Chapter 15
An Evaluation Framework and a Benchmark for Multi/Hyperspectral Image Compression

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ABSTRACT

This paper benchmarks three multi/hyperspectral image compression approaches: the classic Multi-2D compression approach and two different implementations of 3D approach (Full 3D and Hybrid). All approaches are combined with a spectral PCA decorrelation stage to optimize performance. These three compression approaches are compared within a larger comparison framework than the conventionally used PSNR, which includes eight metrics divided into three families. The comparison is carried out with regard to variations in bitrates, spatial, and spectral dimensions variations of images. The time and memory consumption difference between the three approaches is also discussed. Results of this comparison show the weaknesses and strengths of each approach.

INTRODUCTION

A hyper/multispectral imaging system splits the light spectrum into more than three frequency bands (dozens to hundreds) and records each of the images separately as a set of monochrome images. This type of technique increases the number of acquisition channels in the visible spectrum and extends channel acquisition to the light that is outside the sensitivity of the human eye. Such systems offer several advantages over conventional RGB imaging and have, therefore, attracted increasing interest in the past few years. However, multispectral uncompressed images, in which a single image-band may occupy hundreds of megabytes, often require high capacity storage.

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Compression is thus necessary to facilitate both the storage and the transmission of multispectral images.

Generally, a multispectral image is represented as a 3D cube with one spectral and two spatial dimensions. The fact that a multispectral image consists of a series of narrow and contiguously spectral bands of the same scene produces a highly correlated sequence of images. This particularity differentiates multispectral images from volumetric ones with three isotropic spatial dimensions, and also from videos with one temporal and two spatial dimensions. Conventional compression methods are not optimal for multispectral image compression, which is why compression algorithms need to be adapted to this type of image.

One of the most efficient compression methods for monochrome images compression is the JPEG 2000 (Boliek, Christopoulos, & Majani, 2000; Boliek, Majani, Houchin, Kasner, & Carlander, 2000; Christopoulos, Skodras, & Ebrahimi, 2000; Taubman, 2000; Taubman, Marcellin, & Rabbani, 2002). Its extension to multi/hyperspectral images yields to different approaches. These approaches depend on the manner of which one consider the multi/hyperspectral cube after the decorrelation stage (Figure 1):

- In the Multi-2D approach, each image band of the multi/hyperspectral image is considered separately (2D wavelets + 2D SPIHT) (Du & Fowler, 2007; Kaarna, Toivanen, & Keränen, 2006; Mielikäinen & Kaarna, 2002),
- The whole cube is considered as input leading to two main implementations:

Figure 1. Graphical representation of the three compression approaches