Possible Procedure Modification and a System Likeness for Object Identifying on Remote Sensing Images

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ABSTRACT

Modified grey-scale image objects classification on the basis of variance analysis of their vectorial models is suggested. After calculating the generalized, the intergroup and the average of particular dispersions the variance ratio of vectorial models of analyzing objects is computed and classification on the basis of threshold values of their similarity is made. Experimental classification data are cited.

INTRODUCTION

Similarity measure is one of the important instruments of data analysis in matching, classification, similarity evaluation and correlation of analyzing objects [1]. Wide application of the correlation coefficient as a measure of similarity of analyzing objects becomes above all clear due to its stability as an image recognition characteristic both under gross and small volume of sampling [2]. It should be stated that the correlation coefficient is near true as few as there is a gross number of independent observations subject to the same near-normal distribution. In cases with limited number of experimental data and their non-linearity it is recommended [2] to use correlation ratio (CR) – η.

$$\eta = \sqrt{\frac{\bar{\delta}_i^2}{\sigma^2}}, \tag{1}$$

where $\bar{\delta}_i^2$ - intergroup (intragroup) dispersion; σ^2 - generalized dispersion.

1. CORRELATION RATIO MODIFICATION

Weights of vectors of the tracing contour described similarly the chain code (table 1) would be used as invariant information features.

Table 1

Normalized vectorial models of analyzing objects

Object number	Vector weights	Rotation angle, α
1	2,2,1,2,4,5,6,5,5,5,7,8,8 (13)	0^0
2	2,1,2,2,4,5,6,5,5,5,7,8,8 (13)	0^0
3	2,2,1,2,4,5,5,6,5,5,7,8,8 (13)	0^0

Weights of vectors of the object #1 used as etalon features are labeled as A_I. Features of analyzing objects #2 and #3 (table 1) are correspondingly labeled as $B_2[i]$ and $B_3[i]$. Visualization of 3 object contours and superimposed image of these synthesized objects are shown on fig 3.

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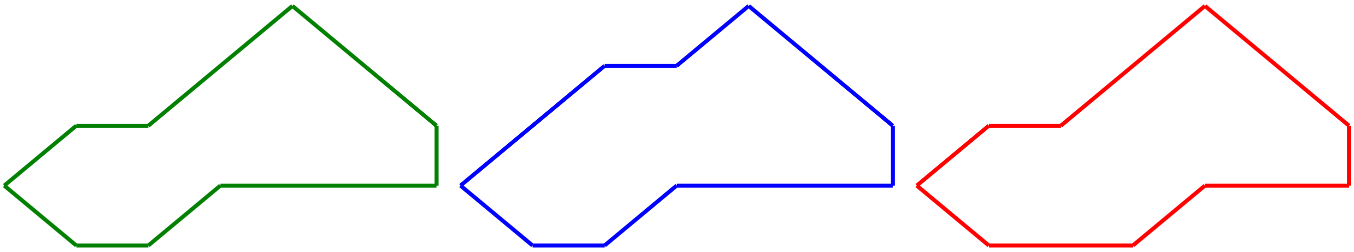
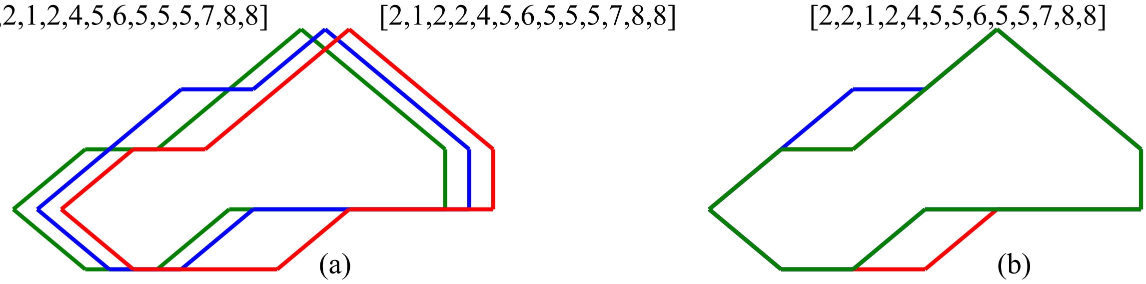


Object 1 (etalon) [2,2,1,2,4,5,6,5,5,5,7,8,8]

Object 2 [2,1,2,2,4,5,6,5,5,5,7,8,8]

Object 3 [2,2,1,2,4,5,5,6,5,5,7,8,8]



(a) (b)

Fig.1. Sub-superimposed (a) and superimposed (b) image of 3 synthesized objects

The average of particular dispersions [3] for objects #2 and #3 is correspondingly

$$\bar{\sigma}^2{}_{A(B_2)} = \frac{\sum (A[i] - B_2[i])^2}{n} = \frac{2}{13} = 0{,}15384615;$$

$$\bar{\sigma}^2{}_{A(B_3)} = \frac{\sum (A[i] - B_3[i])^2}{n} = \frac{2}{13} = 0{,}15384615.$$

Generalized dispersion

$$\sigma_A{}^2 = \frac{\sum A_I{}^2}{n} - \overline{A}_I^2 = \frac{342}{13} - \frac{60}{13} = 5{,}00591716.$$

Intergroup dispersion for objects #2 and #3

$$\bar{\delta}^2_{B_2} = \left|\sigma^2_A - \bar{\sigma}^2_{A(B_2)}\right| = 4{,}85207101; \quad \bar{\delta}^2_{B_3} = \left|\sigma^2_A - \bar{\sigma}^2_{A(B_3)}\right| = 4{,}85207101.$$

Correlation ratio

$$\eta_{(A,B_2)} = \sqrt{\frac{\bar{\delta}^2{}_{B_2}}{\sigma^2_A}} = \sqrt{\frac{4{,}85207101}{5{,}00591716}} = 0{,}98451366;$$

$$\eta_{(A,B_3)} = \sqrt{\frac{\bar{\delta}^2{}_{B_3}}{\sigma^2_A}} = \sqrt{\frac{4{,}85207101}{5{,}00591716}} = 0{,}98451366.$$

Calculated CR of analyzing objects B_2 and B_3 relative to CR of the etalon are equal although descriptions of their contour representation are different (table 1). Analysis of vector weights and experiments to qualify correlation ratio have shown [5, 6] that it is necessary to inset ranking of differential values $(A[i] - B_l[i])k$. Insertion of k-coefficient for differential values ranking of vectors is **the first modification** of the utilized correlation ratio [6, 9]. Differential values ranking could be made using the following mathematical equations:

$$k_1 = \sqrt{\frac{i(A[i] + B_l[i])}{n(S_1 + S_l)}} \quad (2); \quad k_2 = \sqrt{\frac{i}{n}\left(\frac{A[i]}{S_1} + \frac{B_l[i]}{S_l}\right)} \quad (3); \quad k_3 = \sqrt{\frac{i}{n}} \quad (4),$$

where i – running number of the analyzing object vector whose differential weight is other than zero;

n – number of vectors of etalon or the analyzing object (the most of them is chosen);

S_1 – sum of weights of vectors of the etalon;

S_l – sum of weights of vectors of analyzing object (*l*).

Second modification of CR is bound up with the requirement fulfillment about the similarity measure symmetry [2] $\eta_{(A,B)} = \eta_{(B,A)}$. Modified CR (MCR) meeting mathematical requirements of similarity measure [2] is given by the following [5]:

$$\eta_M = \sqrt{\frac{\bar{\delta}^2_{R_l}}{\sigma^2_{R_l}}}, \quad (5)$$

where $\sigma^2_{R_l} = \sigma^2_A + \sigma^2_{B_l}$ – sum of generalized dispersion of the etalon (A) and the analyzing object (B_l);

$\bar{\delta}^2_{R_l} = \bar{\delta}^2_A + \bar{\delta}^2_{B_l}$ – sum of intergroup dispersion of the etalon (A) and the analyzing object (B_l).

Experiments gave preferences to the ranking coefficient selection and the add-on of lacking direction vectors up to the equinumerous set of features by mathematical expectation meanings of their vectorial models:

$$\eta_{(A,B_2)} = \eta_{(B_2,A)} = 0{,}99437419; \ \eta_{(A,B_3)} = \eta_{(B_3,A)} = 0{,}99209212.$$

2. VARIANCE RATIO FORMATION OF VECTORIAL MODELS OF ANALYZING OBJECTS.

On a basis of MCR utilized as a similarity measure of analyzing objects boundary representation on grey-scale images, we'll consider the following variance ratios:

- intergroup and generalized dispersions (5) – correlation ratio;
- generalized dispersion to the sum of the generalized and the average of particular dispersions

$$\eta_2 = \sqrt{\frac{\sigma^2_{R_l}}{\sigma^2_{R_l} + \bar{\sigma}^2_l}}; \quad (6)$$

- intergroup dispersion to the sum of the generalized and the average of particular dispersions

$$\eta_3 = \sqrt{\frac{\bar{\delta}^2_{R_l}}{\sigma^2_{R_l} + \bar{\sigma}^2_l}}, \quad (7)$$

aimed for evaluation of a similarity measure and subsequent objects classification.

3. EXPERIMENTAL VERIFICATION OF AN EQUINUMEROUS SET OF FEATURES FOR OBJECTS CLASSIFICATION.

To process a grey-scale remote sensing space image on a computer it is necessary to digitize it. A digital image of certain locality is depicted on the figure 2. Optical density (image density) value and its outside configuration (geometry) characterize a grey-scale image of the locality. A contour carries the maximal information about an object image and significantly enables to decrease the computer input of information content during selective inputting but particularly affected to brightness and geometric distortions. In this context utilization of optimum intervals of brightness threshold values and local anisotropic filtration of search zones of the nearest point enables to get more higher boundary representation of grey-scale image objects and forms its vectorial model in a boundary tracking process.

The digital image after its filtration and boundary extraction utilizing the concurrent activities in displacement and summation during the image convolution with mask transform [5] is depicted on the Figure 3. In process of boundary extraction the vectorial models of boundary representation of analyzing object are formed.

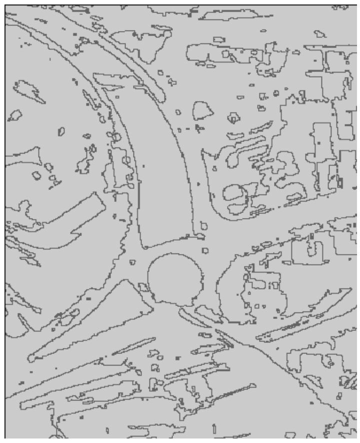


Fig. 2 Digital image of the locality

Fig. 3 Digital image processing effect

To increase accuracy and trustworthiness of contour's readout on grey-scale object images in the United Institute of Informatics Problems, Belarus it was developed a system providing automatic selective readout and boundary representation [8]. The subsystem for boundary representation (Fig. 4) contains Scanner (S), Photoelectric converter (PhC), Analog-digital conversion unit (ADCU), Memory unit (MU), Boundary points selection unit (BPSU), Control unit (CU) Searching scan unit (SCU), Graphics tracking unit (GTU), Threshold value formation unit (TVFU) and Commutator (C)

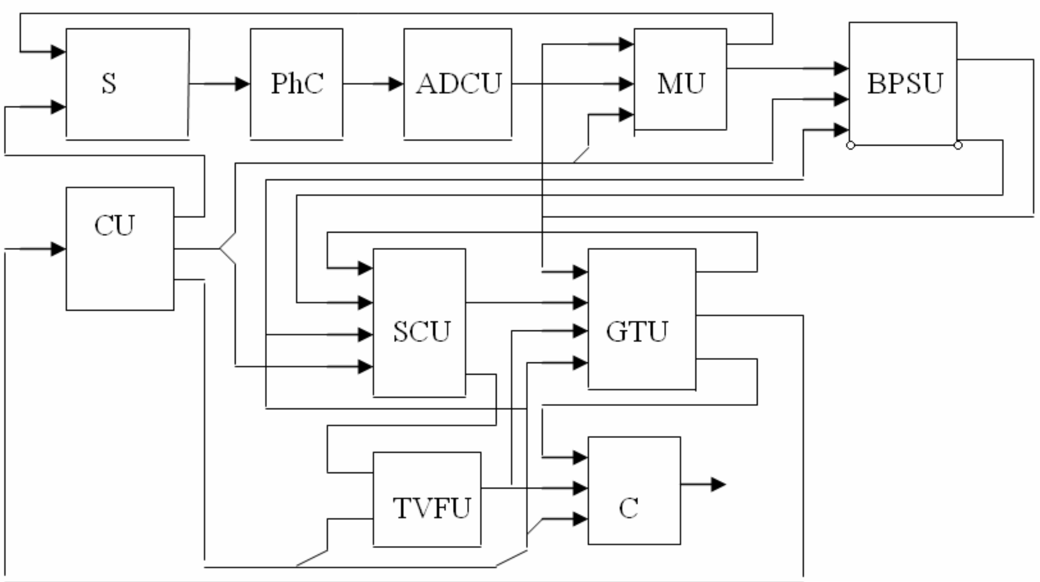


Fig.4 Block diagram of object edge recognition subsystem on remote sensing images

Normalization of analyzing objects vectorial models by scale and orientation [6] enables to form invariant information features. Normalized vectorial models of 7 analyzing objects, first of which was set for the etalon are located in table 2.

Adding the lacking vectors weights up to the equinumerous set of features by mathematical expectation meanings and using the ranking coefficient we compute variance ratios (5) and (6) for the locality situated analyzing objects by the worked out software module TKO7, and classify them by threshold values of similarity measure [7].

Table 2

Normalized vectorial model of initial image objects

No	Vectors weights {number of vectors}	Rotation angle, α
1	1,1,1,1,3,3,3,3,3,5,3,3,3,5,5,5,5,7,5,7,7,7,1,7,7,7,1,7 {28}	0^0
2	1,1,1,3,3,3,3,3,3,3,3,3,3,5,5,5,5,5,7,7,7,7,7,7,7,7,1,1,7,7 {30}	0^0
3	1,1,3,3,1,1,1,3,3,3,5,5,5,5,5,3,5,5,7,7,5,7,1,7,7,1,1,7 {28}	180^0
4	1,1,1,1,1,1,1,3,3,3,3,3,5,5,3,5,5,5,5,5,5,5,7,7,7,7,7,1,1,7 {30}	0^0
5	1,1,1,3,1,1,1,1,3,3,3,5,5,5,5,5,5,5,5,7,7,7,1,7 {24}	0^0
6	1,1,1,1,3,1,3,3,1,3,3,3,3,5,3,3,5,3,5,5,7,5,5,5,7,5,7,5,5,7,5,7, 1,7,1,7,7,1,7,1,1,7 {42}	0^0
7	1,1,1,3,1,1,1,3,3,3,3,3,3,3,5,3,5,5,5,5,5,7,7,7,5,5,7,7,7,7,7,1,1,7 {34}	270^0

Results of a similarity measure computing for analyzing objects using variance ratios (5) – (7), the ranking coefficient and an add-on of lacking direction vectors weights of the etalon or the analyzing object by mathematical expectation meanings are located in the Table 3. It should be stated that ranking of analyzing objects (table 3) in decreasing order of their variance ratios has the same distribution for utilized variance ratios (5)-(7).

Table 3

Computation of variance ratios value

Object number	η_M	η_2	η_3
1	1,00000000	1,00000000	1,00000000
2	0,89260599	0,91168540	0,81373810
3	0,90017516	0,91681997	0,82529857
4	0,82261843	0,86930268	0,71510441
5	0,90868641	0,92281044	0,83854531
6	0,84103261	0,87954314	0,73972447
7	0,83581908	0,87658396	0,73266559
$\sum \Delta\eta_i / n$	0,11415176	0,08903634	0,19070336

It follows from the Table 3 that variance ratio values (7) have the smallest similarity measures for analyzing objects relative to values computed with equations (5) and (6). Hence the variance ratio (7) $\sum \Delta\eta_3 / n = 0{,}19070336$ is more sensitive to the similarity measure of analyzing objects relative to distinguishing [observable] features of direction vectors weights in the capacity of their boundary representation.

Boundary representations of 7 analyzing objects with their variance ratios are depicted on the Figure 5.

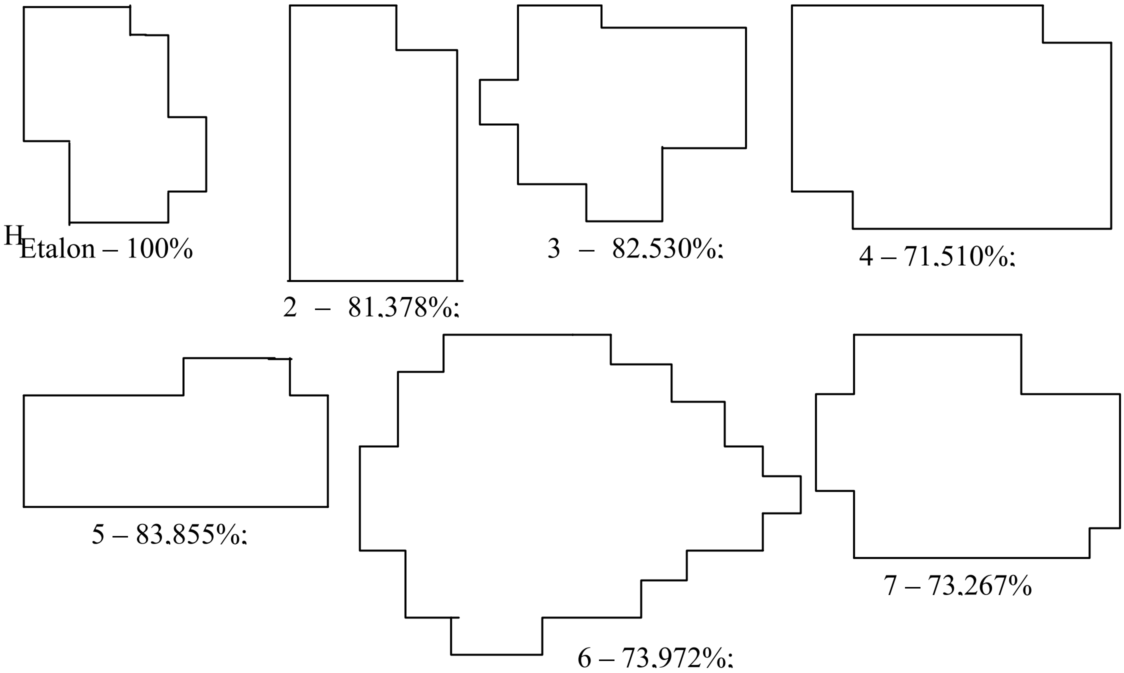


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Fig. 5 Boundary representations of analyzing objects with their variance ratios

Classification results of analyzing objects by threshold values of their variance ratio are located in the table 4.

Table 4

Analyzing objects classification

Object numbers	MCR, %	Object's cluster number	Cluster number	Thresholds Similarity measures
1	100,00	1	1	99,953 – 100,000
2	81,373	10	2	99,730 – 99,952
3	82,530	10	3	99,400 – 99,729
4	71,510	11	4	98,760 – 99,399
5	83,855	9	5	97,560 – 98,759
6	73,972	11	6	95,450 – 97,559
7	73,267	11	7	92,810 – 95,449
	-	-	8	89,040 – 92,809
	-	-	9	83,850 – 89,039
	-	-	10	76,990 – 83,849
	-	-	11	68,270 – 76,989
	-	-	12	57,630 – 68,269
	-	-	13	45,750 – 57,629
	-	-	14	31,080 – 45,749
	-	-	15	15,850 – 31,079
	-	-	16	0,800 – 15,849

System likeness for object identifying on remote sensing images is shown on the fig. 6.

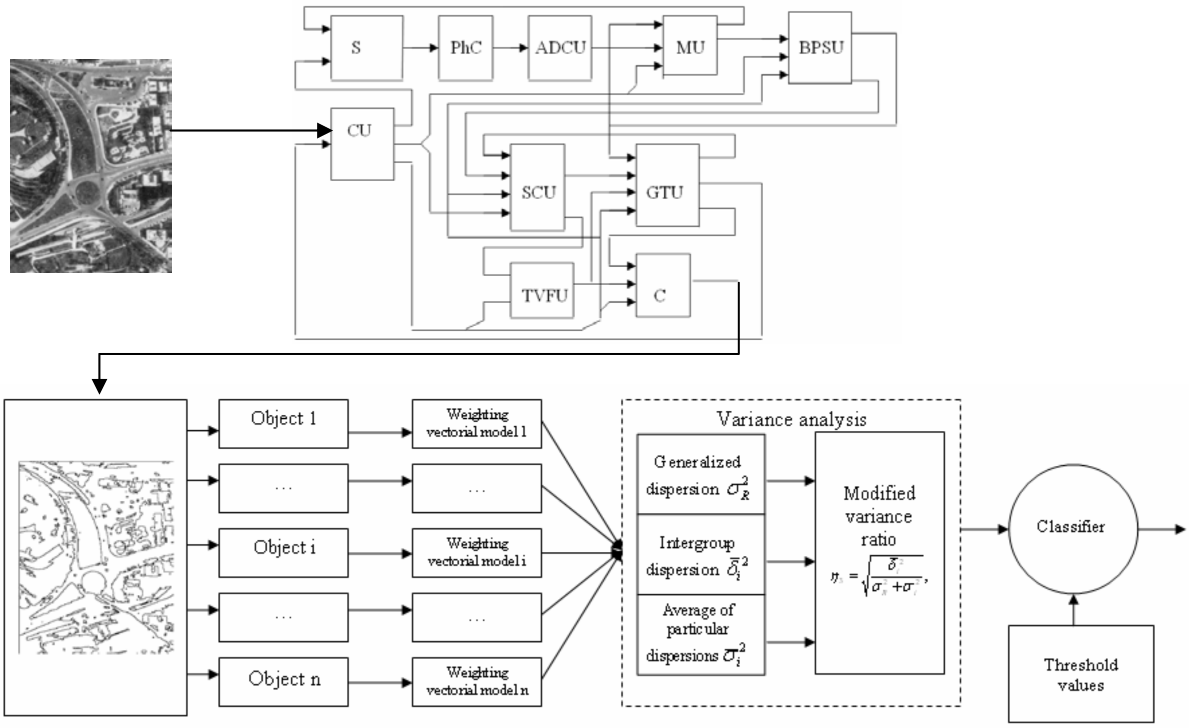

Fig. 6. Object identifying system likeness

CONCLUSION

The sensitivity of variance ratio computing is increasing up to 5,74% relative to utilized variance ratio (5) by forming and using of equinumerous set of features (adding direction vectors weights by mathematical expectation and computing the ranking coefficient of difference between etalon vector weight and analyzing object vector weight) for classification of analyzing objects on remote sensing images by their boundary representation with the aid of variance ratio (7) of their vectorial models.

REFERENCE

[1] G.V.Raushebakh. Measure of Adjacency and Similarity // Analysis of Non-numerical Information in Social Case Studies. Moscow: Naukha (Science), 1985. – pp 169-203.

[2] Applied Statistics. Classification and Dimension Reduction. Book of Reference. S.A. Ajvazjan, K.M.Bukhshtaber, I.S. Enjukov, L.D.Meshalkin / Edited by S.A. Ajvazjan. - Moscow: Finansy and Statistika (Finance & Statistics), 1989.

[3] Venetsky I.G., Kildishev G.S. Theory of Probability and Mathematical Statistics. - Moscow: Statistika (Statistics), 1968.

[4] Lapa V.G. Mathematical Fundamentals of Cybernetics. – Kiev: Vysshaya Shkola (The Higher School), 1971.

[5] Identification of Contour Objects on Remote Sensing Images / Ablameyko S.V., Borichev S.P. Kruchkov A.N., Kuleshov A.Y. // 1-st Byelorussian Space Congress: Materials of the Congress 28-30 October, 2003. – Minsk: UIIP NAS of Belarus, 2003. – pp 143-145.

[6] Kuleshov A.Y., Romanchik D.V. Classification of Scale-grey Images in the Absence thereof Learning Samples // Digital Image Analysis: Collected articles / Edited by S.V.Ablameyko – Minsk: UIIP NAS of Belarus, 2002. – pp 59-68.

[7] Ablameyko S.V., Kuleshov A.Y. Definition of Contour Objects Similarity Measure, approximated by Circular Arcs // Pattern Recognition and Image Analysis: Paper theses of the 2-nd All-Russian Conference attended by CIS scientists. – Moscow, 1995. – part 2. – pp 53-56.

[8] USSR Certificate of Authorship #1785014 (G06 K 9/00). Extraction System for Contour Object Images / V.K.Erokhovets, M.A.Samoshkin, A.Y.Kuleshov (USSR). - № 4873043/24; Rights claimed on 30.08.90; Published 30.12.92, Bulletin № 48 // Discoveries. Patents. – 1992. - № 48. – p. 166.

[9] Kuleshov A.Y., Formation of Characteristics for Object Identification on Remote Sensing Images Using Correlation Ratio // Information Processing and Control in Emergencies and Extremis. Proceeding of the 4th international conference 29 November – 1 December 2004. Minsk: UIIP NAS of Belarus, 2004. pp 152-157.