Multispectral Image Compression, Intelligent Analysis, and Hierarchical Search in Image Databases

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ABSTRACT

In this paper, a new approach is offered for the efficient processing and analysis of groups of multispectral images of the same objects. It comprises several tools: the Modified Inverse Pyramid Decomposition; the invariant object representation with Modified Mellin-Fourier transform, and the hierarchical search in image databases, for which the invariant representation is used. The new approach permits the definition of a large number of parameters, which are used for object analysis and evaluation. When combined with the KASER expert system, this approach yields a flexible tool for the analysis of multispectral images of the same object.

Keywords: Hierarchical Search in Image Databases, Invariant Object Representation, KASER Expert Systems, Modified Mellin-Fourier Transform, Multispectral Images

INTRODUCTION

The multispectral (MS) image is a set of several monochrome images of the same scene, each taken with a different sensor. The wavelengths may be separated by filters, or through the use of instruments that are sensitive to particular wavelengths – including near infrared light, middle infrared light, and far infrared light. Each image contains some additional information, due to changes in the used frequencies for the corresponding band. Images should be considered as one MS image, rather than as a set of monochrome grey level images, in order to fully exploit this additional information. In many cases, MS images allow extraction of additional information, which the human eye fails to capture. Depending on the frequency of

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light used, different objects could be noticed in the same picture. MS images are widely used for surveillance of large areas of Earth (forests, deserts, etc.), where humans are generally not present. Another very interesting application is the reading of old manuscripts, in which part of the written information could be hidden under daylight; but, by imaging fragments in the infrared, differences in light reflectivity render the texts readable.

The main problems of MS images are related to their archiving (compression) and content analysis. Special attention is also needed for the efficient object search in groups of MS images of the same scene. Various tools have already been developed for the compression of MS images. Most of them are based on the use of the wavelets in the spatial domain, and the Karhunen-Loeve transform in the spectral domain (Gelli & Poggi, 1999; Cagnazzo, Cicala, Poggi & Verdoliva, 2006). Other algorithms are aimed at their lossy and lossless coding and for this are used spectral linear prediction and entropy coding with context modeling (Ma, Shi, and Tang) and JPEG2000 LS (Shinoda, Murakami, Yamaguchi, & Ohyama, 2011) or Shape-Adaptive Wavelet Transform (Cagnazzo, Parrilli, Poggi, & Verdoliva, 2006; Wu & Wu, & Unay, 2004). The research activity on this topic (Gelli & Poggi, 1999; Cagnazzo, Cicala, Poggi & Verdoliva, 2006; Dragotti, Poggi & Ragozini, 2000; Fowler & Fox, 2001; Tang, Pearlman & Modestino, 2003; Cagnazzo, Poggi & Verdoliva, Gersho & Gray, 2004; Kaarna, 2001) is focusing, particularly, on transform-coding techniques, due to their good performance and limited computational complexity. Linear transform coding, however, does not take into account the nonlinear dependences existing among different bands, due to the fact that multiple land covers, each with its own interband statistics, are present in a single image. For this, a class-based coder was proposed in (Cagnazzo, Parrilli, and Poggi & Verdoliva, 2007) that address the problem of interband dependences by segmenting the image into several classes and corresponding as much as possible to the different land covers. Satellite-borne sensors have ever-higher spatial, spectral, and radiometric resolution. The most critical phase is on-board the satellite, where acquired data easily exceeds the capacity of the downlink transmission channel, and often large parts of images must be simply discarded. The reasonable approach is to resort to data compression, which allows significant reduction in the data volume without serious effects on the image quality. The transform coding is one of the most popular approaches for several reasons. Transform coding techniques provide excellent performance in the compression of images, video, and other sources, have a reasonable complexity and besides, are at the core of the famous standards JPEG and JPEG2000 (Acharya & Tsai, 2005, Bitaa, Barretb & Phamc, 2010). The common approach for coding MS images (Markas & Reif, 1993) is to use some decorrelating transforms along the spectral dimension followed by JPEG2000 with a suitable rate allocation among the bands. Less attention has been devoted to techniques based on vector quantization (VQ) because, despite its theoretical optimality, VQ is too computationally demanding to be of any practical use. Nonetheless, when dealing with multiband images, VQ is a natural candidate, because the elementary semantic unit in such images is the spectral response vector, which collects the image intensities for a given location at all spectral bands. For this, some constrained VQ techniques were investigated (Gersho & Gray, 1992), which are suboptimal but simpler than full-search VQ, and show promising performances. Besides, a hybrids transform/vector quantization (VQ) coding scheme is also proposed (Gersho & Gray, 1992; Aiazzi, Baronti & Lastri, 2006). Another approach, based on the Karhunen-Loeve transform (KLT), followed by a two-dimensional (2D) Discrete Cosine Transform (DCT), is used to reduce the spectral and spatial redundancies (Gelli & Poggi, 1999). A quad-tree technique for determining the transform block size and the quantizer for encoding the transform coefficients were applied across KLT-DCT method (Kaarna, 2001). In Cagnazzo, Parrilli, and Poggi & Verdoliva and Aiazzi, Baronti & Lastri, (2006) the researchers...
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