EVALUATION AND CORRECTION OF VISUAL CHARACTERISTICS OF IMAGES

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DOI: https://doi.org/10.30525/978-9934-26-499-3-11

Abstract. Considering the rapid development of image processing technologies and the growing dependence on high-quality visual data, improving the efficiency of image processing is one of the most urgent tasks in the field of computer vision, medical technology and automated control systems, where the accuracy of visual information is critical to ensure safety and efficiency. At the same time, the most important tasks that provide a solution to this problem include the task of evaluating and correcting the brightness and contrast of bitmap images. **The subject of the research** are models and methods of image processing to modify their visual characteristics. **The purpose of the work** is to determine the approaches and methods that should be used to evaluate and correct the visual characteristics of images in various conditions of use. **The research methodology** is based on the theory of digital processing of signals and images and system analysis and provides for the formation of a list of proven approaches and methods for evaluating and correcting the visual characteristics of an image, determining their mathematical support and conducting computer experiments aimed at their verification in various conditions of application. **As a result of the conducted research**, a list of proven approaches and methods for evaluating and correcting the visual characteristics of the image was determined. It is shown that approaches based on the use of the maximum, minimum, and average values of brightness for the entire image, as well as for its individual areas or color channels, are used to estimate the brightness of the image. Areas of application of approaches to

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image contrast assessment are shown. The conditions for the expediency of using proven image processing methods for brightness modification have been determined. Threshold processing method – image binarization and segmentation in character recognition and technical quality control. The method of linear transformation - for pre-processing of images, if it is necessary to select individual objects and correct excessively bright or dark areas. The method of logarithmic transformation is for displaying details in the shadows and in light areas at the same time, if it is necessary to increase the contrast of small details when recognizing X-ray and ultrasound images of medical diagnostics. The gamma correction method is used to improve the quality of image display, which is used in pre-processing before they are submitted to recognition tools. Conditions for the feasibility of using proven image processing methods for contrast modification are also defined. The method of linear contrast – to improve the visual quality of the image obtained in conditions of insufficient lighting. The solarization method is used to create dramatic visual effects and to reveal local image features. The partial inverse contrast method is used to highlight objects in a certain range of intensities, which is used to detect local changes in the image texture. It is substantiated that the prospects for further research are related to the development of a methodology for the adaptation of assessment tools and correction of visual characteristics of images to the conditions of use in neural network video stream processing systems in real time.

1. Introduction

In general, the concept of a digital image is understood as a type of digital signal that represents information in the form of discrete values [2; 3; 6]. In the context of a digital signal, a digital image is a signal that describes visual information and can be transmitted, processed and stored in digital format. According to the method of representation of graphic objects, digital images can be classified into vector and raster. A vector image is a graphical representation that is created and stored as mathematical formulas that describe geometric primitives such as lines, curves, polygons, and points. Unlike a vector image, a raster image is a set of individual elements – pixels. Further, in this work, attention is focused on raster images.

The main terms describing a raster image include [2; 10]:

– Pixel – the smallest possible element of an image.

– Resolution – characterizes the number of pixels horizontally and vertically per unit of image length. Resolution is measured in the number of pixels per unit image area. The higher the resolution, the more detailed the image is displayed.

– Color model – defines how colors are displayed in a digital image. One of the most common color models is the RGB model, which involves forming the color of each pixel by combining red, green, and blue colors. When using the monochrome model, a single pixel can be either black or white. When using a halftone image, the pixel color is displayed in shades of gray.

– Color depth is determined by the number of bits used to represent the color of one pixel. For example, for a halftone image at 8-bit color depth, a pixel's color can represent 256 different shades of gray. When using the RGB color model at 24-bit color depth, a pixel can display more than 16 million colors.

– An image file format is a way of storing digital image data in a computer system that defines how information about pixels, colors, and other image characteristics is encoded, compressed, and stored in a file. Each format has its own features used in a certain application area.

The most common image formats include JPEG, PNG, GIF, BMP, TIFF. Let's consider the features of these formats. JPEG – used to compress images with a partial loss of quality. Using this format allows you to reduce the image file size by removing subtle details. PNG – supports lossless image compression and provides background transparency. GIF – supports animation and limits the number of colors to 256. BMP – an uncompressed image format that preserves the parameters of all pixels. TIFF – Used for high quality images and supports both lossless and lossless compression. A description of common image storage formats helps to understand how image information is structured at the digital level. However, an equally important aspect is the analysis of visual characteristics that determine the perception of an image by a person. It is the visual characteristics of the image that shape its visual appeal and suitability for further use. Nowadays, image characteristics are described using a large number of parameters. However, most researchers [5; 7; 17] agree that the basic parameters are brightness and contrast, which determine the overall illumination, the ratio of light and dark areas, and also affect the ability to distinguish details. Combined, these parameters create the basis for determining the color reproduction, sharpness and saturation of the image. Although a large number of scientific and practical works have been devoted to the development of tools for modifying the visual characteristics of raster images, the task of adapting these tools to the expected conditions of use is far from being solved [8; 12; 17]. Thus, the purpose of this scientific work is to determine the most effective approaches to the assessment and correction of visual characteristics of images in various conditions of use. To achieve **the goal** of the research, the following tasks should be solved:

Determination of the scope of application of known approaches to the assessment of image brightness and contrast.

To conduct an analysis of known methods of modifying the brightness and contrast of images, which allows to outline the expediency of their use in different conditions.

2. Evaluation of brightness and contrast of images

Image brightness is a characteristic that shows how light or dark the image looks in general or its individual elements. For physical objects, brightness is related to the amount of light emitted or reflected by the object and perceived by the human eye. Brightness plays an important role in human perception of an image, and therefore it is one of the key parameters used for quality assessment and image processing [1; 18].

Candela per square meter (cd/m^2) is used as the basic unit for measuring the brightness of a real object. Note that the candela is a unit of light intensity. One candela corresponds to the power of light emitted by one wax candle. In the context of a digital image, the brightness of a pixel is represented as a numerical value that determines the level of intensity of its color.

For monochrome images, the brightness of a pixel can take two values (0 or 1), corresponding to black and white.

For a single-channel 8-bit grayscale image, the pixel brightness ranges from 0 (black) to 255 (white).

For three-channel images in RGB format, the brightness of a pixel is determined using an expression of the form [2; 9]:

$$I = 0,299 \cdot R + 0,587 \cdot G + 0,114 \cdot B, \qquad (1)$$

where R, G, B are the values corresponding to the red, green, and blue colors of the image pixel.

The maximum, minimum and average brightness values are determined for the image as a whole. Expressions of the type are used to calculate the specified parameters:

$$I_{max} = max\left(I_1, I_2, \ldots, I_N\right), \tag{2}$$

$$I_{min} = min\left(I_1, I_2, \ldots, I_N\right), \tag{3}$$

$$I_{avg} = \frac{1}{N}\sum_{n=1}^{N} I_n, \tag{4}$$

where I_{max}, I_{min}, I_{avg} – maximum, minimum and average value of image brightness; N is the number of image pixels; I_n – is the brightness of the nth pixel.

In addition to I_{max}, I_{min}, I_{avg}, when solving practical problems, the maximum, minimum, and average brightness of a certain predefined area of the image $|$ are also calculated, denoted as $I_{max}\left(\Omega\right)$, $I_{min}\left(\Omega\right)$, $I_{avg}\left(\Omega\right)$. Expressions similar to expressions (2-4) are used to calculate these indicators. Also, when solving practical problems, indicators corresponding to the color intensity of each of the color channels of the image as a whole or a given area of the image are used:

$$D_{X,\, max} = max\left(D_{X,1}, D_{X,2}, \ldots, D_{X,N}\right), \tag{5}$$

$$D_{X,min} = min\left(D_{X,1}, D_{X,2}, \ldots, D_{X,N}\right), \tag{6}$$

$$D_{X,\, avg} = \frac{1}{N}\sum_{n=1}^{N} D_{X,n}, \tag{7}$$

where $D_{x,\, max}$, $D_{x,min}$, $D_{x,\, avg}$ – the maximum, minimum and average value of the color intensity of the image in the X channel; N is the number of image pixels; $D_{X,n}$ is the color intensity in the X channel for the nth pixel.

One of the main tools used for integral assessment of image brightness is the intensity histogram, which provides a graphical representation of the distribution of image pixel brightness [2; 4; 11]. In other words, the brightness histogram shows how many pixels in the image have each of the possible brightness values. Pixel brightness values are plotted on the histogram along the horizontal X axis. The possible range of values along the X axis is determined depending on the conditions of the practical task. For halftone images with a color depth of 8 bits, as a rule, the specified range has limits from 0 to 255. Black corresponds to 0, white to 255. The number of pixels with the corresponding brightness value is plotted on the vertical Y axis. In some cases, not the absolute number of pixels is delayed, but the relative number. The higher the bar on the histogram, the more pixels in the image with the corresponding brightness value.

Note that in various sources, depending on the conditions of the image quality assessment task, the brightness histogram is called the brightness distribution histogram, the intensity distribution histogram, the level histogram, the illuminance histogram, or even the image histogram. An example of a brightness histogram constructed using MatLab tools for a color image is shown in Figure 1.

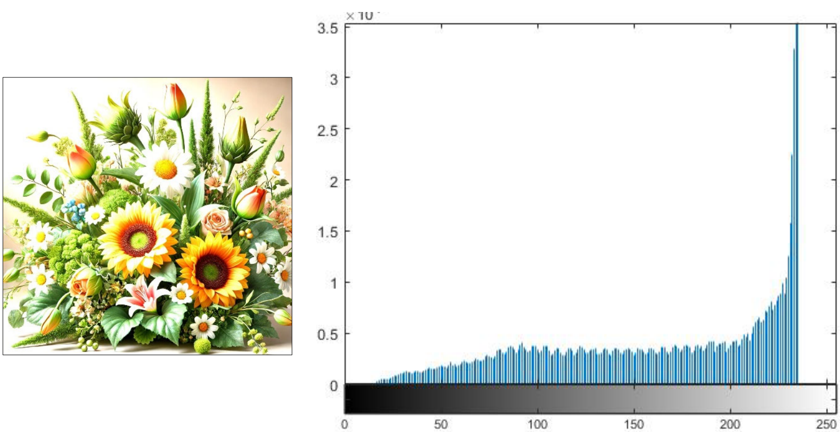

Figure 1. Example of a histogram for a color image

The use of MatLab tools made it possible to illustrate the histogram by displaying in the lower part of this diagram the distribution of the color gamut, which corresponds to the range of possible values of the X axis. Note that the construction of the brightness histogram for a color image involves either the calculation of the average brightness of each pixel for each color channel, or the transformation image into the YCbCr color space, where the Y component represents luminance.

In Figure 2 shows the brightness histogram constructed for a halftone image, which was obtained by converting the color image shown in Figure 1.

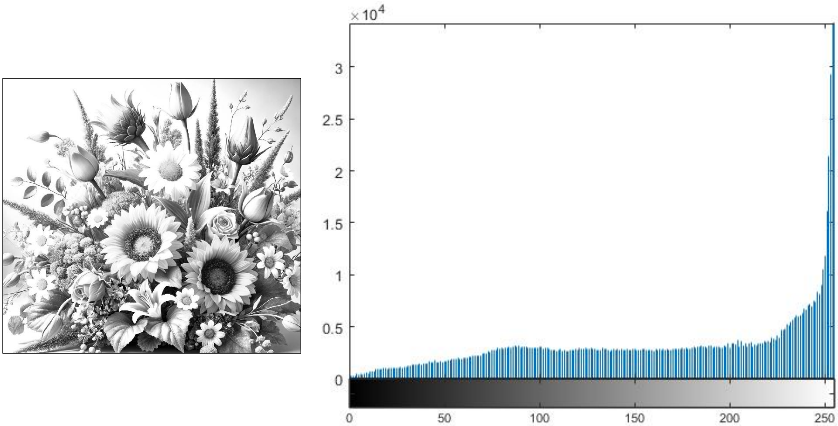

Figure 2. Brightness histogram for a halftone image

In some cases, it is convenient to use a normalized luminance histogram, on which for each of the luminance levels on the vertical Y axis, not the absolute, but the relative number of pixels, which is calculated using the expression:

$$\overline{n}\left(l_I\right)=\frac{n\left(l_I\right)}{N}, l_I \in\left[0, L_I-1\right], \tag{8}$$

where $\overline{n}\left(l_I\right)$ is the reduced number of pixels with brightness level l_I; $n\left(l_I\right)$ – the number of pixels with brightness level l_I; l_I – brightness level; L_I is the number of brightness levels.

It should be noted that for 8-bit halftone images, $L_I=256$. It is customary to believe that for a digital image with an ideal brightness distribution, the brightness histogram should have the shape of a Gaussian curve, shown in Figure 3. This is due to the fact that in such an image, most of the pixels have average brightness values, and the number of pixels with extreme brightness values (very dark or very light) decreases with distance from the average value, which is characteristic of a normal distribution.

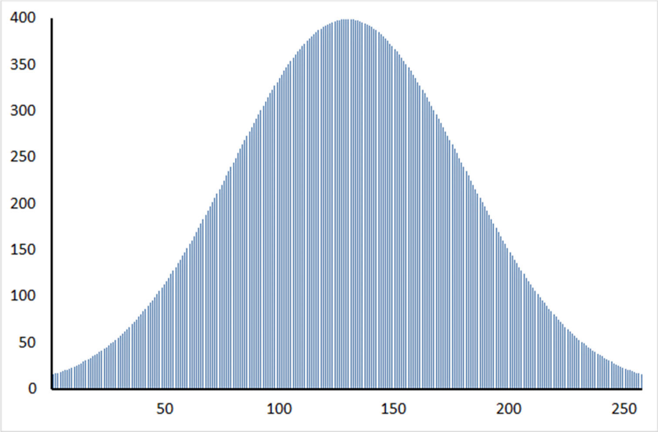

Figure 3. Brightness histogram for a digital image with ideal brightness distribution

According to the brightness indicators, dark and light images are distinguished.

An example of a histogram of a darkened image is shown in Figure 4, and an example of a light image histogram is shown in Figure 5.

As shown in Figure 4 and Figure 5, on the brightness histogram of a darkened image, non-zero values are mainly concentrated in the region corresponding to low brightness, and on the histogram of a bright image, non-zero values are mostly located in the region of high brightness.

Another important indicator used to describe the image is contrast [2; 10]. In general, image contrast describes the difference between the lightest and darkest parts of an image. In essence, contrast determines how strongly objects and details stand out in the image due to the difference in brightness. Quite often, the term image contrast is used as an analogue of the term image contrast. However, in [2] it is indicated that the contrast of the image is a parameter that determines the difference in brightness

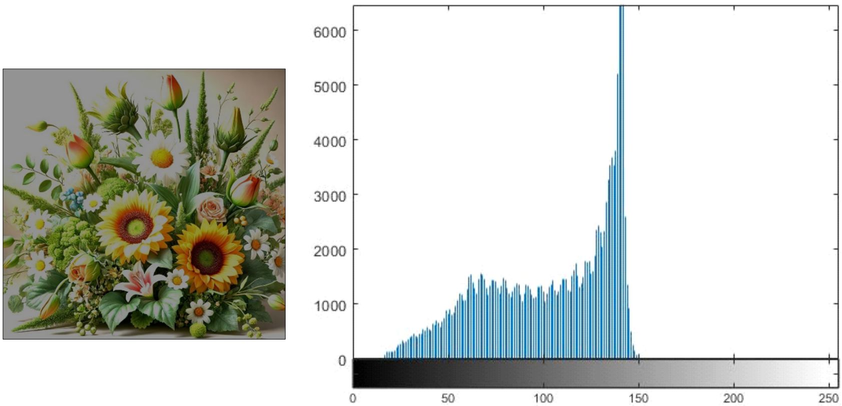

Figure 4. Histogram of brightness for a darkened image

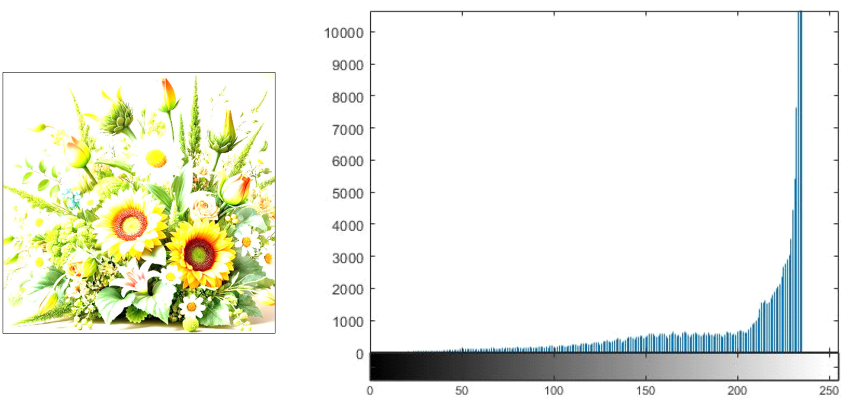

Figure 5. Brightness histogram for a bright image

relative to the average level and is numerically equal to the ratio of the difference between the maximum and minimum brightness to their sum, and the contrast of the image is a parameter that is equal to the ratio of the maximum brightness to the minimum in the image field. A number of indicators calculated using expressions (9-16) [2; 14; 16] are used to evaluate image contrast. Note that the C_W indicator is called Weber contrast, C_M – Michelson contrast, a C_P – Peli contrast.

$$C_W = \frac{I_O - I_F}{I_F}, \tag{9}$$

$$C_M = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}, \tag{10}$$

$$C_{RMS} = \left(\frac{1}{N} \sum_{n=1}^{N} \left(I_n - I_{avg} \right)^2 \right)^{0,5}, \tag{11}$$

$$C_P = \frac{I_i - I_j}{I_i + I_j}, \tag{12}$$

$$C_l = log\left(I_{max} / I_{min} \right), \tag{13}$$

$$C_A = \frac{I_t - I_f}{I_t + I_f}, \tag{14}$$

$$C_{PD} = \frac{1}{X \cdot Y} \sum_{x=1}^{X} \sum_{y=1}^{Y} \left| I_{x,y} - I_{x+1,y+1} \right|, \tag{15}$$

$$C_{ma} = \frac{1}{N} \sum_{n=1}^{N} \left| I_n - I_{avg} \right|, \tag{16}$$

where I_O is the brightness of the object; I_F – background brightness; I_{max} – maximum brightness; I_{min} – minimum brightness; N is the number of image pixels; I_{avg} – average image brightness; I_i – the brightness of the ith pixel; I_j – the brightness of the jth pixel; I_t – text brightness; I_f – brightness of the text background; X, Y – the number of image pixels along the axes; I_n – the brightness of the nth pixel.

The use of a specific image contrast assessment indicator is determined by the specifics of the practical task:

C_W (Weber contrast) – used in tasks related to object visualization on a uniform background;

C_M (Michelson contrast) – used in evaluating the visibility of test images;

C_{RMS} – used to estimate the overall contrast if it is necessary to take into account the variation in the brightness of the entire image;

C_P (Peli contrast) – used in tasks related to the processing of high-contrast images;

C_l – used when contrast analysis is necessary in images where the transfer of details in shadows and light areas is important;

C_A – used to evaluate the readability of the text on the screen;

C_{PD} – used to evaluate the contrast of textures and on the borders of objects;

C_{ma} – used to evaluate the contrast of images with small variations in brightness.

As an example, we note that for the one shown in Figure 6 color image value $C_W = 1$, $C_M = 1$, $C_{RMS} = 49.23$, $C_l = 3.06$.

Figure 6. The image used to calculate the values of the contrast indicators

It should be noted that the generally accepted methodology for determining contrast indicators requires the conversion of a color image into a halftone 8-bit image in shades of gray. In addition to the specified indicators, a histogram of contrast (contrast) is used to evaluate the contrast of a digital image, which displays the distribution of contrast values over the entire image. Since in the basic version the contrast is measured as the difference in brightness between neighboring pixels of the image, the histogram of contrast shows the values of the absolute difference in the brightness of neighboring pixels on the X axis, and the number of cases of such a difference on the Y axis. Among other things, the contrast histogram shows the presence of sharp transitions between light and dark areas in the image. High peaks in the contrast histogram indicate that the image has significant transitions in brightness (high contrast), while low contrast will correspond to values close to zero. A contrast histogram is typically used to analyze and improve image sharpness, as well as to assess the level of detail and visible boundaries between objects.

3. Analysis of approaches to modifying image brightness and contrast

Approaches to image processing in order to modify their brightness and contrast are determined by the conditions of the given task [2; 13; 19]. For example, in the task of searching for a certain object in the image, as a rule, there is a need to increase the contrast of the image, which makes it possible to highlight the contour of the target object more accurately. At the same time, when processing photos, there is often a need to create soft and calm visual effects, which is realized by reducing the contrast. This can be used in portrait photography to soften the image and minimize attention to fine details. Photos taken in conditions of insufficient lighting need processing to increase brightness, and photos taken in conditions of too high lighting, on the contrary, need processing to reduce brightness.

The methods used for image processing in order to modify their brightness and contrast are classified into two main classes. The first class includes methods of elemental image processing, and the second class includes methods of correlation processing.

Elemental processing methods are based on the premise that the parameter values of individual pixels are independent of each other. Therefore, when using these methods, the result of processing a single image pixel depends only on the values of the parameters of this pixel.

The methods of correlation processing are based on the postulate that there is a certain correlation between the pixels of the image, therefore, when modifying the brightness and contrast of a certain pixel, the values of the parameters of the neighboring pixels are used.

Although the context of the image is not taken into account when using elemental processing methods, due to their simplicity and proven effectiveness, these methods are basic in tools designed to modify image brightness and contrast. Correlation methods are more complex, robust to noise, and are mainly used in image processing tools designed for contour extraction, object detection, and texture processing.

Basic element-by-element methods of image processing for brightness modification include [2; 10]:

– threshold processing;
– linear transformation;
– logarithmic transformation;
– gamma correction (power transformation).

Let's consider the main characteristics of these methods.

Threshold processing, which is often enough to simplify the image, select certain areas, define the background and increase the contrast of the image. Under the condition of binarization of an 8-bit halftone image, the expression describing the procedure for threshold processing of image pixels can be written as:

$$I_{bn}(x,y)=\begin{cases}0 & if\ I_{init}(x,y)\le\delta\\ 255 & if\ I_{init}(x,y)>\delta\end{cases},\tag{17}$$

where $I_{bn}(x,y)$ – the brightness of the pixel with coordinates (x,y) after applying the binarization procedure; $I_{init}(x,y)$ – the initial brightness of the pixel; δ – the brightness threshold value.

Note that the threshold processing procedure, implemented using expression (17), leads to image binarization, that is, to its conversion into black and white format. Generally, when binarizing 8-bit images $\delta=128$, although in general, the value of δ can be in the range from 0 to 255.

Threshold processing can also be applied to change the brightness of an individual color channel. In this case, expression (1.17) is modified as follows:

$$I_{th}(ch,x,y)=\begin{cases}I_{th}(ch,x,y)\cdot k_1 & if\ I_{init}(ch,x,y)\le\delta_{ch}\\ I_{th}(ch,x,y)\cdot k_2 & if\ I_{init}(ch,x,y)>\delta_{ch}\end{cases},\tag{18}$$

де $I_{th}(ch,x,y)$ – the brightness of the pixel with coordinates (x,y) in the ch -th color channel after applying the threshold processing procedure; $I_{init}(ch,x,y)$ – the initial brightness of the pixel in the ch -th color channel; δ_{ch} – brightness threshold value for the ch -th color channel; k_1, k_2 – given coefficients; ch – color channel identifier.

Linear brightness transformation is implemented in tasks related to the modification of too dark or too light images. The procedure for linearly transforming the brightness of a pixel of an 8-bit halftone image can be described as follows:

$$W_{lt} = a \cdot I_{init}(x,y) + b\,, \tag{19}$$

$$\begin{cases} if\, W_{lt} < 0\, then\, I_{lt}(x,y) = 0\, else\, I_{lt}(x,y) = W_{lt} \\ if\, W_{lt} > 255\, then\, I_{lt}(x,y) = 255\, else\, I_{lt}(x,y) = W_{lt} \end{cases}, \tag{20}$$

where $I_{lt}(x,y)$ – the brightness of the pixel after applying the linear transformation procedure; a, b – given coefficients.

Linear luminance shift and luminance scaling are special cases of linear transformation. In these cases, instead of expression (19), expressions (21, 22) are used, respectively.

$$W_{ld} = I_{init}(x,y) + b\,, \tag{21}$$

$$W_{m} = a \cdot I_{init}(x,y)\,. \tag{22}$$

The logarithmic transformation is used in cases where it is necessary to increase the brightness of the dark areas of the image and can be determined using expressions of the form:

$$W_{log} = a \cdot \log\left(1 + I_{init}(x,y)\right), \tag{23}$$

$$\begin{cases} if\, W_{log} < 0\, then\, I_{log}(x,y) = 0\, else\, I_{log}(x,y) = W_{log} \\ if\, W_{log} > 255\, then\, I_{log}(x,y) = 255\, else\, I_{log}(x,y) = W_{log} \end{cases}, \tag{24}$$

where a – given coefficient.

The Figure7 is an illustration of the results of applying the method of logarithmic transformation to modify the one shown in Figure 6 images. Note that Figure 7 obtained with $a = 0{,}8$. At the same time, the modified image became slightly brighter because the original image contained many bright areas, and the logarithmic transformation increased their brightness. In addition, as a result of the logarithmic transformation, the dark areas of the image became less contrasty, which also creates a lighting effect.

Gamma correction (power transformation) is used for uneven modification of image brightness and can be specified by expressions of the following form:

$$W_{\gamma} = I_{init}^{\gamma}(x,y)\,, \tag{25}$$

$$if\, W_{\gamma} > 255\, then\, I_{\gamma}\left(x,y\right) = 255\, else\, I_{\gamma}\left(x,y\right) = W_{\gamma}. \qquad (26)$$

An illustration of the results of applying the gamma correction method to modify the image shown in Figure 6 image is Figure 8. Note that Figure 8 obtained with $\gamma = 0{,}5$.

Figure 7. The result of applying the logarithmic transformation method

Figure 8. The result of applying the gamma correction method

It should be noted that often in the scientific literature, brightness modification methods are not separated from contrast modification methods, since in many cases both brightness and image contrast change as a result of their application. However, it is possible to consider that brightness modification methods include those methods, the result of which is mainly correlated with the overall change in image brightness, and the main result of using contrast modification methods is a change in the difference in brightness. Common image contrast methods based on the element-by-element approach and not related to the brightness modification methods discussed above include: linear contrast, solarization, and partial inverse contrast [13; 16; 17].

Let's consider the fundamental principles of these methods. The linear contrast method is used to increase the contrast of the image by bringing the brightness range of the image to a given range. The transformation of pixel brightness implemented by this method can be described using the following expression:

$$I_{cl}(x,y)=\frac{I_{init}(x,y)-I_{min}}{I_{max}-I_{min}}\times\left(L_{max}-L_{min}\right)+L_{min}, \tag{27}$$

where $I_{cl}(x,y)$ is the brightness of a pixel with coordinates (x,y) after implementing the linear contrast method; $I_{init}(x,y)$ – the initial value of the pixel brightness; I_{max}, I_{min} – the maximum and minimum brightness values of the pixels in the initial image; L_{max}, L_{min} – the upper and lower values of the specified brightness range.

The Figure 9 is an illustration of the results of the application of the contrast method for the modification shown in Figure 6 image.

Figure 9. The result of applying the method of linear contrast

Note that Figure 9 obtained with $L_{max}=77$, $L_{min}=50$, $I_{max}=255$, $I_{min}=0$.

Solarization of the image is carried out to enhance visualization of contours and clearer separation of different areas of the image. It is used to create visual effects in order to focus attention on objects with certain brightness levels. Image processing by the solarization method leads to the fact that pixels with an average level of brightness become dominant, which increases the contrast between midtones and extreme values of brightness. The transformation of the brightness of a pixel, which is implemented when using the solarization method, is described by an expression of the following form:

$$I_{solar}(x,y) = L_{solar} \cdot I_{init}(x,y) \cdot \left(I_{max} - I_{init}(x,y)\right), \tag{28}$$

where $I_{solar}(x,y)$ is the brightness of the pixel with coordinates (x,y) after solarization of the image; L_{solar} – coefficient of solarization level.

An illustration of the results of applying the solarization method for the modification shown in Figure 6 images, there are Figure 10. Note that Figure 10 is obtained with $L_{solar} = 1$.

Figure 10. The result of applying the solarization method with $L_{solar} = 1$

Partial inverse contrast, sometimes called classical solarization, is used to dramatically change the contrast of an image to create sharp transitions between areas. Classical solarization changes the image contrast by partially inverting the brightness value. At the same time, instead of a linear increase in contrast, certain brightness ranges are inverted, which creates an effect in which the image partially looks like a negative. Some parts of the image become brighter, others – darker, which leads to the creation of unique visual effects. In this case, an expression is used to modify the brightness of a pixel of an 8-bit halftone image:

$$if\ I_{init}(x,y) \le \delta_{inv} \quad then\, I_{p_{inv}}(x,y) = I_{init}(x,y) \tag{29}$$

$$else\ I_{p_{inv}}(x,y) = 255 - I_{init}(x,y), \tag{30}$$

where $I_{p_{inv}}(x,y)$ s the brightness of a pixel with coordinates (x,y) after partial inverse image contrast; δ_{inv} is the brightness threshold value.

In the case when δ_{inv} is equal to the average value of the brightness range, that is, when $\delta_{inv} = 127$ or $\delta_{inv} = 128$, the application of partial inverse contrast will lead to image binarization.

An illustration of the results of applying the method of partial inverse contrast for the modification shown in Figure 6 images, there are Figure 11 and Figure 12.

Note that Figure 11 was obtained with $\delta_{inv} = 12$, and Figure 12 with $\delta_{inv} = 127$.

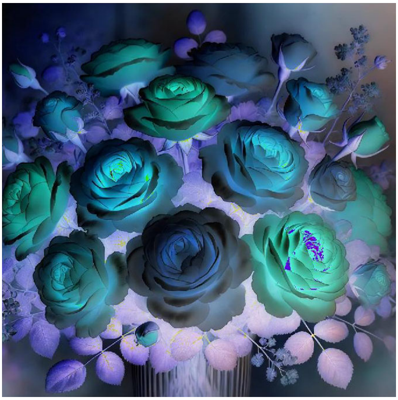

Figure 11. The result of applying the partial inverse contrast method with δ_{inv}=12	**Figure 12. The result of applying the partial inverse contrast method with δ_{inv}=127**

Visual analysis of Figure 11 and Figure 12 obtained by using the method of partial inverse contrast indicates that the use of this method allows you to enhance the visibility of weakly expressed details that are difficult to notice in a normal image, for example, in shadows or bright areas. It also provides the ability to change the contrast only in defined brightness ranges without affecting the rest of the image, which is useful for analyzing specific areas of the image.

Taking into account the perspective of the use of neural network systems for visual information processing that function in a real time scale [2; 19], it is possible to assert the expediency of further research related to the development of a methodology for adapting assessment tools and correcting the visual characteristics of images to the conditions of use in such systems.

4. Conclusions

As a result of the research, a list of proven approaches and methods for evaluating and correcting the visual characteristics of the image was formed. The mathematical support of each of these approaches and methods was determined, and computer experiments aimed at their verification were conducted. At the same time, it is shown that approaches based on the use of the maximum, minimum and average value of brightness for the entire image as a whole and for each of the color channels or for a given area of the image are used to estimate the brightness of the image. To evaluate image contrast, approaches based on the use of indicators are used, which allow to evaluate: the ability of the observer to distinguish individual objects; visibility of test images; image brightness variability; high-contrast images; contrast in images where the transfer of details in shadows and light areas is important; readability of the text on the screen; texture contrast and object boundary contrast; contrast of images with small variations in brightness. In addition, an intensity histogram is used for the integral assessment of image brightness, which provides a graphical representation of the distribution of image pixel brightness.

Conditions for the feasibility of using proven image processing methods for brightness modification have been determined. Threshold processing method – image binarization and segmentation in character recognition and technical quality control. The method of linear transformation – for pre-processing of images, if it is necessary to select individual objects and correct excessively bright or dark areas. The method of logarithmic transformation is for displaying details in the shadows and in light areas at the same time, if it is necessary to increase the contrast of small details when recognizing X-ray and ultrasound images of medical diagnostics. The gamma correction method is used to improve the quality of image display, which is used in pre-processing before they are submitted to recognition tools. Conditions for the feasibility of using proven image processing methods for contrast modification are also defined. The method of linear contrast – to improve the visual quality of the image obtained in conditions of insufficient lighting. The solarization method is used to create dramatic visual effects and to reveal local image features. The partial inverse contrast method is used to highlight objects in a certain range of intensities, which is used to detect local changes in the image texture. Prospects for further research are related to the development of a methodology for the adaptation of evaluation tools and correction of visual characteristics of images to the conditions of use in neural network systems for processing video streams in real time.

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