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Analysis of Digital Image Segments Through the Standard Deviation and Level of Detail

Ratko Ivkovic / Dragisa Miljkovic
Department of Electronic and Computer Engineering
University of Pristina, Faculty of Technical Sciences
Kosovska Mitrovica, Serbia
ratko.ivkovic@pr.ac.rs / dragisa.miljkovic@pr.ac.rs

Ivana Milosevic
SP Audio and Video Technologies
The School of Electrical and Computer Engineering
Belgrade, Serbia
ivana.milosevic@viser.edu.rs

Miroslav Pavlovic
Department of Technical Sciences
State University of Novi Pazar
Novi Pazar, Serbia
mpavlovic@np.ac.rs

Boris Gara
Ministry of Interior Republic of Serbia
Belgrade, Serbia
boris.gara@mup.gov.rs

***Abstract*—This paper presents analysis of digital images through the small areas of an image, which could be defined by some function. These areas are defined as segments of an image, by the criteria of square resolution and without any extreme changes of attributes of digital images. The analysis was made through parameters of Level of Details and Standard Deviation in Matlab software. All results are presented in tables and graphically as well. Obtained results can be used as a basis for further research and development of quality of a digital image and for better exploring of the segments' characteristic.**

Keywords-Digital Image Segments; Standard Deviations; Level of Detail (LoD); The Discrete Cosine Transform (DCT)

I. INTRODUCTION

Digital image has a uniform display on the screen; it consists of three completely separate RGB channels (signals). The values of these three separate channels are not uniformly distributed throughout the image, but every channel has variation depending on different areas of an image. The best result in measuring the image quality comes from evaluation of the level of details. The level of detail is further divided into three areas: the low level details (LL), medium level of detail (ML) and high level of detail (HL). The mean value of the level of detail is then used as a reference for image compression [1].

Each image has its specific features, which in complex cases increases the number of parameters to be processed in order to achieve the unique conclusion. It is of a great importance to separately conduct these processes for different parameters: brightness, filtering, edge detections, etc. Major challenge for the whole field of Digital Image Processing (DIP) is extracting unique conclusions for different parameters [2].

Image quality can be determined through direct and indirect parameters. Every situation requires specific tools for determination of an image quality. One of these tools is SD (Standard Deviation). The concept of SD represents deviation from the mean value of the observed environment. SD, due to nonlinearity of information of an image, cannot be used on a whole image or the entire channel. It is important, and rational, to evaluate only specific areas of the image. These areas are defined as segments. The most important feature of an image segment is the absence of any area that could be defined as the edge (by basic definition of any algorithm for detecting the edges) [3]. These segments provide relatively homogeneous areas of digital images where measurements and variations of specific parameter, like Level of Detail (LoD), give the maximum deviation from the mean pixel values of the observed environment. These measurements are conducted on each channel individually.

II. THEORETICAL FRAMEWORK

If you take into consideration different type of materials, natural or artificial, such as metal, textiles, plastics, leather, sand, wall, glass, rubber, etc. for these, it is hard to clearly distinguish their edges due to low rate of changing value degree (for any parameter) in comparison to the degree of edge detections. These kinds of materials can be recognized thanks to their structure; in most part of scientific literature they are referred under the term texture [4].

Texture is a concept defined through human perception, especially in the field of 3D modeling and definition of materials for 3D objects. However, in the field of Digital Image Processing, definition of texture is not precise, most of the used definitions describes a certain situation in which it is used, and suitable for the specific purpose.

According to IEEE Journal list of terms, one of definitions of a texture says that, texture is a certain part of the image with a specific regulated level of grayscale [5]. If we consider other definition [6], texture can be seen as the area of an image in which the group of image characteristics is almost unchangeable, constant or periodic in a precisely determined way. For areas in which texture characteristic is taken as structure [7] the emphasis is on the specifics of image segments that are repeated in certain intervals. A certain set of tools for image separation into areas with the same or similar characteristics is defined as segmentation of digital image. In case of color images (with three channels) the main characteristic is the color value; for black and white images the main characteristic is brightness, sometimes instead of these, edge detection algorithms, level of detail, etc. can be used for segmentation of digital image.

In a number of scientific papers there is no unique approach to image segmentation, only because theoretical frameworks is not yet clearly defined. Similar to the statistics, in field of DIP, SD tells how the average pixel values deviate from the mean of the observed sample. It is calculated by the following formula:

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2} \qquad (1)$$

where x_i represent observed pixel, $\bar{x}$ is the arithmetic average of the pixels environment, n is number of processed pixels.

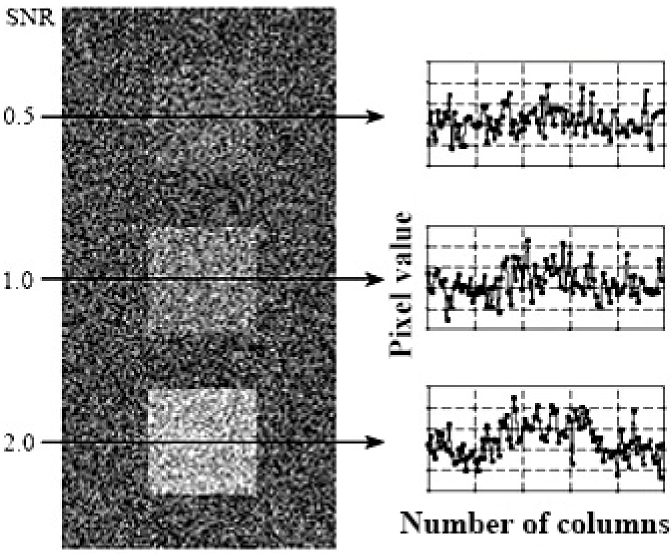

Figure 1. SNR depending on the noise in digital image

Discrete Cosine Transform (DCT) is image-compressing process (in signal form) for the elementary frequency components. Nowadays, this technique represent one of most widespread method for digital image compressing. LoD is measure of variation of pixel values in observed image. The probability of major changes corresponds to a greater level of detail, and a small change in the details corresponds to low-level details. Because of LoD’s nonlinearity it must be defined locally.

The analysis is performed according to three separate groups of image: the low level of details (LL), medium detail level (ML) and high level of detail (HL). The results can be divided into four quadrants: the upper left for the lower frequencies, (2) and (3) the upper right and upper left with higher frequencies and (4) the lower right quadrant with higher frequencies. All these results are taken for all three channels. After that process including calculating mean value of the amplitude and establishing a new quadrants: DCT in quadrant (1) (dctd); DCT in quadrants (2) and (3) (dctm) [1].

Fig. 1 summarizes the changes in value of SNR (Signal-to-Noise Ratio) parameter in situation of increase of the degree of noise in the digital image [8]. With increasing noise comes to increase in the variation of pixel values in comparison to its own surrounding area. This leads to errors in the edge detection analysis. Situations like this lead to appearance of the edges in undesirable places giving not valid results of analysis. According to all above, all image are first extracted in their original format with no compression (TIFF), while analysis of the level of detail is conducted according to DCT.

III. Methodology

The analysis included characteristic images from theoretical DIP area. All images can be founded at http://sipi.usc.edu/database/misc.zip.

Figure 2. Original images for research

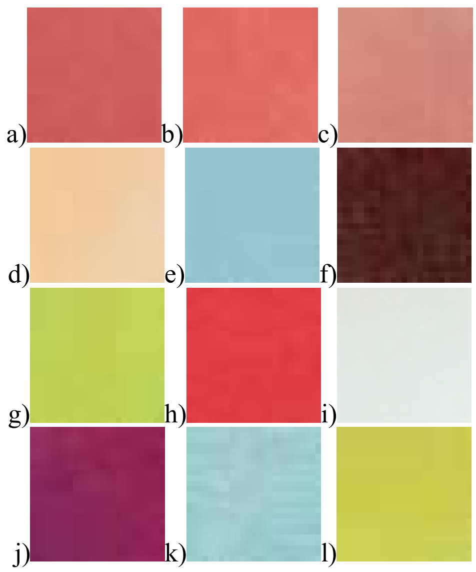

Figure 3. Separated segments from the original images

Fig. 2 shows two original images that were used for segmentations. The original images were square 512x512 resolutions (square-resolution), with 96 horizontally and vertically dots per inch (dpi) and 24 bit color depth (8 bits per channel).

From the observed images, square-resolution segments were separated. The criteria for segments extraction are taken from the definition of image texture. Segments are 25x25 pixels resolutions, with identical properties as the original image. Analyzed segments are shown at Fig. 3.

With the help of Matlab software package, the LoD for DCT is determined

```
function [ dctx dcty dctd dctm] = izracunajkoef(I)
im = I;
[rw cl d] = size(im);
if d == 1
    imbw = im;
    else
    imbw = rgb2gray(im);
end
if (rw > cl)
    imbw = imbw(1:cl, 1:cl);
    rw = cl;
    else
    imbw = imbw(1:rw, 1:rw);
    cl = rw;
end
B = dct2(imbw);
dcty = sum(sum(abs(B(rw/2+1:rw, 1:cl/2)), 1), 2)/(rw*cl/4);
dctx = sum(sum(abs(B(1:rw/2, cl/2+1:cl)), 1), 2)/(rw*cl/4);
dctd=sum(sum(abs(B(rw/2+1:rw,cl/2+1 :cl)),1), 2)/(rw*cl/4);
dctm = (dctx+dcty+dctd)/3;
end
```

where variable I represents observed segment. On the other hand, the value of the SD for the given segment is calculated by the algorithm:

```
SD=imread('address/image.tiff');
[m,n,k]=size(SD);
SDr=std2(SD(:,:,1));
SDg=std2(SD(:,:,2));
SDb=std2(SD(:,:,3));
```

Since the observed pixels values vary for certain segments in relation to channels (R, G, B); it is necessary to implement particular analysis for each channel individually.

All received results for a certain segment are from each of the three channels separately.

IV. Results

Terms of defining segments are:

- Square-resolution,
- Segment does not contain any edge defined by any algorithm for edge detections.

For this purpose the selected edge detection algorithms is algorithm with the lowest threshold of sensitivity as defined in [9]. Based on all above criteria segments are separated from the original images. According to the established criteria, all obtained segments have partial homogeneity (per channel) as their main characteristic.

The numerical values for LoD and SD are shown in Table 1. Fig. 4 gives defined value per channel (low, medium, high). The lowest value is for blue, red is medium and greatest values are marked as purple. This division is used for easier track of changes for the values per signal for SD and LoD.

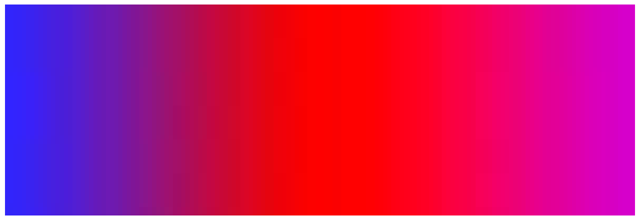

Figure 4. Defining values per channel

TABLE I. Value of SD and LoD for the observed segments

	SD			LoD (DCT)		
	R	*G*	*B*	*R*	*G*	*B*
1	3.3913	4.1215	5.3713	1.509	2.3775	3.4644
2	2.0092	4.4874	5.8205	1.015	1.9805	3.4446
3	2.6171	4.8066	5.3025	1.2494	2.2171	3.7483
4	1.7097	3.0526	7.8134	0.6718	0.8817	2.5449
5	4.0419	4.1324	2.2068	3.1014	3.7047	1.7847
6	1.8292	1.249	1.3528	0.855	0.7108	0.854
7	7.5798	4.6801	3.6611	3.3463	3.2685	2.0247
8	8.2297	7.8244	6.1435	6.4547	4.6277	3.427
9	1.2749	3.8481	3.1977	0.5024	2.2394	2.234
10	6.8335	4.0097	4.2159	1.8703	1.5216	1.8233
11	3.805	2.924	5.5168	2.5263	1.8103	2.6366
12	8.0963	8.3961	6.1597	5.3596	5.778	4.1943
13	1.2285	2.3371	3.3282	0.255	0.3434	0.3756
14	0.7773	0.5637	0.7341	0.4015	0.2993	0.3145
15	6.0053	4.2402	4.763	3.7153	2.539	2.6659

As seen in Table 1, the SD completely follows the value of the LoD for the specific segment. If the SD for R channel has a high value in some segments, than in that case value of LoD for R channel in the same segment is also on the high value. In other case if G channel for SD has a medium value, it is expected that G channel in LoD also have a medium value.

The values for the different segments are separated by the channels. In Table 1, the colors are indicated by the values according to Figure 4.

It is very important to describe in which conditions the results are valid. Namely, all isolated segments are in square resolutions and separated in TIFF format images. This format is the format of the image without compression, thus it gives a possibility to avoid any kind of noise induced by compression side effects.

V. CONCLUSION

This paper presents the results obtained by analyzing digital images through small areas that are covered by the function. Original digital image is square-resolution 512x512 pixels, divided into areas defined as segments in resolution 25x25 pixels. Analysis was done through the parameter LoD and SD in the Matlab software package.

The results showed that a small areas of an image, defined as segments according to previously defined criteria (without lines of edge detections inside segments, square-resolution), completely follows one another along the channels by the value of LoD and SD. Achieved results can be used as a basis for further consideration and improvement of the quality of digital images, as well to define more precisely the definition of the image segments characteristics.

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ANALYSIS OF DIGITAL IMAGES SEGMENTS THROUGH THE STANDARD DEVIATION AND LEVEL OF DETAIL

Ratko Ivkovic, Ivana Milosevic, Boris Gara, Miroslav Pavlovic, Dragisa Miljkovic