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Method for Determining the Contrast of a Digital Image

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ABSTRACT

Many of the developed methods and algorithms are associated with a wide variety of plots that have to be described using various mathematical models. In addition, the application of various optimality criteria also leads to the development of various filtration methods. Finally, in many cases, very often, due to mathematical difficulties, it is not possible to find the optimal image filtering procedure. The complexity of finding exact solutions leads to the generation of various variants of approximate methods of digital image analysis.

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Many of the developed methods and algorithms are associated with a wide variety of plots that have to be described using various mathematical models. In addition, the application of various optimality criteria also leads to the development of various filtration methods. Finally, in many cases, very often, due to mathematical difficulties, it is not possible to find the optimal image filtering procedure. The complexity of finding exact solutions leads to the generation of various variants of approximate methods of digital image analysis.

The image processing process consists of a number of stages, among which one of the most important is the pre-processing of images. Preprocessing and contour extraction on digital images have a wide range of applications in various fields, ranging from image preparation to recognition, image improvement in various recording devices by low-frequency filtering and equalization of brightness histograms - photo and video cameras, scanners, sonar, images obtained using ultrasound, X-ray, radio location, astronomical photographs, electron microscopy, etc.

During preprocessing, an image analysis is performed that determines various statistical characteristics of the image, such as mathematical expectation and standard deviation of brightness, contrast, construction of a histogram of brightness and contrast, selection of the most suitable model and parameters of digital noise [4; 37-38]. At the stage of preprocessing, low-frequency filtering is performed, which removes digital noise in the image [5; 18-19].

As a rule, after low-frequency filtering, the contrast of the image decreases and, therefore, it needs to be corrected. To correct the contrast, the contours of the image are calculated. As a result of summing the brightness of the pixels of the image with the brightness of the calculated contours, the contrast correction of the image is carried out [14,15].

The general block diagram of image preprocessing is shown in Fig.1. The original raw image is taken as input data A, for which the brightness histogram is calculated H such statistical characteristics of image pixel brightness as mathematical expectation are determined μ, standard deviation σ and the median $\mu_{1/2}$, and also the mathematical expectation is calculated μ_n and the standard deviation σ_n digital noise.

To remove digital noise and enhance the contours of the image A processed by low-frequency filters. The result of low-frequency filtering is an image A', on which the contours are calculated D.

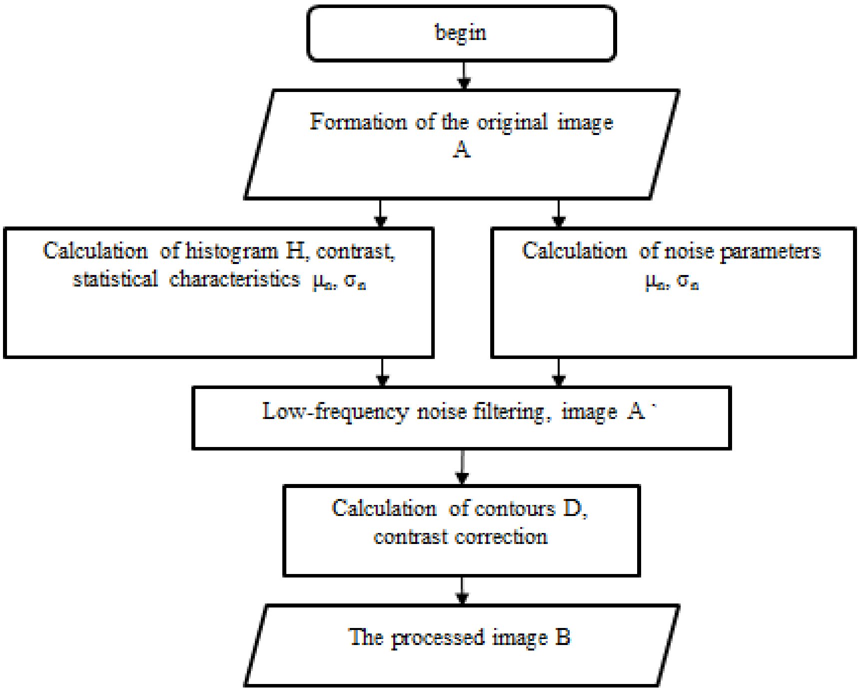

Figure 1. Block diagram of image preprocessing

Also, the result of preprocessing is an image B about balanced contrast and suppressed low-frequency noise.

For image preprocessing, statistical characteristics, contrast ratio, and noise are calculated on the original image. Then low-frequency noise filtering is performed, removing the noise component of the image. At the final stage, the image contours are searched and contrast correction is performed using the calculated contours.

When forming a digital image, it uses three main definitions of contrast to measure contrast. The Weber contrast is determined by the ratio [2-3]:$C = (I - I_b)/I_b$, where I - the brightness of a single image element at which the contrast is estimated, I_b- background brightness (the brightness of neighboring image elements averaged in some way). Usually, when small details are present in the image against the background of large objects that differ little in color, Weber contrast is used. The disadvantage of such a contrast detection mechanism is a decrease in the calculated value with an increase in background brightness, therefore, such a determination mechanism for calculating the contrast of light images is unacceptable.

For images where the number of dark and light areas is approximately the same, the Michelson contrast is determined by the ratio: $C = (I_{max} - I_{min})/(I_{max} + I_{min})$, where I_{min} and I_{max} accordingly, the minimum and maximum brightness values in the analyzed area of the image, and the denominator is twice the value of the average brightness.

The most common mechanism for determining contrast is the RMS contrast, which is applied to all types of images and is determined by the formula: $C = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(I_i - \bar{I})^2}, \bar{I} = \frac{1}{n}\sum_{i=1}^{n} I_i$, where I_i, - brightness of i - the pixel of the area for which the contrast is estimated. The main disadvantage of this definition is its low performance compared to the contrast of Weber and Michelson. The less common way to determine contrast is the formula of V.F. Nesteruk and N.N. Porfiriev: $= (I^{2\gamma} - I_b^{2\gamma})/(I^{2\gamma} + I_b^{2\gamma})$, where I - the brightness of the image element for which the contrast is estimated, I_b- background brightness, γ- parameter that characterizes the physiological properties of a particular object. The disadvantage of this detection mechanism is a large number of conditions under which the contrast value reaches a maximum.

To determine the overall contrast of a digital image using one of the contrast definitions (Weber, Michelson or RMS), local contrast values are calculated in all pixels of the image or in certain groups of pixels, after which the values obtained are somehow averaged. The resulting value is the overall contrast of the image [15].

The R.A. Vorobel method is an alternative method for determining how contrasting a digital image is:$C_L = (I_1 - I_2)/I_{max}$, where I_1, and I_2 - brightness of image elements, I_{max}- the maximum brightness value of the image elements. Thus, the maximum value of local contrast is achieved with the minimum brightness value of one of the elements and the maximum brightness value of the other, and the minimum - with equal brightness of the compared elements. Vorobel proposed a method based on a linear description of local contrasts to calculate the total contrast: $C_G = \frac{1}{2I_{max}}\int_0^{\infty}\left|2(I - \bar{I}) + I_{max} - |2(I - \bar{I}) - I_{max}|\right| * h(I)dI$, where $h(I)$- histogram of the brightness of the analyzed image.

The above-mentioned standard method for determining the contrast of a digital image has a characteristic disadvantage that they provide a qualitative assessment of the contrast of the image. In order to use them to determine how contrasting the image is relative to an image with balanced contrast, it is necessary to evaluate the contrast of any reference image and compare the resulting value with the value calculated for the analyzed image.

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