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COLOR CORRECTION OF THE INPUT IMAGE AS AN ELEMENT OF IMPROVING THE QUALITY OF ITS VISUALIZATION

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ABSTRACT:

Image analysis and processing is constantly in the focus of attention of researchers. At the same time, special attention is paid to improving the quality of visualization, which is in demand in various applications: from medicine to printing. The solution to the problem is proposed to be achieved by correcting the color rendition of the original image, where the corresponding image perception metrics are used for analysis. The paper presents the results of the study based on the example of a well-known digital image.

Key words: Analysis, Metrics, Color rendition, Visualization, Correction, Quality, Digital image, RGB image

INTRODUCTION

Digital image processing is one of the current areas of research [1]-[5]. This is due to the fact that a digital image is a kind of source of information that allows you to operate with data in real time and remotely from the object that is being studied. This approach allows for a comprehensive analysis and obtaining additional data about the surrounding world. It is also possible to remotely and indirectly influence the object or process being studied based on the results obtained.

Among the various results of the analysis and study of digital images, one can highlight: removal of noise, improving image quality based on its contrast, highlighting the edge of an object, segmentation, pattern recognition and much more [6]-[10]. For these purposes, classical methods and approaches of digital image processing are used, which are based, for example, on [11]-[20]:

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– implementation of individual operators for highlighting the edge of an object,

– application of filtering methods to eliminate noise or smooth out differences in brightness for individual image fragments;

– various methods of fuzzy set theory for clustering image fragments and objects, texture analysis or generating appropriate conclusions for developing the necessary algorithms,

– statistical analysis to obtain a description of image objects, and so on.

At the same time, non-standard approaches to image research can be used here, which allow one to obtain additional information or identify new ways in the study of such images and justify the adoption of the necessary decisions [21]-[25].

If we talk about the results of digital image analysis, we should also pay attention to improving the visualization of images, which is important, for example, in medicine or printing. Here it is necessary to pay attention to the color rendition of the various presented details and the possibility of its correction based on the conditions of the tasks.

Thus, the main objective of this work is to consider the procedure for correcting the color rendition of a digital image in the context of improving the quality of its visualization.

Related work

Given the importance of the objectives of this study, it is worth noting the various directions that individual authors consider.

First of all, color correction and visualization of the corresponding data are highlighted here.

For example, S. H. Lee and J. S. Choi explore various issues in the design and implementation of a color correction system for images captured with a digital camera [26]. At the same time, the authors emphasize that the quality of a digital image is influenced by various factors that can be compensated for by color correction procedures. The main goal of the research is to develop an easy-to-use color correction system. The accuracy and reliability of the proposed system are verified using experimental results from several different images.

The work of N. A. M. Isa considers a color correction procedure with a shift in the pixel distribution for digital color images [27]. This approach uses the process of shifting the pixel distribution of a color image to correct the white reference point and make the white reference point achromatic [27]. This method has been tested on numerous types of images. Qualitative and quantitative analysis showed strong

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evidence that the proposed method outperforms some state-of-the-art methods such as Gray World, White Spot, and General Gray World methods [27].

A. Rizzi, C. Gatta and D. Marini propose and study an unsupervised global and local color correction algorithm [28]. This allows you to automatically align the color data. This approach is based on a computational model of the human visual system, which combines the two main global alignment mechanisms “Gray World” and “White Spot” [28]. Therefore, the proposed algorithm is able to “adapt” to a wide variety of lighting conditions and effectively extract visual information from the environment. The work shows that this approach provides a solution to various equalization problems [28].

C. Sinthanayothin, W. Bholsithi and N. Wongwaen analyze the possibility of color correction of a digital image based on reference color diagrams surrounding the object [29]. This approach is based on the fact that the color of the image may differ from the actual colors of the object due to lighting conditions and different illumination. For these purposes, six transformation matrices are used for color correction, which are calculated based on six color diagrams surrounding the object, rather than a single color diagram [29]. This technique was tested on a table of 132 colors shot in four different lighting conditions. The work notes that the color correction method can be used for work that requires precise color selection, as it is less expensive [29].

D. H. Lee, Y. J. Yoon, S. J. Kang, and S. J. Ko study a procedure for correcting overexposed area in a digital color image [30]. The authors emphasize that this area appears in the image due to the limited dynamic range of the digital camera and low dynamic range display. Based on this, the paper proposes a method consisting of illumination correction and color restoration. It is also emphasized that the proposed approach effectively improves the visual quality of overexposed images compared to state-of-the-art methods [30].

Thus, what has been presented above confirms the importance of considering this line of research.

Basic procedures in the study of color correction to improve the quality of image visualization

Solving the issue of color rendition correction and its research includes several stages, among which the following should be highlighted:

– assessment of the quality of the light source,

– adjusting the color balance of the image,

– assessment of image visualization after color correction.

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Before moving on to such steps, we note that RGB images are considered here. This is due to the fact that this format is prevalent. At the same time, another image format can be converted to RGB format.

Assessing the quality of a light source can be carried out using various methods [31]. In this paper, we use principal component analysis estimation [32], which is easy to implement and intuitive to understand. The implementation of such an assessment is based on the fact that the colors of the image pixels are represented as vectors in the RGB color space. Then the colors are ordered in accordance with brightness (the norm of their projection onto the average color of the image) [32]. This keeps the darkest and brightest colors in that order. Next, principal component analysis is performed on a subset of colors. The first component indicates the evaluation of the light source.

Adjusting the color balance of an image can also be done using various procedures [33]. Here we use chromatic adaptation [34]. Chromatic adaptation is the ability to adjust to changes in light to maintain the appearance of an object's colors [34]. It is responsible for the consistent appearance of an object's colors despite the wide variation of light that may be reflected from the object and observed by our eyes. Here you can use scaling using the Bradford cone or Von Kries cone response model, as well as scaling using a light source [34], [35]. In our studies, we consider the standard function chromadapt (Matlab) [36], [37].

Various metrics can also be used to evaluate the visualization of an image after color correction. Here we use non-reference image quality assessments. This allows you not to be tied to any reference models and expands the scope of research. For these purposes, the metrics niqe and brisque are considered.

The niqe metric calculates an image quality score using the Naturalness image quality estimator, comparing it to a default model calculated from images of natural scenes [38].

The brisque metric calculates an image quality score using a blind/baseless image spatial quality estimator with a default model calculated from images of naturally occurring scenes with similar distortions [39]. Brisque predicts the score using a support vector regression model trained on an image database with corresponding differential mean opinion score values [40].

Then, by alternating the procedures described above and based on the efficiency of visualization, you can achieve the most acceptable correction of the color rendition of the original image. Next we will look at the results of this process.

Here we note that the well-known image (Fig. 1) is considered as an example.

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Figure 1: Original Image

It is visually clear that in the original image the red component predominates in the formation of color rendering.

This fact is confirmed based on source quality assessment data: R – 0.7596; G – 0.5463; B – 0.3528.

Thus, we should talk about the advisability of color correction in this case.

Results of color correction and visualization quality assessment

To correct color rendering and obtain appropriate results, a procedure is used to adjust the color balance of the image. Here we consider two options for such adjustment.

In the first case of adjusting the color balance of the input image based on chromatic adaptation, the color space of the input image and the light source is considered as "srgb", where the gamma correction for converting linear three-color RGB values into three-color sRGB values is determined in a predetermined manner according to [41].

In the second case, to adjust the color balance of the original image, the "linear-rgb" function is used, which allows you to adjust the color balance of an RGB image, the intensity of which is linear. Taking into account different approaches to adjusting color balance allows you to evaluate the effectiveness of such approaches and determine the most effective result, taking into account the achievement of the best visualization.

In Fig. 2 shows the results of adjusting the original image for different approaches described above.

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a) "srgb" b) "linear-rgb"

Figure 2: Results of color correction of the original image

It should be noted that there are differences in the color rendering of the data in Fig. 1 and Fig. 2. This is also confirmed by assessments of the quality of the source. So for the data in Fig. 2a: R – 0.5157; G – 0.6906; B – 0.5071. For the data in Fig. 2b: R – 0.4775; G – 0.6807; B – 0.5556.

At the same time, assessments of the quality of perception are as follows.

For Fig. 1: niqe =5.0197; brisque= 26.8723.

For Fig. 2a: niqe =4.3357; brisque= 26.6554.

For Fig. 2b: niqe =4.3140; brisque= 22.9075.

It should be emphasized that both the first and second image perception evaluators have the best values for the image in Fig. 2b.

These data coincide with the visualization presented in Fig. 1 and fig. 2.

At the same time, the presented procedure for correcting the color rendition of the original image can be represented by the following sequence of actions:

– the quality of the light source for the original image is assessed, and obvious distortions in the color rendition of the data are determined;

– the color balance of the image is adjusted using various methods of such adjustment;

– the visualization of the original image and after its color correction are assessed;

– the analysis and selection of the best one according to the parameters for assessing the visualization of the processed or original images is carried out.

CONCLUSION

The work examines the classical fundamentals of color rendering for color digital images and their subsequent correction. The purpose of such a study is confirmed by considering a number of works on this topic.

Based on standard procedures for analyzing color images, a general approach is considered for correcting the color rendition of the input image as an element of improving the quality of its visualization. The basis of this approach is the

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assessment of the quality of image perception. The results are confirmed using one of the known color images.

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