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# Transform-based coding method for remote sensing hyperspectral data compression

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**Abstract**

A version of the transform-based coding compression method for remote sensing hyperspectral data is proposed. New version is based on the calculation of a separate quantization matrix for each image and the preliminary removal of low-frequency components in the input data. Larger compression ratios are shown in comparison with the layered JPEG algorithm with the same mean square recovery error.



*Keywords:* transform-based coding method; remote sensing hyperspectral data; image compression

## 1. Introduction

According to [1], most on-board image compression algorithms can be divided into two groups: differential coding methods and transform-based coding methods. Among the transform-based coding methods, algorithms based on discrete cosine transform (DCT) and wavelet transform are widely used.

In this paper, we propose a variant of the transform-based coding method for the compression of remote sensing hyperspectral images (HSI) with some modifications, including the calculating of a separate quantization matrix for

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each image, evaluating corresponding scan order of quantized coefficients and the preliminary removal of low-frequency components in the input data.

The paper has the following structure. The second section describes a transform-based coding method using the standard JPEG algorithm for 2D images and its application to compress 3D HSI. The third section describes the modification of JPEG for the compression of HSI with the modifications listed above. The fourth section presents the results of experimental research of the proposed modifications.

## 2. Transform-based coding method in JPEG

The principal idea of the transform-based coding method is use of so called "transformants" (coefficients of decomposition in terms of some basis) instead of the original signal values (see [2] or Section 6.5.1 in [3]). The effectiveness of the transformants follows from the fact that their values may be less correlated than the original signal values. Therefore, they can contain the same information with a smaller amount of data.

One of the most well-known implementations of the transform-based coding method is the JPEG compression standard of images [4], where the 2D DCT is used as the orthogonal transformation (basis).

Let $f(n_1, n_2)$ be a 2D image of $N_1 \times N_2$ dimension, $n_1 = 0 \ldots N_1 - 1$, $n_2 = 0 \ldots N_2 - 1$. The JPEG algorithm splits the data into 8×8 disjoint blocks for following independent processing (hereinafter it is assumed that the image size is divisible by block size without remainder).

Let consider in more detail an example of encoding one of such blocks $b(n_1, n_2)$. Firstly, the 2D DCT is performed in the block to obtain transformants $B(n_1, n_2)$. Secondly, the resulting transformants are quantized:

$$BQ(n_1,n_2) = \left[ \frac{B(n_1,n_2)}{Q(n_1,n_2)} \right], \quad n_1,n_2 = \overline{0,7},$$

where $Q(n_1, n_2)$ is a quantization matrix, $[\cdot]$ is the rounding operator to the nearest integer. The JPEG standard offers quantization values that have been selected experimentally based on the perception of the human visual system.

At the final step, $BQ(n_1, n_2)$ values are divided into two groups, each of which is further statistically coded in its own way.

The values $BQ(0, 0)$ are called DC coefficients. For encoding, instead of the value of the DC coefficient itself, its difference with the corresponding value of the previous row of the block is used. Obtained difference values are encoded by a modified Huffman code. Note that DC coefficients are directly related to the average brightness value in the block (it follows from the DCT properties).

The remaining coefficients $BQ(n_1, n_2)$ for $(n_1, n_2) \neq (0, 0)$ are called AC-coefficients. In each block, the AC coefficients are ordered in a zigzag manner and encoded with a modified Huffman code using the run length encoding.

The decoding process consists of the following steps. Firstly, the values of the quantized transformants $BQ(n_1, n_2)$ are decoded. Secondly, the transformants are dequantized:

$$\overline{B}(n_1,n_2) = BQ(n_1,n_2) \cdot Q(n_1,n_2), \quad n_1 = \overline{0,7}, \quad n_2 = \overline{0,7}.$$

At the final step, the reverse DCT is performed to obtain the reconstructed image values.

One of the trivial ways to generalize the 2D JPEG algorithm for compressing 3D HSI is its layer-by-layer application. The 3D data are divided into a set of independent 2D images, which are further encoded (decoded) independently of each other.