

COLOR SPACE IMAGE AS A FACTOR IN THE CHOICE OF ITS PROCESSING TECHNOLOGY

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Information plays an important role in the modern world. Information becomes the basis for the functioning of various spheres of human activity, the development of production and the economy. Information takes the lead when everything goes digital.

The digital image is a source of information about the real world [1]. This information is presented as individual brightness values at each point in the image. The brightness values of each point in the image are interconnected with neighboring points. Then you can get the information you need about the real world. Such digital information is transformed into data, knowledge bases. This allows you to better understand the world and make the necessary decisions.

There are various methods for analyzing digital images. These methods make it possible to use a digital image as a source of information in medicine [2, 3], technology [4, 5], for technical vision systems [6], for artificial intelligence systems [7], and various fields of human activity [8-12]. Such analysis allows not only to analyze the original image, but also to obtain additional information. Then the primary and additional information allows you to make the right decision. For example, for medicine, this is a timely diagnosis of a disease, for a technical vision system – identifying objects in an image, for an artificial intelligence system – making decisions about the movement of a robot. Therefore, methods of image analysis and obtaining the necessary information are in the focus of researchers.

A digital image can be presented as a black and white image or as a color image. Classical image analysis methods are designed to process original images, which are black and white images.

A color image is used to render the real world. A color image allows you to convey the features of the phenomenon that is being investigated. Nowadays, the use of a color image is a common practice [13]. These images have found wide application in all areas of human activity, fields of scientific research and applications. However, for the analysis of such images, it is advisable to use classical methods of image processing. This makes it necessary to convert a color image to a black and white image or use special methods for analyzing color images.

Special methods for analyzing color images involve the decomposition of such an image into separate components. This decomposition is defined by the set of color spaces in which the color image is represented. This ultimately determines the color image processing technology.

There are various types of color spaces for representing a color image. These types of color spaces include [14-16]:

RGB color space, which combines the following colors: red (R), green (G), blue (B);

CMY color space – uses a combination of colors: cyan (C), magenta (M), yellow (Y). The main difference from RGB in the application is the use of such spaces. RGB – used to display color on the monitor screen, CMY – in printing;

Lab color space, which is hardware independent. L – information about color brightness, a – information ranging from green to magenta, b – information ranging from blue to yellow. This allows independent control of color, brightness, contrast, and sharpness;

HSV color space. H – hue, S – saturation, V – brightness. It also allows independent control of color and contrast of the image;

HSL color space. H – hue, S – saturation, L – lightness. Here brightness is an absolute characteristic, and lightness is an integral characteristic of a color. This difference allows you to build different algorithms for image processing, take into account the features of the original image.

Thus, the original image can be decomposed into a series of images, where such decomposition is determined by the set of each color space.

For example, if we have some image W, which is defined by coordinates (i, j), then in the RGB color system such decomposition can be written as follows:

$$W(i, j) = R(i, j) \cap G(i, j) \cap B(i, j), \quad (1)$$

where:

R(i, j) – definition of colors in the channel R at the point (i, j) for the original image W,

G(i, j) – definition of colors in the channel G at the point (i, j) for the original image W,

B(i, j) – definition of colors in the channel B at the point (i, j) for the original image W,

\cap – color fusion operation in the model RGB.

Similarly, for the HSL color space, you can write:

$$W(i, j) = H(i, j) \cap S(i, j) \cap L(i, j), \quad (2)$$

where:

$H(i, j)$ – component of color in the channel H at the point (i, j) for the original image W,

$S(i, j)$ – component of color in the channel S at the point (i, j) for the original image W,

$L(i, j)$ – component of color in the channel L at the point (i, j) for the original image W,

\cap —color fusion operation in the model HSL.

Decomposition of the color space into a number of components allows you to obtain more additional information, to build various algorithms for analyzing the original image.

We can also make a transition between color spaces. For example, the transition between RGB and HSV color spaces can be done as follows [16]:

$$H = \begin{cases} 0, \text{ if } \text{MAX} = \text{MIN}, \\ 60 \times \frac{G - B}{\text{MAX} - \text{MIN}}, \text{ if } \text{MAX} = R, G \geq B, \\ 60 \times \frac{G - B}{\text{MAX} - \text{MIN}} + 360, \text{ if } \text{MAX} = R, G < B, \\ 60 \times \frac{B - R}{\text{MAX} - \text{MIN}} + 120, \text{ if } \text{MAX} = G, \\ 60 \times \frac{R - G}{\text{MAX} - \text{MIN}} + 240, \text{ if } \text{MAX} = B, \end{cases} \quad (3)$$

$$S = \begin{cases} 0, \text{ if } \text{MAX} = 0, \\ 1 - \frac{\text{MIN}}{\text{MAX}}, \text{ if } \text{MAX} > 0, \end{cases} \quad (4)$$

$$V = \text{MAX}, \quad (5)$$

where:

$$\text{MAX} = \max(R, G, B), \quad (6)$$

$$\text{MIN} = \min(R, G, B). \quad (7)$$

Thus, we can obtain additional sources of information for the analysis and processing of the original image. At the same time, the general technology for processing color images is as follows:

the decomposition of the original image into separate color components is carried out;

carried modification source color space and obtain further information sources.

In Fig. 1a shows the original color image. In Fig. 1b-1d shows the decomposition of the original color image in RGB space.

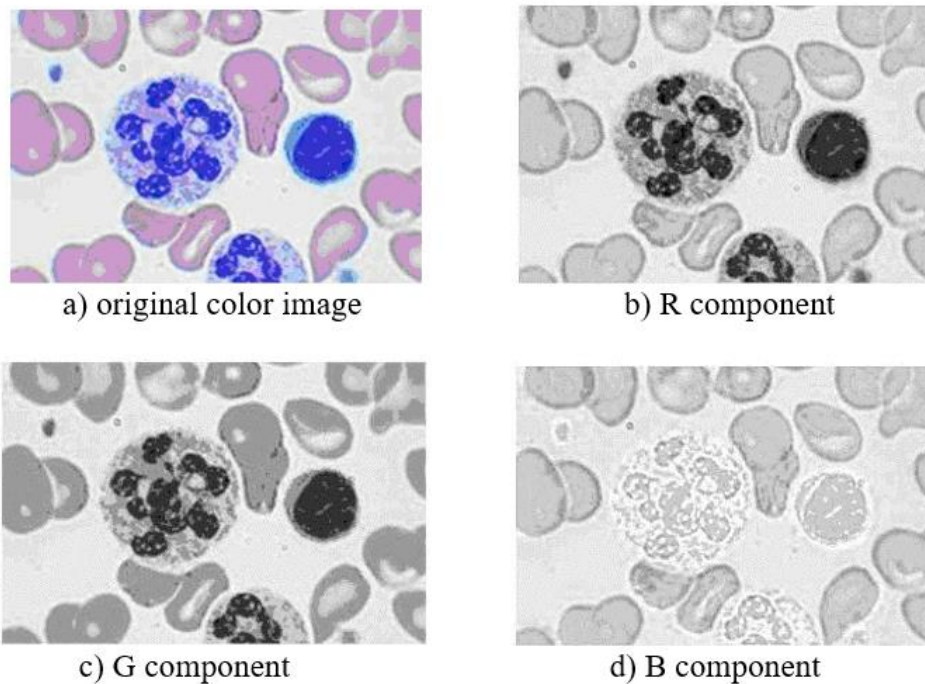


Figure 1. The original color image and its color components in RGB space

We can see that the images of the components are different from each other. This is especially evident if you do image processing. In Fig. 2 shows the processing results (contour selection) for the original color image and its color components.

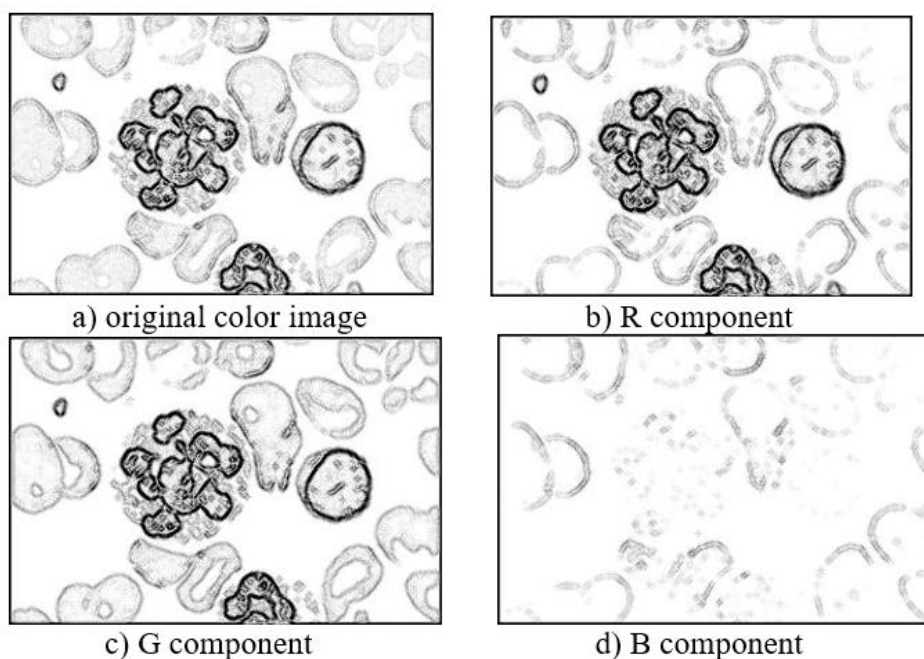


Figure 2. An example of the outline selection for the original image and its color space components

In this case, the color image processing technology consists of:
 preliminary decomposition of the original image into color spaces,
 processing of each color space,

collapsing all color spaces for images that have been processed. Moreover, such a convolution can have different strategies. It all depends on the task that is posed in the process of analyzing the original image.

We can also use different color spaces to modify and correct the original image. In Fig. 3 shows the contrast correction of the original color image (Fig. 1a) in RGB color space (Fig. 3a) and HSV color space (Fig. 3b).

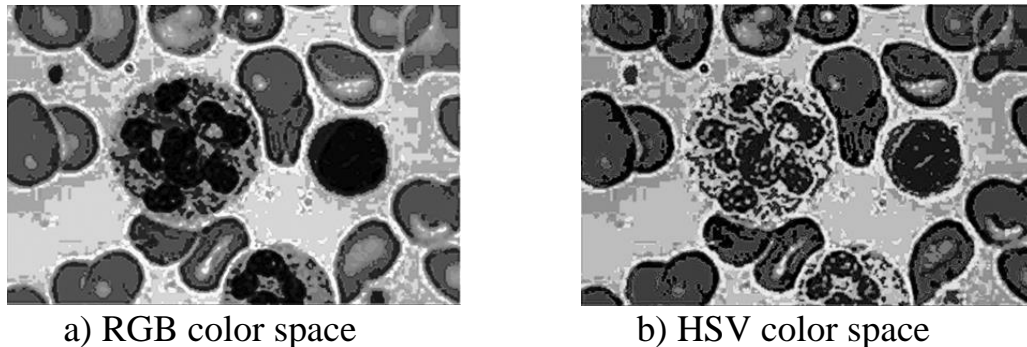


Figure 3. An example of contrast correction for the original color image in different color spaces

In Fig. 4 shows the results of image processing (contour selection) after appropriate contrast correction.

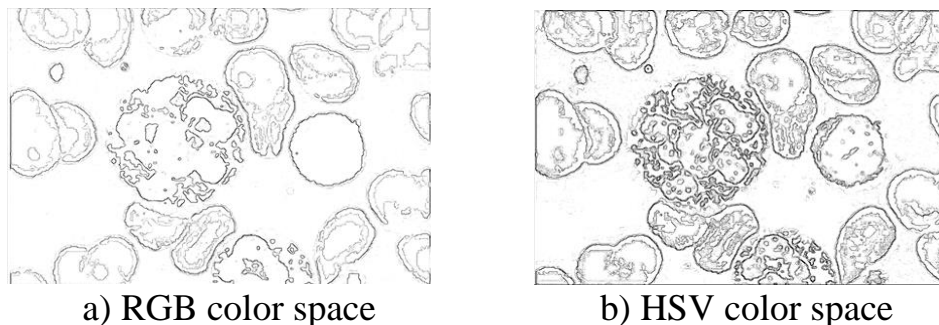


Figure 4. An example of image processing after contrast correction for different color spaces

We see significant differences in image processing for different color spaces. Thus, in this case, the technology for processing a color image consists in choosing a color space where the processing of the original image will be carried out.

The choice of the color space is a priority in the case of solving the problem of balancing the color space of the image. In particular, it is important in the printing industry for the transmission of the required gamut of colors [10, 11].

Consequently, the choice of color image processing technology is primarily determined by the tasks that need to be solved. However, it is important to obtain additional information for image analysis. This can be done by considering the different color spaces and their components. An important point is also the decomposition of the color space into separate components. Further, after processing different components of the color space, it is necessary to convolve such results. This

will improve the quality of color image processing and improve the perception of the analysis results.

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