

PCA and JPEG2000 Still Image Compression

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1 Introduction

The purpose of this script is to perform simple image compression on still, gray-scale images. The algorithm will comprise of two parts in both the compression and decompression stages. These will be 1) reducing the dimensionality of the image using PCA; and 2) encoding this reduced image into a JPEG2000 bit-stream. The reasoning behind such a technique is two-fold:

1. PCA de-correlates the image and reduces its dimensionality, while ensuring the reconstruction error is negligible in terms of human visual perception of the image, especially when the images are natural/scene images.
2. JPEG2000 can take advantage of the decorrelation achieved by PCA, which will result in an even more efficient encoding of the reduced image. Further, JPEG2000 imposes very little noticeable degradation to the image.

2 Algorithm

2.1 PCA

The steps of the PCA stage of the algorithm is as follows:

1. Normalize the image I by performing: $I := \frac{I}{2^d - 1}$, where d is the bit-depth of the image. In the case of the test image in the repository, this is $d = 8$, as it is an 8-bit image (i.e. the conventional gray-scale range).
2. Treating each row of the image as a sample and each column as a feature vector, find the K principle components of the image matrix using the PCA algorithm. This will result in an image of dimensionality $I_{n \times p}$ (from the original $I_{n \times m}$ image), where $p < m$. This PCA transformation mapping will be $f : \mathbb{R}^m \rightarrow \mathbb{R}^p$. This will also result in the inverse transformation $g : \mathbb{R}^p \rightarrow \mathbb{R}^m$.
3. Assuming we have a feature vector γ_i , the transformation and inverse transformation mappings will be such that $\gamma_i \approx f(g(\gamma_i))$. This is essential by the very nature of image compression.

2.2 JPEG2000

The JPEG2000 stage of the algorithm takes the reduced image $I_{n \times p}$ from PCA, and encodes it into a JPEG2000 bit stream. This is the final compressed representation of the image. This vector is what is sent to the decoder/decompression part of the algorithm