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Naturalness Preserving Image Recoloring Method for People with Red-Green Deficiency

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Abstract

People with red-green color vision deficiency may experience difficulties in discriminating colors. To enhance the visual details and improve their color perception, several recoloring methods have been considered. However, most of the recoloring methods take into consideration only the needs of red-green deficients, which may look unnatural to normal viewers or trichromats. This paper proposes a simple and efficient recoloring method that not only improves visual details and enhances the color perception of the red-green deficients but also preserves the naturalness of the recolored images for both trichromats and red-green deficients. Objective and subjective evaluations are conducted to evaluate the performance of the proposed method and three other recoloring methods. Results show that the proposed method performs better in terms of naturalness preservation and overall preference by trichromats and red-green deficients.

Keywords: Red-green deficients, Recoloring method, Naturalness, Color adaptation

1. Introduction

Color vision is a part of the human central nervous system which interprets information from the visible light to form the visual color perception of the surrounding world. Individuals with normal color vision or trichromats have three independent channels to convey information of colors [1]. These three independent channels are namely cone cells sensitive in the red, green and blue spectral range in human eyes and they are generally represented by the long (L), medium (M), and short (S) cone respectively [1–3].

About eight percent of the male population have some kind of color vision deficiency [4, 5]. Dichromacy is one of the color vision deficiencies, and it occurs when one of the cones is absent or not functioning. Thus, individuals with dichromacy or dichromats have a color perception in two-dimensional color space [1, 6]. Dichromacy can be classified into three categories; protanopia, deuteranopia, or tritanopia depending on whether the missing cone is the L-cone, M-cone, or S-cone respectively. Protanopia and deuteranopia are called red-green deficiency, and are common types of dichromacy [4, 5]. Individuals with red-deficiency are called protanopes while individuals with green-deficiency are called deuteranopes. Red-green deficients have difficulty in distinguishing between red and green [4, 6]. They view red and green as yellow, orange, and beige colors [4]. Thus, they experience great difficulties with color discrimination that not only affect their social life but may also affect their careers [7, 8].

In order to understand dichromat color perception, Brettel et al. [9] proposed a computerized simulation of dichromatic vision that correctly presents the dichromat's color confusions and color palette to trichromats. A further experiment on the Brettel's algorithm by Vienot et al. [10] produced the linear transformations from trichromatic vision to dichromatic vision. Based on these findings, several techniques using different strategies have been proposed to enhance the visual details missed by red-green deficients [11–16]. Rasche et al. [11] proposed a recoloring process that implemented a constrained multivariate optimization procedure to optimize the entire set of colors in the images.

Kuhn et al. [12] utilized a mass-spring system to enhance the color contrast for red-green deficients. However, the recolored images remained in the reduced color space of dichromats, thus decreasing the general color contrast for trichromats [17]. Meanwhile, Doliotis et al. [13] implemented a clustering system to divide the colors in the images