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Hue preservation based color space transformation for brightness-robust tracking

Minjie Wan*, Guohua Gu, Weixian Qian, Kan Ren, Qian Chen

The authors are with the Jiangsu Key Laboratory of Spectral Imaging and Intelligent Sense, Nanjing University of Science and Technology, Nanjing 210094, China

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ABSTRACT

Brightness-robust tracking is always a tough task in the applications of optical signal processing. Conventional red-green-blue (RGB) space based visual tracking always fails due to the sensitiveness to changes in brightness. Hue is a robust color feature existing in the aforementioned unstable condition, but seldom considered by researchers. In this paper, a hue preservation based color space is designed to replace RGB space and to stabilize the tracking accuracy for tracking algorithms in case of severe brightness variation. First, RGB space is mapped to hue-saturation-intensity (HSI) space and the hue component remains constant through a hue preservation principle. Then, the saturation and intensity components which are easily affected by brightness are regularized through shifting and scaling operations. When finally converted back to RGB space, connection lines that connect the three corners of the RGB cube as well as the geometric center of the lines are selected as the new color space. Experimental results demonstrate that when applied to visual tracking algorithms, our color space transformation method can improve the accuracy and stability under the condition of varying brightness, or even in the low-light-level environment.

1. Introduction

Robust tracking [1–11] in case of varying brightness is always a significant research topic in the area of optical signal processing, like military attack, video surveillance, robot vision and so on, but drifting may easily occur due to changes in brightness caused by shade, weather, camera parameter, etc. In order to overcome the influences of brightness, many RGB space based algorithms have been presented, which can be classified into two categories: online updating-based methods [12] and invariant feature-based methods [13]. The former ones are intended to update color models according to the current state of target so that the adaptiveness of color variations can be guaranteed. Limited to the update speed, however, this kind of methods cannot solve the problem of steep variation. The latter ones are robust to the changing rate of brightness, but still suffer from the computational burden to some extent.

In this letter, we concentrate on designing a novel brightness-robust color space, instead of studying a complicated algorithm using tedious theories. Hue is a representative color feature that reflects the substantial color attribute of object and always remains stable in the aforementioned challenging circumstances. Motivated by this, a novel color space is presented for visual tracking in the varying brightness environment via hue preservation and regularization of the brightness-sensitive components. By this means, colored pixels with the same hue are mapped to the lines connecting the three corners of the

* Corresponding author.
E-mail address: wilson.1992@qq.com (M. Wan).

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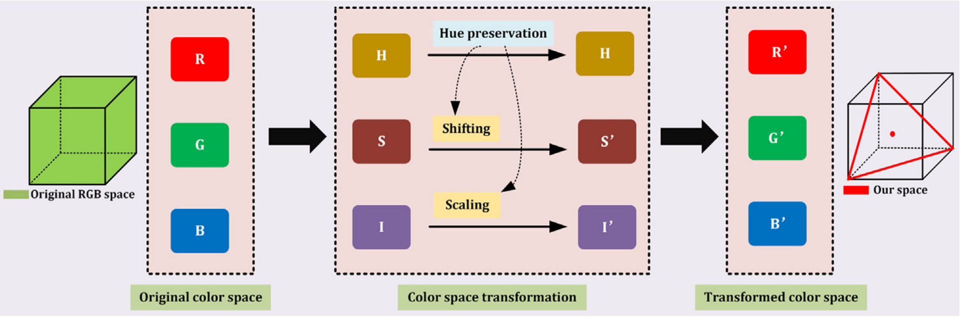

Fig. 1. Flow chart of the presented method.

RGB cube while gray pixels without color characteristics are mapped to the geometric center of the lines. In real practice, our method is only put into use when serious changes in brightness occur rather than the overall process of tracking in consideration of efficiency.

2. Theoretical analysis

In this section, a detailed introduction of the theories related to this color space transformation method is presented. Here, a complete flow chart is given in Fig. 1 to show a clear skeleton.

2.1. Principle of hue preservation

Color distortion of images may happen if hues are not well preserved before and after the color space transformation. First, the RGB-HSI conversion equations shown as Eq. (1):

$$\begin{cases} H = \arctan\left(\dfrac{\sqrt{3} \times (G-B)}{(R-G)+(R-B)}\right) \\ S = 1 - \dfrac{3 \times [min(R,G,B)]}{R+G+B} \\ I = \dfrac{R+G+B}{3} \end{cases} \quad (1)$$

where, arctan(·)is an arc tangent function and min(•) means selecting the minimum element of a vector. According to Eq. (1), shifting and scaling are two related operations which can change intensity and saturation, but keep hue constant at the same time. Suppose that a pixel is represented by a color vector $\vec{c} = (R, G, B)$, where R, G and B correspond to the red, green and blue pixel values respectively. For an 8-bit digital image, $0 \leq R \leq 255$, $0 \leq G \leq 255$, $0 \leq B \leq 255$.

Shifting an original color vector $\vec{c}$ to $\vec{c'}$ can be expressed as

$$\vec{c'} = (R+\zeta, G+\zeta, B+\zeta) \quad (2)$$

where, ζ is a shifting factor.

Also, scaling an original color vector $\vec{c}$ to $\vec{c'}$ can be expressed as

$$\vec{c'} = (\lambda \times R, \lambda \times G, \lambda \times B) \quad (3)$$

where, $\lambda > 0$ is a scaling factor.

In conclusion, a complete formula combing both shifting and scaling operation is written as

$$\vec{c'} = (R', G', B') = (\lambda \times R + \zeta, \lambda \times G + \zeta, \lambda \times B + \zeta) \quad (4)$$