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HOMOMORPHIC FILTERING OF PHOTOGRAMMETRIC IMAGES

Abstract. The homomorphic filtering based method for pre-processing of digital photogrammetric images, which increases the information value of the primary images for reliable image geometric forms recognition is provided in this paper.
Keywords: homomorphic filtering, photogrammetric image, information entropy, signal entropy.

Problem. Modern remote sensing hardware fix photogrammetric images in the optical, infrared, microwave radiation ranges from long distances. Every such image has separate information value concerning the importance of object presentation characteristics in its visual form. The task of multispectral raster images preprocessing providing an increase in their informative value has its real importance.

Analysis of researches. Several studies devoted to multitone raster image preprocessing improve its visual quality without taking into account the physical mechanisms of landscape information fixing, including band-to-band correlation. Other studies solve this problem basing on the calculation of digital image statistic parameters (principal component analysis).

The homomorphic filtering is generalized technology for digital image processing involving nonlinear reflection in other dimensions, where the theory of linear filters can be used, with reverse reflection in primary space [1].

The essence of homomorphic image processing is to normalize the levels of brightness, namely to narrow their dynamic range while improving his contrast [2] with the result that the efficiency of image processing significantly increases.

The aim of the work is to develop an algorithm of multitone photogrammetric remote sensing images preprocessing while images are obtained by means of scanner, and using the homomorphic filtering in it should ensure their information value increase.

Theoretical information. Brightness may be considered as low-frequency component because of illumination that changes rather slowly in space, and picture (resolution component) may be regarded as high-frequency signal because of small parts that image may contain, that leads to rapid changes in its texture and configuration. The product of these components is a resultant signal of the initial image

$$f(u,v)=f_i(u,v)\cdot f_r(u,v)\ , \qquad (1)$$

where $f(u,v)$ - intensity image, $f_i(u,v)$ - illumination function and $f_r(u,v)$ - resolvability function, u,v - discrete spatial variables.

For the purpose of dynamic range narrowing the component of illumination have to be processed, and to enhance the contrast we should to process the component of resolvability. To this effect the task comes to a linear by means of homomorphic processing

$$f^{¿}(u,v)=\ln[f(u,v)]=\ln[f_i(u,v)\cdot f_r(u,v)]=¿$$
$$¿\ \ln f_i(u,v)+\ \ln f_r(u,v)=f_i^{¿}(u,v)+\ f_r^{¿}(u,v)\ , \qquad (2)$$

where $f^{¿}(u,v)$ – image density, $f_i^{¿}(u,v)$ and $f_r^{¿}(u,v)$ - in accordance the densities of illumination and resolution functions.

Thus, the multiplicative components of the image are separated and then can be processed independently. The linear high-frequency filter is applied to the received signal $f^{¿}(u,v)$, then in order to linear systems properties the following expression is obtained

$$g^{¿}(u,v)=g_i^{¿}(u,v)+\ g_r^{¿}(u,v)\ , \qquad (3)$$

where $g^{¿}(u,v)$ – image density processed, $g_i^{¿}(u,v)$ and $g_r^{¿}(u,v)$ – in accordance the densities of illumination and resolution functions processed.

In order to return to the original space should use the potentiating

$$g(u,v)=\exp[g_i^{¿}(u,v)+\ g_r^{¿}(u,v)]=¿$$
$$¿\ \exp[g_i^{¿}(u,v)]\cdot\exp[g_r^{¿}(u,v)]=g_i(u,v)\cdot g_r(u,v)\ , \qquad (4)$$

where $g(u,v)$ – image intensity processed.

Information entropy is one of the main characteristics of multispectral raster image information value and is calculated by the expression [3]

$$E(x)=-\sum_{k=0}^{N-1} p_k\cdot\log_2 p_k\ , \qquad (5)$$

where N – number of brightness levels, p_k – k-th luminance level frequency of the sample x; k - integer brightness level, which belongs to the interval [0, 255].

Signal entropy is a measure of multispectral images information value [4]

$$E_{сигн}(x)=-\sum_{i=0}^{N-1} p_i\cdot\log_2 p_i\ , \qquad (6)$$

where N - number of brightness levels, $p_i = \frac{i \cdot x_i}{\sum_{j=0}^{255} j \cdot x_j}$ is an analog to the *i*-th luminance level frequency of sample x; i - integer brightness level, which is owned by the interval [0, 255].

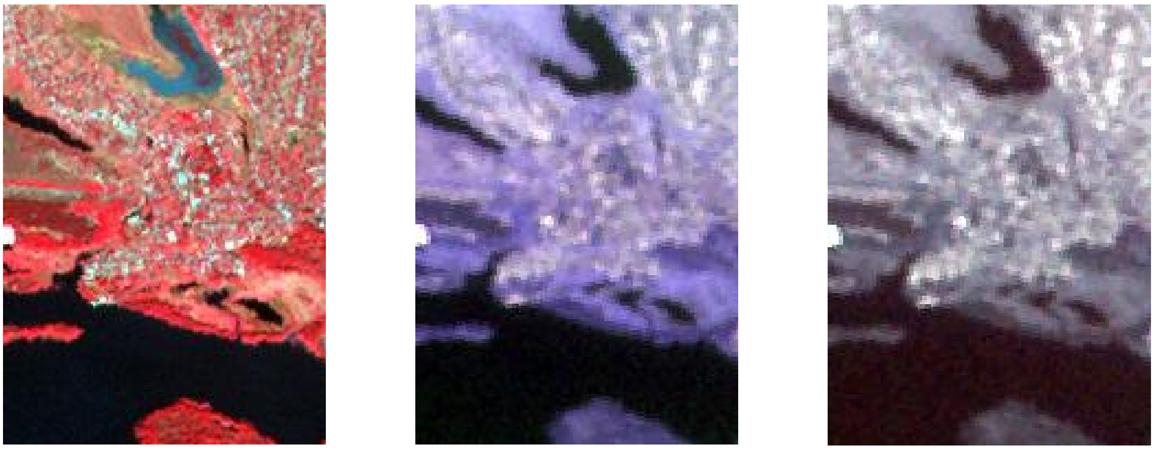
Results. The homomorphic processing of landscape data removes (filters) the excess (introduced) information from the initial images; that one is brought into being fixed landscape picture with the influence of optical complex imaging devices during land survey.

The proposed homomorphic processing algorithm consists of following stages:

– Determination of initial image complex cepstrum;
– Determination of the optical transfer function and its spectrum;
– Calculation of the difference between image complex cepstrum and optical transfer function spectrum taking the natural logarithm;
– Inverse transforms for the purpose of obtaining the natural image sought-for.

It should be noted that the calculation of the spectrum was performed using two-dimensional fast Fourier transform.

The initial data for the homomorphic processing algorithm research was a stack of spacecraft Terra (Aster scanner) initial landscape images, fixed in nine spectral ranges of electromagnetic radiation (Figure 1).



a *b* *c*

Figure 1 – Initial images

a) the first RGB-image formed with images of 1st, 2d and 3d bands;

b) the second RGB-image formed with images of 4th, 5th and 6th bands;

c) the third RGB-image formed with images of 7th, 8th and 9th bands

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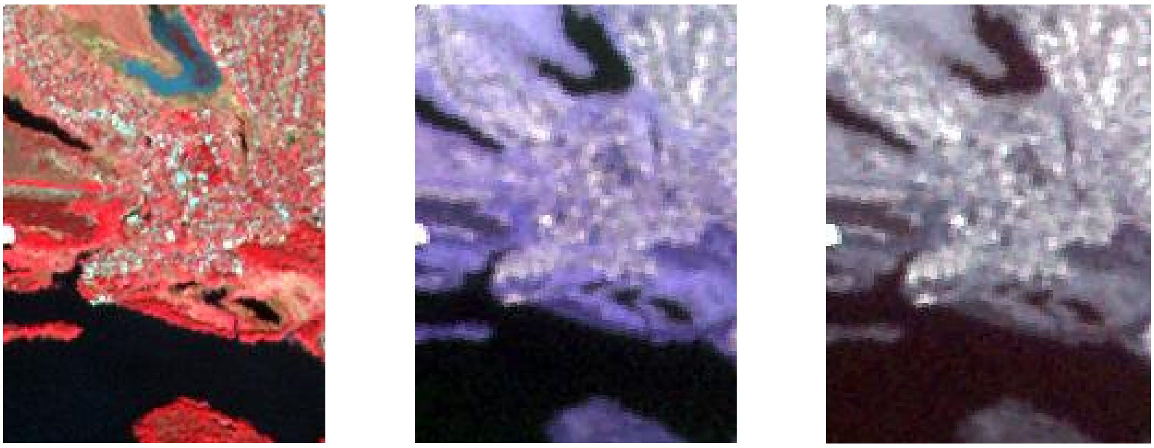
The images obtained in the issue of initial images homomorphic filtering form appropriate RGB - images shown in Figure 2.



a *b* *c*

Figure 2 – Results of homomorphic processing

a) the first RGB-image generated with images of 1st, 2d and 3d bands; b) the second RGB-image generated with images of 4th, 5th and 6th bands; c) the third RGB-image generated with images of 7th, 8th and 9th bands

The values of information and signal entropies calculated for each of nine bands of initial and resulted images accept in the issue of homomorphic filtering are shown below in the table 1.

Table 1

Information and signal entropies

Processing / Band №	Information entropy		Signal entropy	
	Initial	Processed	Initial	Processed
1	4.6392	5.0167	4.7139	5.2269
2	4.6527	5.0463	4.6970	5.2519
3	4.9739	5.5735	4.7303	5.5085
4	4.9132	5.5212	4.5634	5.3544
5	4.6431	5.1213	4.4294	5.0717
6	4.8352	5.3312	4.5899	5.2545
7	4.7105	5.2654	4.5222	5.2350
8	4.7585	5.2519	4.6294	5.2881
9	4.4914	5.0395	4.4913	5.1587

Increasing of signal and information entropy values (see table) for homomorphicaly processed images as compared with initial ones indicates about the increase of image information value in the issue of the image homomorphic processing application due to clearance of image noise introduced by filming equipment.

Conclusions. Homomorphic filtering was used for information value increase of images have been processed. Homomorphic processing allows normalizing photogrammetric image brightness levels and simultaneously increasing their contrast. It also removes the multiplicative noise from the processed image.

Further development of the proposed researches may hold towards new ways of spatial intensity distribution converting during preprocessing by using other homomorphic filtrating approaches in order to increase the efficiency of the proposed methods.

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REFERENCES

1. Залманзон Л. А. Преобразования Фурье, Уолша, Хаара и их применение в управлении, связи и других областях / Л. А. Залманзон.- М.: Наука. - 1989. - 496 с.

2. Гренандер У. Лекции по теории образов: в 2 томах / Том 2: Анализ изображений / У. Гренандер: пер. с англ. – М.: Мир, 1981. – 448 с.

3. Шеннон К. Работы по теории информации и кибернетике / К. Шеннон: пер. с англ. – М.: ИИЛ, 1963. – 830 с.

4. Корчинський В. М. Підвищення інформативності проекційних растрових зображень / В. М. Корчинський, О. М. Гордієнко // Прикладна геометрія та інженерна графіка / Праці Таврійської державної агротехнічної академії. – Вип. 4, т. 25 //. – Мелітополь: ТДАТА, 2004. – С. 33-37.