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Comparison of the Efficiency of Compression Algorithms for Multispectral Satellite Imagery

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Abstract

A quantitative and qualitative assessment of the effect of lossy compression on the results of uncontrolled classification of satellite imagery has been performed. The efficiency of compression algorithms for multispectral satellite imagery has been compared. The MRSID format provides the best compression, but it also contributes the errors to the classification results. The JPEG2000 format makes the smallest errors in the classification results with average compression.

Keywords: Earth remote sensing (ERS), multispectral satellite imagery, data compression, information loss, uncontrolled classification

INTRODUCTION.

Earth remote sensing (ERS) is currently one of the most promising ways to obtain geospatial data [1-3]. Scientific and technical achievements of recent years in the field of creation and development of space systems, technologies for processing, storage, interpretation and use of ERS data have greatly expanded the range and scale of tasks solved using satellite imagery [4-6]. The number of users of ERS data continues to grow rapidly, since satellite imageries have actively been used not only for scientific and industrial purposes, but also in everyday life [7-9].

High-and ultra-high-resolution ERS data, especially multispectral satellite imageries, are the most popular [10-12]. Such imageries can take up huge amounts of disk space, reaching several gigabytes for a single scene [13-15]. Various data compression algorithms are used to save disk space and reduce data transfer time.

Compression on board the satellite is particularly effective, which significantly reduces the requirements for the bandwidth of the ERS data dump line, which is extremely important for micro - and nanosatellites [16-18].

ERS data compression algorithms are divided into two groups:

- lossless compression algorithms (ZIP, RAR, 7Z, JPEG-lossless, etc.) that reduce the volume by 1.5...3 times;
- lossy compression algorithms (JPEG, ECW, JPEG2000, MRSID, etc.) that reduce the volume tenfold depending on the acceptable losses.

When compressing with losses, it is very important to correctly set the compression ratio and the degree of acceptable loss of information. To do this, it is necessary to evaluate not only the visual loss of image quality, but also the impact of radiometric distortions (artifacts) on the results of further image processing. Lossy compression artifacts affect both the results of pre-imagery processing (geographical reference, orthorectification, spatial improvement, etc.) and the results of thematic imagery processing (calculation of spectral indices, classification and segmentation, object recognition, etc.).

The main objective of the research is to assess the impact of compression with losses on the results of uncontrolled classification of satellite imagery in order to compare the effectiveness of existing compression algorithms for multispectral satellite imagery.

METHODS

The research has been carried out by qualitative and quantitative comparison of the results of uncontrolled classification performed for the original multispectral imagery and compressed imagery.

The most popular algorithm for non-controlled classification ISODATA (Iterative Self-Organizing Data Analysis Technique) has been chosen as an example. The main advantage of this algorithm is the ability to perform classification of satellite imageries in automatic mode without training.

The source data was a fragment of a multispectral imagery of farmland (Picture 1) in GeoTIFF format (green, red and near-IR channels).

First, the source imagery was compressed with minimal loss of information using the most common and effective methods:

- using discrete cosine conversion (JPEG format);
- using discrete wavelet transform (JPEG2000 and MRSID formats).

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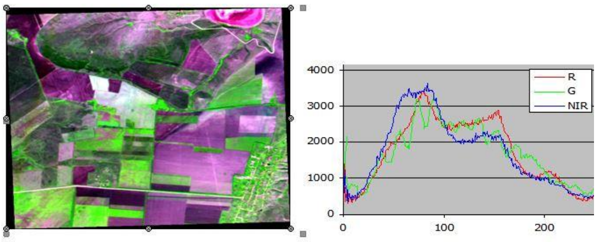
Table 1

File format	File size	Compression ration	Expected mean			Dispersion		
			R	G	NIR	R	G	NIR
tif	1415400	1	111.03	112.09	104.46	63.72	66.54	64.03
jpg	88890	15.9	111.33	112.11	104.76	63.05	66.30	63.57
jp2	83738	16.9	111.05	112.14	104.55	62.11	66.02	62.60
sid	61757	22.9	105.09	112.87	111.91	63.93	66.49	63.46



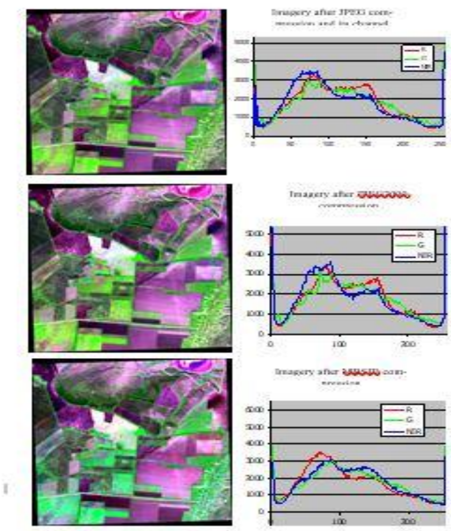
Picture 1- Fragment of the source imagery and histogram of spectral channels

RESULTS AND DISCUSSION

The maximum possible compression has been set for the selected compression algorithms, in which the losses are visually invisible or barely noticeable (Table 1)

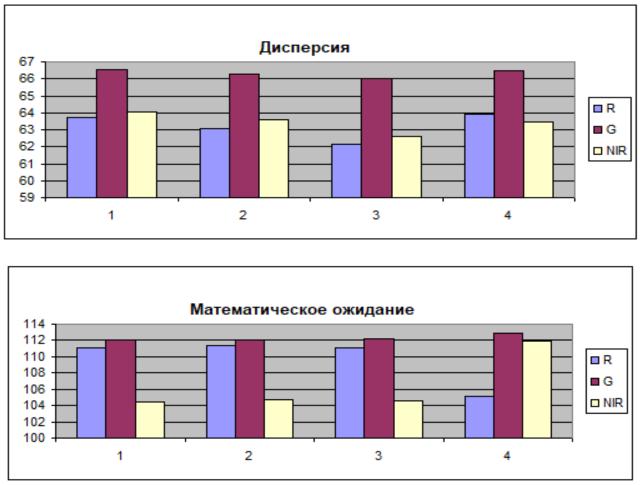
As you can see from the Table 1, the MRSID format provides the best compression, but it makes the most losses, and the JPEG2000 format makes the most losses with average compression.

Compressed imageries and histograms of spectral channels are shown in the Picture 2.



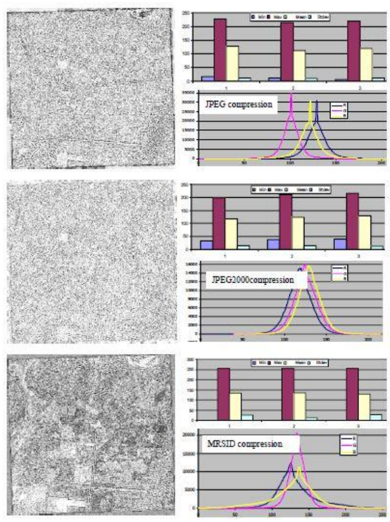
Picture 2 - Compressed images and histograms of spectral channels

Picture 3 shows the main statistical characteristics of imageries calculated for each compression method.



(1 – source imagery , 2- JPEG compression, 3 – JPEG2000 compression, 4 – MRSID compression)
Picture 3- Statistical characteristics of imageries

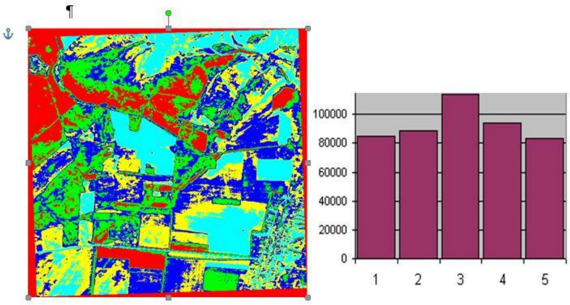
Picture 4 shows the components of the source imagery that were removed during compression (compression losses), as well as the main statistical characteristics calculated for each compression method (statistical moments and histograms for each channel)



Picture 4 - compression loss

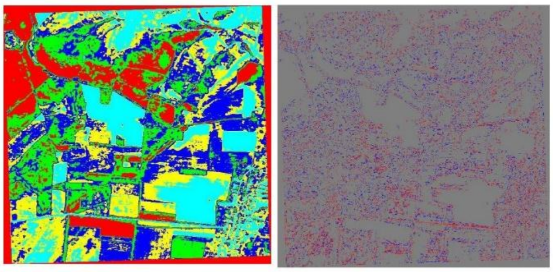
Figure 4 shows that JPEG and MRSID compression removes primarily the signal components of the imagery, while JPEG2000 compression removes primarily the noise components.

Then an uncontrolled classification of the source imagery was performed using the ISODATA algorithm (Picture 5).



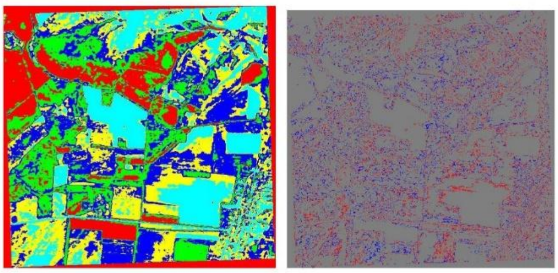
Picture 5

Then the classification results were compared with the ISODATA algorithm for the source and compressed imageries (Picture 6-8).



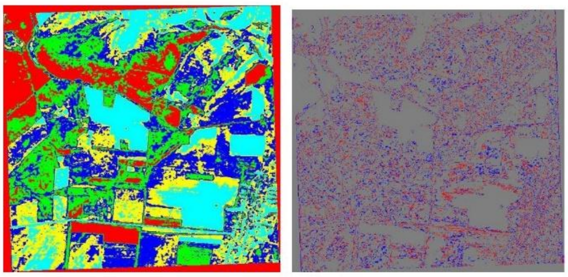
a) classification result b) difference from the original

Picture 6 - JPEG Compression



a) classification result b) difference from the original

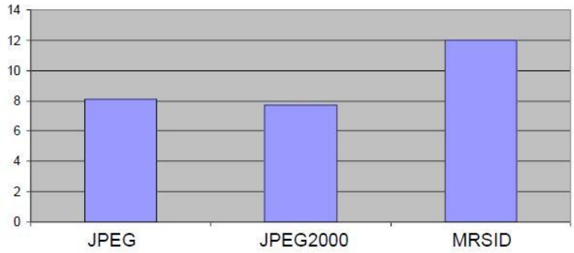
Picture 7 - JP2 compression



a) classification result b) difference from the original

Picture 8 – MRSID compression

Picture 9 shows classification errors due to compression loss - the percentage of pixels that did not match the classification results of the original imagery.



Picture 9 - classification errors (%)

Similar results were obtained as a result of processing and analyzing many multispectral imageries for different territories and shooting seasons.

CONCLUSIONS

In order to save disk space and reduce the time spent on data transmission over communication channels, it is advisable to use compression algorithms for satellite imageries with minimal information loss. Algorithms of uncontrolled classification of K-Means and ISODATA with a small (5...7) number of classes and spectral channels (3...4) give similar results. The MRSID format provides the best compression, but it also contributes the largest errors in classification results (about 12%). The JPEG2000 format makes the smallest errors in the classification results (less than 8%) with average compression (about 17).

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