Image Structure Evaluation by Statistical Intensity Features

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Abstract - In this paper an extraction of intensity variance, size-intensity mean features and color concentration is considered. Their effectiveness is evaluated for image structure analysis.

Key words – image intensity, size-intensity mean value, color concentration.

I. Introduction

Surface structure analysis and defects detection are being used in the automatic production of metal constructions, electronic circuit boards and so on. Automatic control could be realized by software having in its core algorithms to analyze and to compare the patterns of etalon and real samples of controlled surfaces. To simplify the problem the pattern is divided into some fragments and different intensity features for them as charts for similarity are calculated. So, the summary distance is taken as an indicator for surface structure irregularity, metal or board defects.

The pattern features are mainle based on intensity or color histograms, relative location of colored regions of objects, their shape, Fourier-functions coefficients etc. Nowadays there are a number of works dedicated to the algorithms of image features extraction. The [1 − 3] demonstrate the construction of regions, histograms of color blocks and their invariant coefficients. In [4 − 6], the shape construction algorithms of the main objects of attention and their quantitative characteristics are presented. Some systems segment the image into regions by color and size and then the feature vectors are calculated. The majority of the above mentioned approaches are quite complicated and time-consuming. So, in presented article two new statistical features are considered. They are proposed to be useful for surface image analysis, classification and evaluation of changes inserted by exploitation and elaboration.

II. Image Intensity Features

For image analysis and classification statistical features are widely used. The main features are based on intensity histogram and central moments by order *n* **:**

$$\mu_n[z(i)] = \sum_{i=0}^{L-1} (z(i)-m)^n \, p(i), \qquad (1)$$

where $p(i), i = 0,1,2,...,L-1$ is histogram.

However, this small number of statistical features are insufficient information for image classification and searching.. So, we propose to determine the main statistical moment (variance) for a number of image segments.

The image intensity is divided into n horizontal fragments with interval (intensity fragmentation step) d = 255 / n.

The intensity segment of image is a consequence of fragments and its intensity variance is as follows:

$$E^2(1 \div s) = \frac{1}{K_s} \sum_{i \in 1,\dots,K_s} (I_i(1 \div s) - \overline{I}(1 \div s))^2 \qquad (2)$$

where $I_i(1 \div s)$ – pixel intensity in the image segment, K_i – a number of pixels. So, we get the image intensity variance depending on the segment level

The next statistical feature – color concentration - we determine as the ratio of color pixel number and its perimeter length. We consider two sets of pixels : of interesting color (for example, we call them “black”) and the rest all pixels (“white”) of the image. The corresponding numbers of pixels we denote as S_b and S_w. Also we denote the border between the sets as $S_L(b,w)$.

The color concentration of “white” and “black” as follows

$$\begin{aligned} K_k(w) &= S_w / S_L(b,w), \\ K_k(b) &= (S_b - S_L(b,w)) / S_L(b,w) \end{aligned} \qquad (3)$$

By realization of formulas (2) for all 255 intensity segments we get three image intensity features independent from any coordinate transformations.

Close to previous feature is so-called size –intensity feature. Having two image segments of conditionally “black’ and “ white” pixels we can measure the mean value of line lengths (sizes) in the selected segmented part of image. It could be in the “black” or “white” set. Also it could be by OX or OY coordinates, for example :

$$R_L(B_p, y) = \sum_{x \in X} R_{Li}(B_p(x,y))$$

$$\bar{R}_L(B_p, y) = R_L(B_p, y) / N_L \qquad (4)$$

where $R_{Li}(B_p(x,y))$ – i-th size in the segment $B_p(x,y)$, N_L - a number of lines

On fig. 1 an example of image and its intensity features are presented: histogram, cumulative histogram, color concent-ration of “black” pixels, variance and size-intensity.

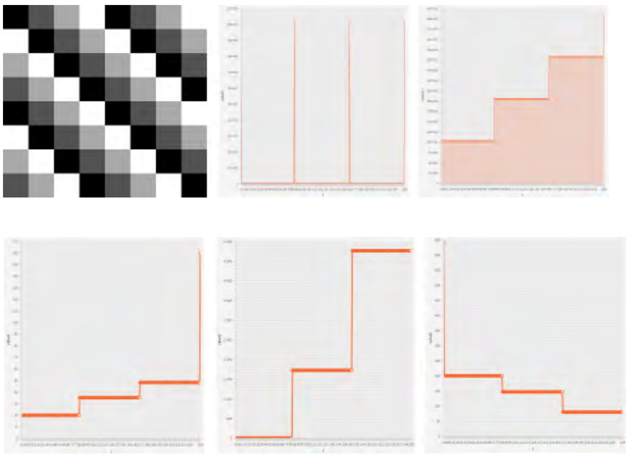

Fig. 1. Intensity features of the image

III. Measurement of Image Structure Regularity

The mage intensity features allow to measure regularity or irregularity of material surface structures. We consider, for example, two images of steel surfaces (fig. 2).

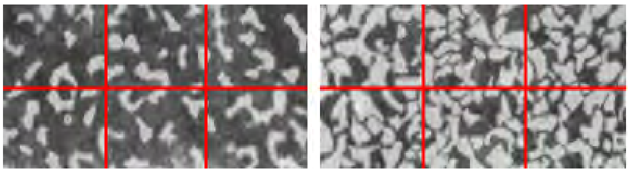

Fig. 2. Steel surfaces

Dividing presented images into six parts we calculate for every of them the intensity features (fig.3).

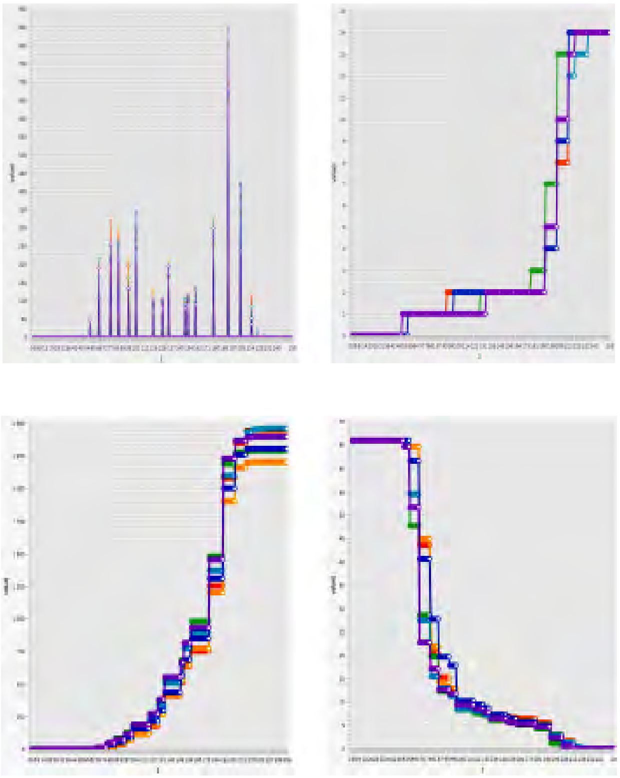

Fig. 3. Histogram, color concentration, variance and size-intensity of six parts

Having four characteristics for every image we calculate similarity function :

$$F_{kl} = \frac{1}{s} \sum_{i \in 1,\dots,s} (f_k(i) - f_l(i))^2 , \quad (5)$$

where $f_l(i)$ $f_k(i)$ - intensity feature values,

An example of similarity matrix is presented in the table 1.

TABLE 1

SIMILARITY MARIX BY SIZE-INTENSITY

	1_0.png	1_1.png	1_2.png	1_3.png	1_4.png	1_5.png
1_0.png	0.0	1.8626	0.3675	7.4492	6.8389	7.237
1_1.png	1.8626	0.0	1.644	2.664	2.6465	2.4813
1_2.png	0.3675	1.644	0.0	5.499	4.8102	5.401
1_3.png	7.4492	2.664	5.499	0.0	0.2301	0.0216
1_4.png	6.8389	2.6465	4.8102	0.2301	0.0	0.3399
1_5.png	7.237	2.4813	5.401	0.0216	0.3399	0.0

To compare effectiveness of the considered intensity features we summarize all elements by every intensity feature of the steel to get the irregularity value by concrete characteristic. So the results are given in the table 2.

TABLE 2

FEATURE SIMILATIRY VALUES OF STEEL IMAGE PARTS

	Intensit y	Concentration	Variance	Size-intensity
Steel 1	12,06	54,10	17,73	49,49
Steel 2	2,25	19,39	12,13	19,04

So, we can notice, that color concentration and size-intensity features give us greater intervals for estimation of image structure regularity or irregularity.

Conclusion

Some intensity features for image structure regularity estimation are proposed. They are based on statistical characteristics: variance and mean sizes value, color concentration. They are applied to measure a structure regularity of material surface. They could be used for image classification and searching on preliminary stages of pattern recognition.

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