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INFORMATION TECHNOLOGY IMPROVING THE SPATIAL FRAGMENTATION OF DIGITAL SATELLITE IMAGES BASED ON ICA- AND WAVELET TRANSFORMS

The paper presents information technology that improves the spatial separation of multichannel images. The results show that the proposed method can have a better trade-off between spectral and spatial information. Moreover, compared with ICA fusion method, it can not only improve the spatial resolution of fused image, but also eliminate the drawback of spectral distortion of ICA fusion method in local regions.

Keywords: photogrammetric, multispectral, panchromatic image, ICA, wavelet transform, entropy.

Statement of the problem.

In systems of remote sensing of the Earth in recent years, widespread scanning devices for imaging the earth's surface in the focal plane are several matrices receivers with charging communication. Each of these matrices provides for the formation of the image in a certain spectral range. Reweighing of this type of scanners is that they are formed spatially combined images. However, the spectral separation of radiation energy leads to a weakening of the detected signal and reduce radiometric differences video. Actual field of modern scientific research is synergistic processing (merger) of such photogrammetric data from multiple channels with the purpose of obtaining artificial image with improved information value in comparison with primary images and their analysis.

Analysis of the last researches.

Currently there are different methods of combining photogrammetric image, allowing to enhance the usefulness of the multispectral imagery. «Perfect» method of Association must have at least two major components, i.e. the increase of high spatial distinction and reduce color distortion. The information contained in the image, received in the merger, is more complete, which leads, in particular, to improve quality of recognition and more qualitative «understanding» of their properties. Unfortunately separate use of the existing methods such as HSV, ICA, Color Normalized Brovey, Gram-Schmidt, PC Spectral Sharpening, does not give the result. General and primary concern associated with the merger of scanner images modern aerospace systems is a significant color violations.

The formulation of the objectives of article (problem).

Thus, there is a need to develop a new technology to increase depth of aerospace images that will get багатоспектральні image more high spatial distinction without loss of spectral information.

Summary of the basic material.

One of the most promising and powerful mathematical apparatus for the merger of aerospace images is the wavelet transform. But a separate application of wavelet-transformation often leads to artifacts in a synthesized image. To avoid this problem, the paper proposed technology staged processing of multispectral images with the help of the method of independent component analysis (ICA) and Wavelet - conversion. Diagram of the algorithm is presented in figure 1.

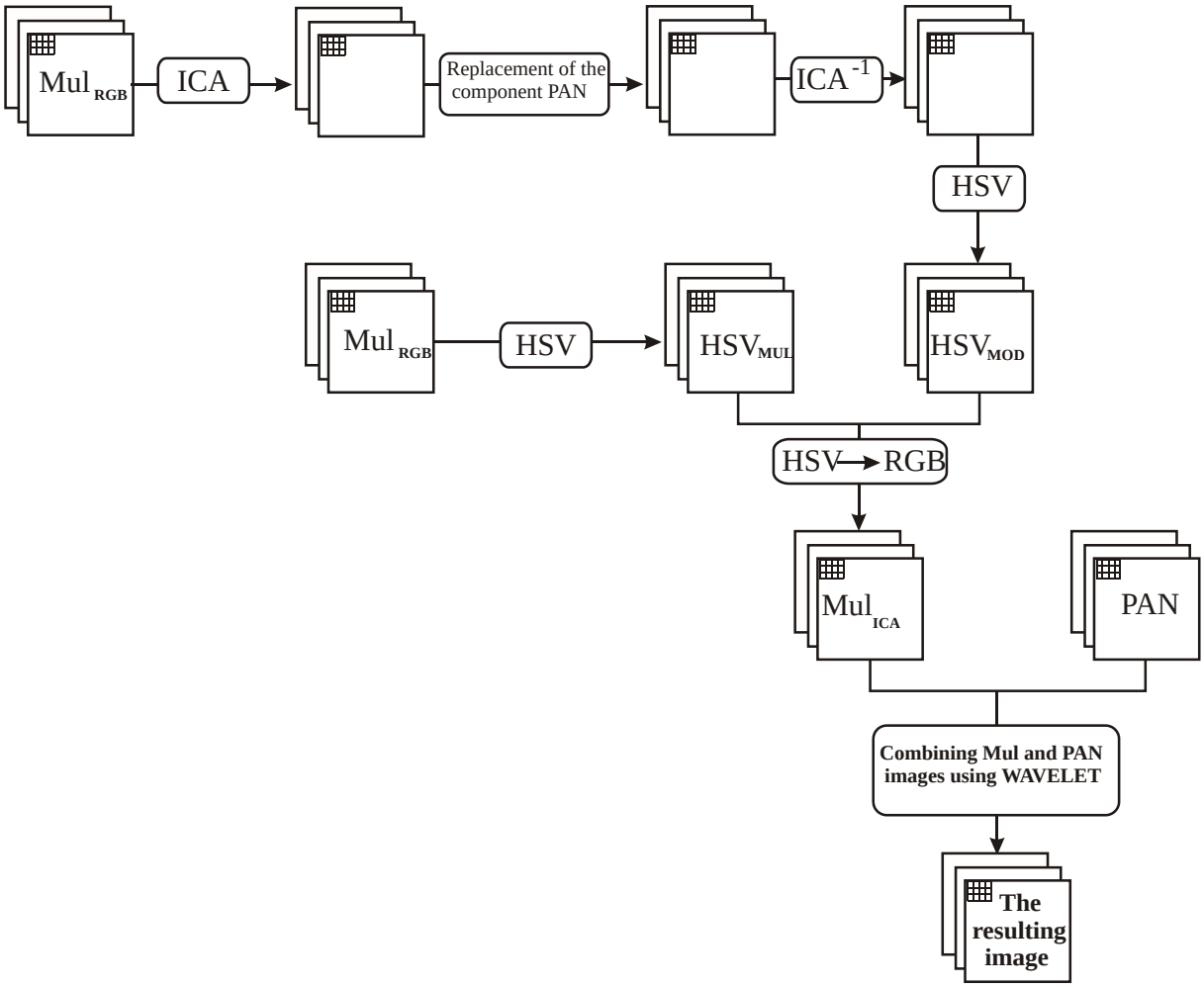


Fig.1. Diagram of the algorithm

Independent component analysis is considered as an extension of a principal components analysis on the task blind separation of independent sources of their linear mixes. As is known, with an analysis of the principal components are closely related concepts such as not correlation and normal distribution of data, while ICA is associated with the statistical independence and негаусовським distribution. In addition, axis does not necessarily have to be orthogonal. The model used in the analysis of independent components can be represented as:

$$\mathbf{y} = \mathbf{H}\,\mathbf{x}, \tag{1}$$

where: **y** — *m*-dimensional random vector, **x** — *n*-dimensional random vector with independent components, **H** — some unknown display $R^n \rightarrow R^m$, $m \geq n$.

The task of ICA is formulated as the problem of search of such a projection of the vector y on a linear space of vectors x, whose components are statistically independent. When this analysis is only available some statistical sampling of values of the random vector y.

The technology offered replacement after conversion ICA first components of multispectral images панхроматичним image. The next step after the replacement is the reverse conversion of the ICA and the conversion of the resulting image in the HSV color model (let HSV_{MOD}). Another step of the algorithm is also the translation of the source of multispectral images in the color space HSV (denote HSV_{MUL}). The next step of forming a new image with a more informative is the replacement of luma V image HSV_{MUL} яскравісною component of the image HSV_{MOD} and conversion with the HSV color model to the RGB color model. The last step of the algorithm is the fusion of the received image MulICA with the PAN with the help of wavelets and obtain the original image.

The use of wavelets differs forming wavelet bases and different principles regarding the selection of Association rules деталізуючих (low-frequency) components. This issue we will be subject of a separate study, but the visual and numerical analysis previously, it was determined that the most effective when the merger is Wavelet Daubechies 20-th order, Wavelet Symlet 15-th order, Wavelet Coiflet 5-th order[2], therefore, in this paper used only these wavelets.

The proposed technology to increase depth of photogrammetric species-based data ICA - Wavelet the transformation was realized on the primary multispectral eight channel images obtained from satellite WorldView-2 (fig. 2). Primary мультиспектральне image was formed 5, 4 and 2 channels, which were elected as channels R,G,B in accordance. After transformation of a Mul-image of this technology was received image that even visually compared with the initial snapshot is more «clarity» (figure 3).

Designed to quantify information value (quality) of the images received at the specified technology, specific entropy, since it is the degree of self-descriptiveness. Entropy explores changes in the information, and the image that contains more information corresponds to the higher value of the entropy. Table 1 shows the entropy values obtained for multispectral and панхроматичного primary images, and for synthesized images to all of these methods (image size 4604*4600 pixels).

Table 1

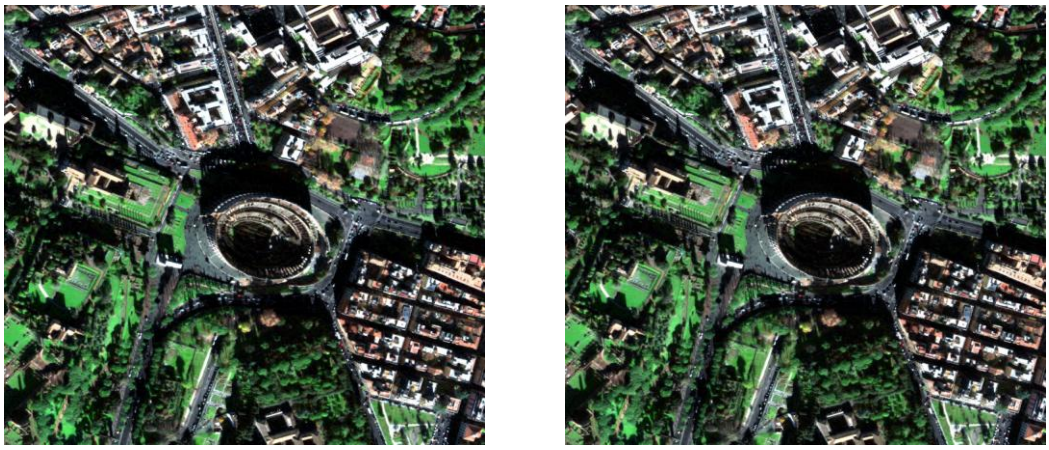
Image	Designation	Entropy
Panchromatic	PAN	7.1028
Native multi-spectral	$Mul_{(RGB)}$	7.0070
Converted algorithm ICA	$Mul_{(ICA)}$	7.1771
Converted technology ICA-Wavelet Coiflet 5–th order	$Mul_{(ICA\text{-}Wavelet\ Coiflet)}$	7.3067
Converted technology ICA-Wavelet Symlet 15–th order	$Mul_{(ICA\text{-}Wavelet\ Symlet)}$	7.3079
Converted technology ICA-Wavelet Daubechies 20–th order	$Mul_{(ICA\text{-}Wavelet\ Daubechies)}$	7.3140

Comparison of values of table 1 indicates that in result of processing of multi-spectral images using the new technology to increase depth of species of remote sensing data based on ICA-Wavelet-conversion, the images are of better quality and increased informativity compared with the primary images. The best result achieved by the use of ICA-Wavelet Daubechies 20-th order with the value of entropy 7.3140 that exceeds the value of the entropy of the primary multispectral images (7.0070).

A visual representation of the obtained values of entropy are given on діаграммі (figure 4).

а) б)

Fig.2. Photometric image:
а) panchromatic; б) native multi-spectral



а) б)

в) г)

Fig.3. Synthesized image:
а) on the basis of ICA-HSV; б) on the basis of ICA-Wavelet Daubechies 20-th order;
в) on the basis of ICA - Wavelet Coiflet 5-th order; г) on the basis of ICA - Wavelet Symlet 15-th order

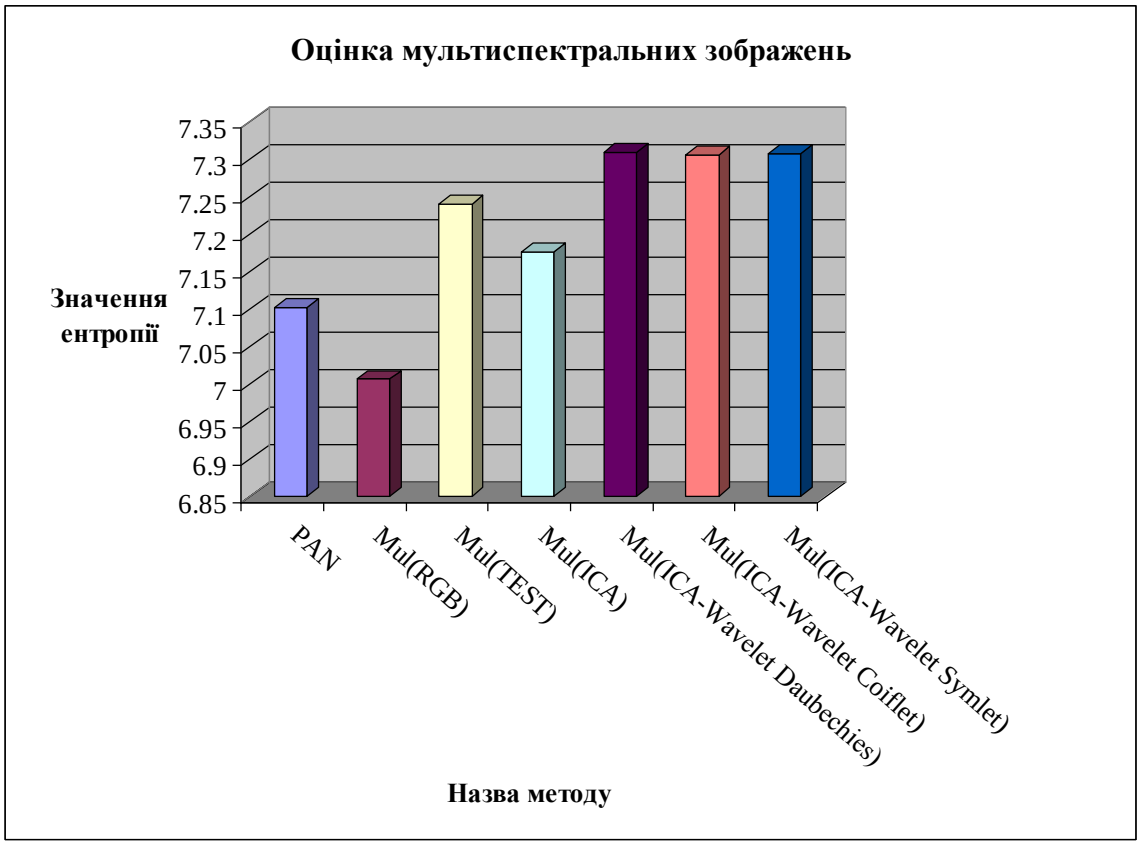


Fig.4. A graphical representation of the estimation of informativity of multispectral images

Conclusions and perspectives of further research.

The obtained characteristics indicate that as a result of processing of multichannel images using technology to increase depth of the species of Earth remote sensing data based on ISA - Wavelet transformation composite images are of a higher quality and increased informativity compared with the primary snapshots. Compared with existing methods of merging the proposed information technology on the basis of ICA Wavelet transform allows to increase the spatial fragmentation of a multichannel image without significant color distortion. Further research will be devoted to the improvement of the offered technology while processing multichannel digital images with the involvement of the information obtained in the infrared range.

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