A Review: Color Models in Image Processing

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Abstract

Nowadays color image processing widely utilized in multimedia, graphics and computer vision applications. Color spaces provide a rational method to specify order, manipulate and effectively display the object colors taken into consideration. There are various models based on human perception, on color recognition, on various color components etc. A few papers on various applications such as lane detection, face detection, fruit quality evaluation etc based on these color models have been published. A survey on widely used models RGB, HSI, HSV, RGI etc is represented in this paper.

Keywords: Image processing, Color models, RGB, HSI, HSV, RGI

1. Introduction

Digital image processing is a new and promptly developing field which finds more and more application in various information and technical systems such as: radar tracking, communications, television, astronomy, etc. There are numerous methods of digital image processing techniques such as: histogram processing, local enhancement, smoothing and sharpening, color segmentation, a digital image filtration and edge detection.[1]

1.1 Color image processing

T. Young (1802) [1] gives a theory in which states that any color can be produced by mixing three primary colors $C_1, C_2, C_3$ at appropriate percentages. Initially, these methods were designed especially for gray scale image processing [2][3]. The RGB color model is standard design of computer graphics systems is not ideal for all of its applications. The red, green, and blue color components are highly correlated. This makes it difficult to execute the image processing algorithms. Many processing techniques work on the intensity component of an image only. These processes are standard implemented using the HSI color model.

1.1.1 Color models

To utilize color as a visual cue in multimedia, image processing, graphics and computer vision applications, an appropriate method for representing the color signal is needed. The different color specification systems or color models address this need. Color spaces provide a rational method to specify order, manipulate and effectively display the object colors taken into consideration.. Thus the selected color model should be well suited to address the problem’s statement and solution. The process of selecting the best color representation involves knowing how color signals are generated and what information is needs from these signals.. In particular, the color models may be used to define colors, discriminate between colors, judge similarity between color and indentify color categories for a number of applications. Color model literature can be found in the domain of modern sciences, such as physics, engineering, artificial intelligence, computer science and philosophy[3].
1.1.2 Categories

(i) **Device-oriented color models**, which are associated with input processing and output signals devices. Such spaces are of paramount importance in modern applications, where there is a need to specify, color in a way that is compatible with the hardware tools used to provide, manipulate or receive the color signals.

(ii) **User-oriented color models**, which are utilized as a bridge between the human operators and the hardware used to manipulate the color information. Such models allow the user to specify color in terms of perceptual attributes and they can be considered an experimental approximation of the human perception of color.

(iii) **Device-independent color models**, which are used to specify color signals independently of the characteristics of a given device or application. Such models are of importance in applications, where color comparisons and transmission of visual information over networks connecting different hardware platforms are required [1].

Besides the above-mentioned color coordinates systems, color models have also been proposed for convenient image display on specific hardware platforms. The purpose of a color model is to facilitate the specification of colors in some standard generally accepted way. In essence, a color model is a specification of a 3-D coordinate system and a subspace within that system where each color is represented by a single point [6]. Various color models are described below.

2. Color models

2.1. RGB and CMY model

Susstrunk, Sabine et.al. (1996)[4], describes the specifications and usage of standard RGB color spaces promoted today by standard bodies and/or the imaging industry. There are some RGB color space implementation issues like sensor, unrendered, rendered or output color spaces, gamut size, encoding, compression, color space conversion etc.

A remarkable property of this representation is that for matter surfaces, while ignoring ambient light, normalized RGB is invariant (under certain assumptions) to changes of surface orientation relatively to the light source [Skarbek and Koschan 1994]. This, together with the transformation simplicity helped this colorspace to gain popularity among the researchers [Zarit et al. 1999], [Soriano et al. 2000], [Oliver et al. 1997],[4]

Xavier Granier et. al (2003), [6], proposed BRDF model based on RGB for representation of light. For accurate representation of phenomena such as interference and color separation generally requires a fine spectral representation of light required instead of the commonly used RGB components. The bi-directional reflectance distribution function (BRDF) has proven its efficiency to describe complex light interactions with surfaces. Two implementations of this approach, a Phong-like specular reflection, and a diffuse model. Even if this models is not completely physically based, these implementations show that realistic effects can be achieved by adjusting a small set of intuitive parameters. This allows for computing a large range of surface appearances that are based on layered materials.

2.2. HSI model

HSI model is proposed to improve the RGB model. The Hue Saturation Intensity (HSI) color model closely resembles the color sensing properties of human vision. To formula that converts from RGB to HSI or back is more complicated than with other color models.

Li, Jian-Feng et.al.(2002),[5], formulates a new formula for saturation in RGB-to-HSI conversion is proposed on the basis of HSI Color Space, aimed to provide more rapidity of computing in real-time control system due to fewer operations needed. The results of comparison between two conversion equations demonstrate that new conversion equation has significant advantages over traditional conversion in aspects of less operation needed in computing. But again conversion time is more.

Tsung-Ying Sun et.al(2006),[8], proposed a new method using HSI color model for lane-marking detection, HSILMD, is proposed. In HSILMD, full color images are converted into HSI color representation, within the region of interest (ROI) aiming to detect road surface on host vehicle, with Fuzzy c-Means algorithm. Thresholds of intensity and saturation are selected accordingly. Results are compared with the same scheme using RGB color model and a different scheme.

R.Aruna Jayasree et.al.(2013),[11], “RGB to HSI color space conversion via MACT algorithm” proposed a new MACT algorithm based on RGB and HSI model which uses lower order polynomials by remez algorithm. MACT algorithm which uses lower order polynomials by remez algorithm. The simulation of MACT is carried out using the lower order polynomial equations. This
decrease in error improves the linearity of the color space models working in real time environment.

2.3 HSV or HSB Model

HSL and HSV are the two most common cylindrical-coordinate representations of points in an RGB color model. The two representations rearrange the geometry of RGB in an attempt to be more intuitive and perceptually relevant than the cartesian (cube) representation. The HSL model describes colors in terms of hue, saturation, and lightness (also called luminance) The model has two prominent properties:

- The transition from black to a hue to white is symmetric and is controlled solely by increasing lightness
- Shading and tinting are controlled by a single value, lightness
- Decreasing saturation transitions to a shade of gray dependent on the lightness, thus keeping the overall intensity relatively constant
- Tones are controlled by a single value, saturation

The properties mentioned above have led to the wide use of HSL, in particular, in the CSS3 color model. The perceived disadvantage of HSV is that the saturation attribute corresponds to tinting, so desaturated colors have increasing total intensity. For this reason, the CSS3 standard plans to support RGB and HSL but not HSV. [7]

Shuhua, Li et.al(2010), [10] proposed a improved Shift-HSV color space model in image processing. HSV color space is another expression of RGB color space. But because of the mathematical definition limitation, it may be inaccuracy to the color classification in some conditions, the instability is eliminated from formula, object tracking algorithm such as MEANSHIFT is tested for this improvement. In the real projects, the improved model should be widely used.

2.4 RGI model

Rashad J. Rasras et.al (2007), [9], proposed a new model for modern real time video processing applications such as radar tracking and communication systems. This model shows conversions of various color models like RGB, HSI. These models are implemented by simple image processing on one pixel by increment in brightness and calculate the new pixel value to recognize object. Experimental results show that the time spent during RGI color model conversion may approximately four times less than the time spent during other similar models. But the object recognition is not proper due to the transformation from RGB to HSI, HSI to RGB color space, RGB to RGI vice-versa is very nonlinear and complicated in comparison to the conversion formulas among the other color models.

There are other various color spaces such as YCbCr Color Space is used in MPEG video compression standards. Y is luminance, Cb is blue chromaticity and Cr is red chromaticity. YIQ, YUV, YCbCr used in television sets and videos.

3. Conclusion

A survey on various color models, their description, comparison and evaluation results is presented. These models used various components of an image to display on specific hardware platform. The purpose of a color model is to facilitate the specification of colors in some standard generally accepted way. Research work also shows the conversions of various models to speed up the image processing with least time delays. But there is invariance in results of various models due to complex mathematical equations. In future, various image processing methods i.e. adaptive histogram equalization and contrast limited adaptive histogram equalization can be used to speed up the image processing by using these color models.

4. References


