

## COLOR IMAGE ENHANCEMENT WITH EXACT HSI COLOR MODEL

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**ABSTRACT.** While enhancing the intensity or saturation component for high-quality color image enhancement, keeping the hue component unchanged is important; thus, perceptual color models such as HSI, HSL and HSV were used. Hue-Saturation-Intensity (HSI) is a public color model, and many color applications are commonly based on this model; however, the transformation from HSI model to RGB model usually generates the out-of-gamut problem after modifying intensity and saturation in the HSI model. Moreover, the saturation component is always increased or decreased following the change of intensity component no matter what the attainable saturation range is. In this paper, we propose accurate formulas for the color transformation between RGB and the proposed HSI color model, called the exact HSI (eHSI) color model, to resolve the out-of-gamut problem directly as well as automatically adapt the saturation range; that is, the saturation component can be enhanced or reduced according to the attainable maximum saturation range. In experiments, we demonstrate how to sacrifice a little contrast to improve the image saturation based on the proposed eHSI color model.

**Keywords:** Color image enhancement, Out-of-gamut, Perceptual color model, Exact HSI color model

**1. Introduction.** Many color models have been proposed for various applications. Each color model has its own advantages and disadvantages. The popular color model *CIELAB* is perceptually uniform scaled but encounters the out-of-gamut problem. The hue-saturation-intensity (*HSI*) color model has human-intuitional advantages in image processing such as color image enhancement, segmentation, fusion, color-based object detection, recognition, traffic signal detection and skin detection, but also partially encounters the out-of-gamut problem.

The *HSI* model describes more exact color than *RGB* model describes for human interpretation [1]. Though the *HSI* model is non-uniform in perception, it is still one of the most popular color models for color image processing. More than 4,670 papers in recent four years (2006-2009) were extracted when we used “*HSI* color” as the keyword to search papers in “Google Scholar” web site. In practical applications, the non-uniformity in perception can be solved by some techniques. For example, in color image segmentation, the deformed boundaries can be used to enclose the target cluster so that the perception uniformity is not so critical. The out-of-gamut problem is really the knotty problem. This study just focuses on solving the out-of-gamut problem for color image enhancement and clarifying the drawback of the traditional *HSI* color model. The whole process is unconcerned with the perception uniformity.

Histogram equalization is a well-known image contrast enhancement method and has been used for various image enhancements [2-5]; however, it often produces images with