The Dynamic Information in the Images

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Динамічна Інформація в Зображеннях

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***Abstract*—Taking into consideration the importance of texture features in the problems of image segmentation, texture evaluation and classification, object recognition and so on, the approach to the texture features extraction with the image dynamics is proposed in this work. The conception of the image δ-entropy, which represents mean value of the signal derivative magnitude, is introduced. It allows detecting and evaluating of the amount of useful (dynamic) information in the image. In addition, it allows extracting from the cross section of the image the following texture features: space frequencies over the image rows and columns, granularity of texture, contrast, directivity and regularity. Such approach allows rather simply conducting a segmentation of the images with the areas of texture type, evaluating of texture parameters and classifying of textures, simplifying of the object recognition with the information from the cross section of the image.**

***Анотація*—Враховуючи важливість текстурних ознак в завданнях сегментації зображень, оцінки і класифікації текстур, розпізнавання об'єктів і тому подібне, в роботі пропонується підхід до виділення текстурних ознак по динамічності зображення. Вводиться поняття δ-ентропії зображення, яке є середнім значенням модуля похідної сигналу. Це дозволяє виділяти і оцінювати кількість корисної (динамічної) інформації в зображенні. Крім того, дозволяє виділяти з поперечних зрізів зображення ряд таких текстурних ознак, як: просторові частоти по рядках і стовпцях зображення, зернистість текстури, контраст, спрямованість, регулярність. Такий підхід дозволяє досить просто проводити сегментацію зображень з ділянками типу текстур, оцінювати параметри і проводити класифікацію текстур, спростити розпізнавання об'єктів за інформацією поперечних зрізів зображення.**

***Keywords*—texture; δ-entropy; dynamic informationм; segmentation; texture characteristics; object recognition**

***Ключові слова*—текстура; δ-ентропія; динамічна інформація; сегментація; текстурні характеристики; розпізнавання об'єктів**

I. Introduction

Object search in the image is one of the fundamental problems of the image processing. The quality of the search algorithms depends on the selected set of the informative features, which describe the searched object most adequately. Specific characteristics for the given field are extracted in the concrete subject area. Those can be common characteristics for the object search in the image: color, texture, shape, orientation in the space and the object motion.

Principal consideration will be given to the issues of the segmentation and the extraction of the informative features in the images of texture type in this work.

II. State of Problem

Texture contains the information about the structure of the surfaces, which constituent the image. It has properties of periodicity and a scale, and it can be described by means of the extraction of orientation, contrast features and blurs. Texture complements the color characteristic and goes far during image comparison.

Taking into consideration the variety of texture types, the big arsenal of the methods for extraction of informative features from the textures is developed. The methods for extraction of the texture features are divided into statistical, geometrical, model and spectral ones [1].

Statistical features describe the distribution of the brightness level over the image by the instrumentality of such statistical characteristics:

- simplest statistical parameters, computed over the brightness values of each pixel;
- parameters, computed in accordance with the adjacency matrices;
- texture histograms, constructed in accordance with the Tamura features and others.

The texture determination by the instrumentality of the constituent texture elements and primitives is common for the geometrical features.

Model methods of texture analysis assume construction of the model, which helps to describe the texture and synthesize it.

Spectral features describe the texture in the frequency domain, using the signal decomposition on the certain basis. At that, the decomposition coefficients act as the elements of the feature vector.

Implementation complexity by means of computer engineering is the common drawback of all these methods.

Therefore, the aim of this work is the development of new approaches to the texture evaluation, using as a prototype the mechanisms of the information perception by the human visual analyser.

III. δ-ENTROPY AS THE MEASURE OF THE IMAGE DYNAMICS

On one hand, arbitrary area of field of view with contrast light and dark areas may be analyzed and transformed into the space frequency – number of luminosity variations on the defined space area, or cycles number of alternation of dark and light stripes on the given space area. More stripes are per the unit of the pattern area; space frequency of that pattern is more that is the patterns with the high space frequencies are made of small elements and vice versa. The space frequency per one degree of the angle of view (cycles/degree) is used practically. As it is known, visual pattern represents the pattern of luminosities that is the sum of a series of simple components. The complex space distribution of entire visual field luminance may be transformed into sinusoidal waves of simple components using mathematical apparatus of the Fourier analysis. Inverse action is summing of sinusoidal waves for the complex pattern synthesis. There are the evidences that there are the detectors of space frequency in the visual system – the specialized cells, which are sensual maximally to certain space frequencies. Thus, our perception of any complex pattern is the result of analysis and synthesis of the constituent parts of space frequencies of that pattern by the visual system and the brain reconstructs visual pattern of the object, integrating the information about different space frequencies [2].

On another hand, a human eye responds not to a magnitude of brightness or chromaticity in the image, but on changes of these variables between brightness values of neighbouring receptors or brightness values of a particular receptor in time, i.e. dynamics of this parameter. Taking into consideration the need to determine changes in brightness between adjacent elements in a row and a column of the matrix picture, it can be represented as a matrix of differences between adjacent elements (matrix increments) [2].

Glushkov V.M. gave in [3] such capacious determination of the information concept that it did not lose its actuality to the presence: " Information is most general own understanding presents the measure of ***the heterogeneity*** of the matter and energy distribution in time and in space, the measure of changes, which accompany all running processes in the world". At that two information kinds are marked out – ***static*** information (which characterizes current state of the certain material or energetic system) and ***dynamic*** information (its variability in time and in space). If the hundreds of the works were dedicated to the static information and it became already classic one, no necessary attention was attended to the dynamic information practically till late XX century. However, the determination of the dynamic information concept turned out extremely fruitful under the study of the information properties of the physical systems and processes.

The author laid down the foundations of theory of the dynamic information in the monograph [4]. That allowed extraction and use of the useful (dynamic) information out of the steady stochastic and unsteady signals, images, spatial fields, iteration processes, recurrent procedures and the like with considerable information redundancy reduction.

In contrast to the statistical information theory C. Shannon, which was created for compression of information during transmission and storage, it proposed a dynamic theory of information, which helps to distinguish useful (dynamic) information from signals, images, sequences, iterative processes, and the like, greatly reducing its redundancy, and can be the basis of transformation processes and information processing in real-time systems. This introduced the concept of entropy the value of the parameter random variable and δ-entropy that is a measure of the changes taking place in space or time. ***δ-entropy*** is defined as the average value of the modulus of the derivative of the video signal on rows or columns of the image, and for video stream – between frames [4].

δ-entropy is defined in discrete form for the evaluation of the amount of information in the image and in the video sequence as:

$$H = \sum_{j=1}^{N} \sum_{i=1}^{M} p_{ij} \, log_2 \left(\left| \frac{\Delta z_{ij}}{\delta z} \right| + 1 \right), \quad (1)$$

where: MN – dimensions of the image field,

Δz_{ij} – differences between brightness of the pixels in rows and columns.

δ -entropy is a measure of the dynamic of image and can be used to evaluate the amount of information in the image and video stream. In addition it is proposed to use a dynamic measure for finding highly dynamic areas, the textures in the image, the selection of informative features for their recognition, and the like.

A known method of averaging the cross-sectional profile of the brightness of the image by rows and columns [5] allows you to determine on the image location of the object on the background, if it differs from the background, however, does not allow allocating objects of type texture.

To search the location of such objects we propose to carry out averaging of the cross-section of image on dynamic features, i.e. the brightness difference between neighbouring pixels in rows and columns [6].

$$H\delta_i = \frac{1}{M}\sum_{j=1}^{M}\left|\frac{\Delta Z_{ij}}{\delta z}\right|; \qquad H\delta_j = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{\Delta Z_{ij}}{\delta z}\right|. \qquad (2)$$

This dynamic measure of information can be effectively used for:

segmentation of the image into high and low dynamic plot;

segmentation of text information in the image;

search and classification of textures;

barcode search, DMX-codes, fingerprints, numbers, car;

selection of motion, change of brightness or chromaticity, etc;

speed control shooting video camera and the like.

Tools are developed, which enable to extract an arbitrary area of the image and to construct diagrams of the module-averaged cross-sections of the changes of brightness along columns and rows, and also to evaluate the mean value of the module of changes across entire image in accordance with the formula:

$$H\delta = \frac{1}{MN}\sum_{j=1}^{M}\sum_{i=1}^{N}\left|\frac{\Delta Z_{ij}}{\delta z}\right|. \qquad (3)$$

The simplified method with the brightness jumps with the sign in the rows and columns can be used in the several cases for the image dynamics evaluation. In these cases it is reasonable to introduce the verification over the jump value threshold or to conduct preliminary low-frequency filtration for the noised images.

The examples of application of the proposed method are given below (Fig. 1. – Fig. 7.).

Fig. 1. Segmentation of the text information.

The text columns are extracted on the vertical cuts, and on the horizontal cuts – the text rows, even if they are overlapped by the gray scale images.

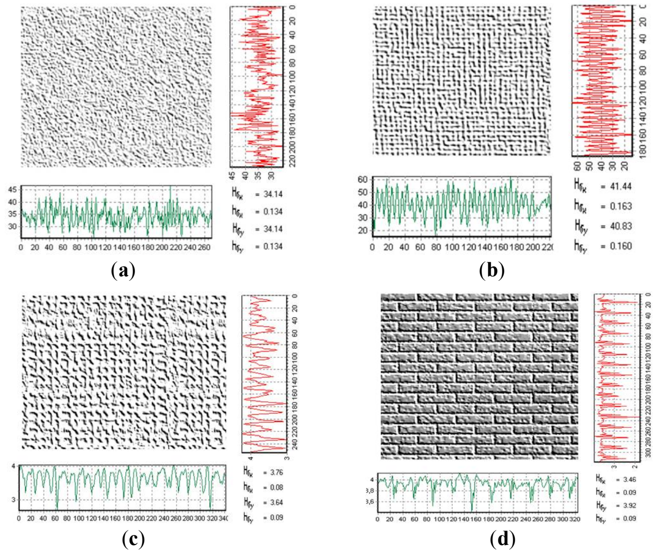

Fig. 2. Evaluation of texture parameters: a) sand, b) linen, c) sacking, d) brickwork.

The step (grain) of texture and mean values of the changes of brightness or chromaticity can be extracted on the figures. The locations of the regularity disturbances (defects) can be detected on the regular textures, for example on the Fig. 2 (c).

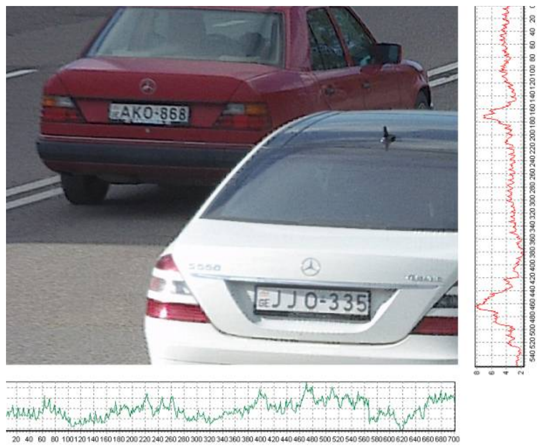

Fig. 3. Search of the car number in the car image.

The car number is clearly extracted on the horizontal cuts and less clearly on the vertical cuts.

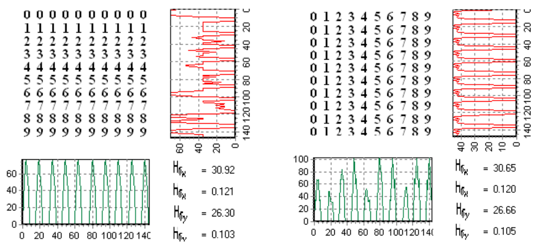

Fig. 4. Dynamical characteristics of the numerals.

All characters on the horizontal cuts a) have the differences in the amplitudes and in the quantity of extreme, which can be used for their recognition. In addition, the amplitude values of the vertical cuts b) may be also used.

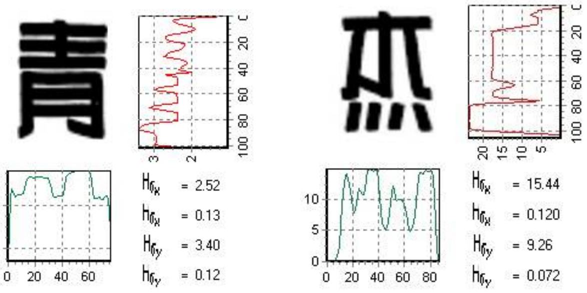

Fig. 5. Dynamical characteristics of Han characters.

Dynamic characteristics allow more simply recognizing more complex figures, for example, Han characters.

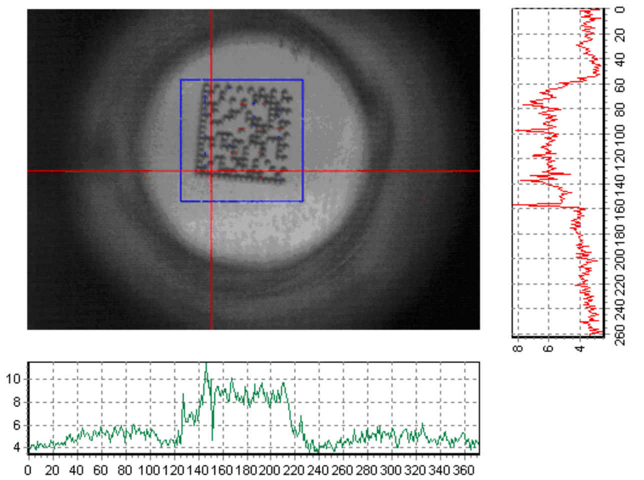

Fig. 6. Searching of the DMX-code in the micro image.

Dynamic characteristics allow determining the location of the bar-codes and DMX-codes on the products.

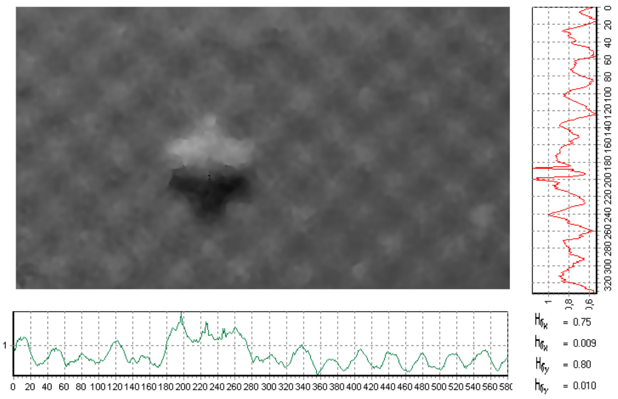

Fig. 7. Searching for defects on the cellular panel.

Dynamic characteristics can be used effectively for the quality control of the different texture surfaces of the products.

IV. Conclusions

The proposed measure of the dynamic information allows evaluating the amount of useful information in the image and in addition allows extracting a series of texture features from the cross section of the image for the image segmentation, for the texture evaluation and classification and for the simplification of recognizing the images of the texture type.

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