications

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ABSTRACT

This chapter focuses on the usage of image orthogonal moments as discrimination features in pattern recognition applications and discusses their main properties. Initially, the ability of the moments to carry information of an image with minimum redundancy is studied, while their capability to enclose distinctive information that uniquely describes the image's content is also examined. Along these directions, the computational formulas of the most representative moment families will be defined analytically and the form of the corresponding moment invariants in each case will be derived. Appropriate experiments have taken place in order to investigate the description capabilities of each moment family, by applying them in several benchmark problems.

1. INTRODUCTION

A crucial part of a modern intelligent imaging system, which learns from its environment and interacts with it, is the pattern recognition procedure. In general, a pattern recognition process employs four stages: 1) image acquisition, 2) image pre-processing (denoising, filtering, etc.), 3) feature extraction and finally 4) classification. The third step is probably the most complicated and it affects the overall performance of the system. A Feature Extraction Method (FEM) can be termed successful if the resulted features (descriptors) describe uniquely the processed object in a scene. The more successful the FEM, the more efficient the classification.

DOI: 10.4018/978-1-61350-429-1.ch003

Image moments constitute an important FEM, which generates high discriminative features, able to capture the particular characteristics of the described pattern, which distinguish it among similar or totally different objects.

In the next sections the most representative moment families are described and their invariants are derived. Moreover, appropriate experimental scenarios for different pattern recognition applications will be arranged, in order to investigate the recognition capabilities of each moment family. For this reason, several benchmark datasets will be selected from the literature, by covering a wide spread of different applications such as face, facial expression, hand postures and object recognition of the artificial intelligence research field the general perspective of the chapter.

2. BACKGROUND IN IMAGE MOMENTS

Although the first usage of moments in image understanding and analysis was a long time ago, they still preserve scientists' interest. Image moments have been used successfully in image processing and pattern recognition after image normalization and proper selection, with Hu (Hu, 1962) being the pioneer in introducing a set of moment invariants for classification purposes. However, Hu invariants and geometric moments suffer from high information redundancy.

More precisely, geometric moments are the projection of the intensity function of an image onto specific monomials, which do not construct an orthogonal basis. Orthogonal moments came to overcome this disadvantage of the conventional moments used until then, since their kernels are orthogonal polynomials. This property of orthogonality gives to the corresponding moments the feature of minimum information redundancy, meaning that different moment orders describe different image parts of the image.

The first introduction of orthogonal moments in image analysis performed by Teague (Teague, 1980), who made use of Legendre (Papakostas et al., 2010a) and Zernike (Papakostas et al., 2010b, 2007a) moments in image processing. Other families of orthogonal moments were proposed through the years, such as Pseudo-Zernike (Papakostas et al., 2010b) and Fourier-Mellin (Papakostas et al., 2007b) moments, to better describe the image in process and to ensure robustness in noise presence. However, the above orthogonal moments used till the recent years, present some approximation errors due to the fact that the kernel polynomials are defined in the continuous space (Liao & Pawlak, 1996; Wee & Paramesran, 2007). Therefore, when the moments of a discrete intensity function are needed to be computed, some errors are generated which influence the final results.

Apart from some remarkable attempts that compute the theoretical image moment values (Liao & Pawlak, 1996; Wee & Paramesran, 2007), new moment families with discrete polynomial kernels, have been proposed, which permit the direct computation of the image moments in the discrete domain. Such discrete moment invariants are the Tchebichef (Mukundan et al., 2001), Krawtchouk (Yap et al., 2003), Hahn (Zhu et al., 2007a), and Racah ones (Zhu et al., 2007a), which present significant properties in describing an image in process.

Due to their high popularity, many works in different research directions have been published the last three decades regarding the computation, usage and enhancement of the image moments for pattern recognition purposes.

3. IMAGE MOMENTS

In this section, a detailed description of the computational formulas of the most representative orthogonal image moments is presented. Also, the main properties of each moment family are discussed and the ability of the families to describe