TECHNOLOGY OF IMAGE PROCESSING

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Abstract

The use of color in image processing is due to two main reasons. Firstly, color is an important feature that often facilitates recognition and selection of an object in an image. Secondly, a person is able to distinguish between thousands of different shades of color and only about two dozen shades of gray. The second circumstance is especially important when visual (that is, performed directly by man) image analysis.

Processing of color images can divided into two main areas: image processing in natural colors and image processing in pseudo-colors. In the first case, the images in question are usually formed by color image recording devices, such as a color television camera or a color scanner. In the second case, the task is to assign colors to some intensity values of a monochrome signal or to some ranges of changes in its intensity. Until relatively recently, digital processing of color images was carried out mostly at the level of pseudocolours. Over the past decade, however, color input devices and color image processing hardware have become quite affordable. As a result, natural image processing technology currently used in a wide range of applications, including publishing systems, visualization systems, and the Internet. It will be clear from the subsequent discussions that some halftone processing techniques developed in previous chapters are directly applicable to color images. Other methods should be reformulated and consistent with the properties of the color space, which constructed later in this chapter. The methods described in this chapter are far from exhaustive; they illustrate a variety of techniques applicable to color image processing.

Keywords

Processing color images, brightness, color conversion of color image

Introduction

The approaches used in color image processing fall into two main categories. Approaches of the first category assume that each color component of the image processed separately, and then the resulting color image is composed of the components processed separately. For the approaches of the second category, direct work with color pixels is characteristic. Since the color image contains at least three components, the value of the color pixel is a vector.

Let c be an arbitrary vector in the RGB color space:

$$\mathbf{c} = \begin{bmatrix} C_R \\ C_G \\ C_B \end{bmatrix} = \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (1)$$

This expression shows that the components of the vector c are the RGB coordinates of a point in the color space. Record

$$\mathbf{c}(x,y) = \begin{bmatrix} C_R\,(x,y) \\ C_G\,(x,y) \\ C_B\,(x,y) \end{bmatrix} = \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \end{bmatrix} \qquad (2)$$

reflects the fact that the components of the vector **c** depend on the spatial coordinates (x, y). For image sizes $M \times N$ exist MN such vectors **c**(x, y), $x = 0, 1, 2, \ldots, M - 1, y = 0, 1, 2, \ldots, N - 1$. Expression (1.1-2) describes a vector whose components are functions of spatial variables x and y. This circumstance is often a source of misunderstandings, which can be avoided by focusing on the fact that our interest lies in the field of spatial processing methods. The fact that the pixels of the image are color leads, in the simplest case, to the fact that we are able to process each color component of the image independently using conventional halftone processing methods. However, the results obtained in this way do not always coincide with the results of processing performed directly in the color vector space; in this case, the development of new approaches is required.

The subject of the methods considered in this article, collectively called color transformations, is the processing of color image components within one single color model. This distinguishes these transformations from color coordinate transformations when moving from one color model to another.

I. Main part

Set the color image conversion with the following expression:

$$g(x,y) = T[f(x,y)] \qquad (3)$$

where f(x,y) — color image at the entrance, g(x,y) — transformed, or processed, color output image and T — acting on the image f operator processing on the spatial neighborhood of the point (x,y). Now the pixel value is a three-dimensional or multidimensional vector, that is, a set of three or more coordinates of the color space that is used to represent the image (see Fig. 1 (b)).

We confine ourselves to the consideration of color transformations of the form.

$$S_i = T_i(r_1, r_2, \ldots, r_n), \quad i = 1,2, \ldots, n, \qquad (4)$$

where simplify writing variables r_i and s_i used to denote the color components of images $f(x,y)$ and $g(x,y)$ at an arbitrary point (x,y), n обозначает число цветовых denotes the number of color components, $\{T_1, T_2, \ldots, T_n\}$ — a variety of conversion functions or color mapping, which, acting on quantities r_i, give values s_i. Note that the entire set n conversion functions T_i defines a single mapping T in terms of (1.1-3). Value n determined by the color space chosen to describe the image pixels f and g. For example, if the RGB color space is used, then $n = 3$ and variables r_1, r_2 and r_3 denote the red, green, and blue components of the input image. For the CMYK and HSI color spaces, we have respectively $n = 4$ и $n = 3$.

HSI components of the original image, which were calculated by the formulas

$$H = \begin{cases} \theta & \text{при } B \le G \\ 360° - \theta & \text{при } B > G \end{cases} \qquad (5)$$

$$\text{and } S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \qquad (1.1\text{-}6)$$

As expected, the intensity component is a halftone image of the original. Further, the color of strawberries is the most saturated among all the colors of the image, i.e., it is less diluted than other colors with white; This color has the greatest saturation. Finally, we note a certain difficulty in interpreting the component of the color tone, which is due to a combination of the following factors: the color tone value in the HSI model undergoes a discontinuity at those points that correspond to 0 ° and 360 ° angles

a, b, c,

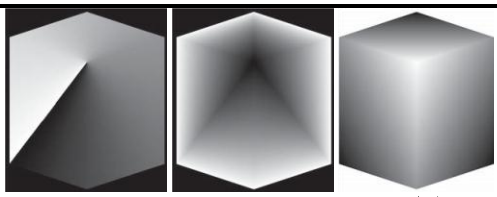
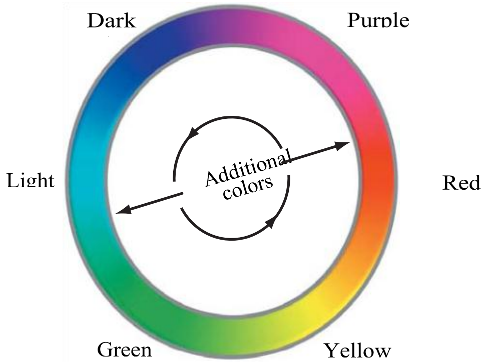


Fig. 1. HSI components of the color cube image: (a) color tone, (b) saturation and (c) intensityand (2) for color dots with zero saturation (i.e. white, black, and gray), the color tone is undefined. The discontinuity of the selected color tone model is most noticeable in the area corresponding to strawberries. At points in this region, the hue component takes values close to both the minimum (0) and the maximum (1). As a result, we have a region with unpredictably alternating extreme values of the range, representing the same color - red.



Any of presented on fig. 1 sets of color components can used in the conversion (4). Theoretically, within each of the color models, any transformation can carried out. In practice, however, some operations are better adapted for implementation within a particular model. When deciding on which color space to implement this transformation, it is necessary to take into account the costs of switching from one color representation to another. Suppose, for example, that we want to change the intensity of a color image in fig. 1 using transform

$$g(x, y) = kf(x, y) \qquad (7)$$

where $0 < k < 1$. In the HSI color space, this can be achieved with a simple conversion

$$S_3 = kr_3 \qquad (8)$$

where $s_1 = r_1$ и $s_2 = r_2$. Only the intensity component is subject to change. In the RGB color space, all three components must changed:

$$S_i = kr_i\,, \quad i = 1,2,3 \qquad (1.1\text{-}9)$$

The CMY space requires the use of a similar set of linear transformations:

$$S_i = kr_i + (1 - k)\,, \quad i = 1,2,3 \qquad (1.1\text{-}10)$$

Although in the HSI model the conversion is performed using a smaller number of operations, the calculations required for the transition from the RGB or CMY (K) space to the HSI space do not just level out (in this particular case) this advantage, but also make such a calculation method completely ineffective. The computational complexity of the transition into the HSI space far exceeds the complexity of the transformation itself. The result of the conversion, however, does not depend on the color system chosen for its implementation.

The result of applying any of the considered transformations (1.1-8) - (1.1-9) with the value = 0,7 . The graphs of the corresponding conversion functions shown in Fig. 4 (c) - (d).

It is important to note that the transformation of each of the components of the color space by the formulas (8) - (10) depends only on this one component. For example, the red component s_1 at the output, in accordance with (1.1–9), depends only on the red component $r_1$at the entrance and independent of the green(r_2) and blue(r_3) component inlet. Transformations of this type are among the most simple and frequently used means of color processing and can implemented independently for each individual color component, which was already discussed earlier in our discussion. In the remainder of this section, we consider several transformations of this kind and discuss cases where the conversion functions depend on all the color components of the input image, and therefore such a transformation cannot carried out separately for each color component.

The colors located opposite each other shown in fig. 2 color wheel called complementary colors. Our interest in the color addition, i.e., the transition from these colors to the corresponding additional colors, is this operation is analogous to the conversion of a halftone image into a negative. As in the halftone case, the color addition is useful for identifying the details inside the dark areas of the color image, especially when the dimensions of the areas are noticeably larger than the dimensions of the details.

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