Perceptually Based Image Comparison Method

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Abstract

In this work a new perceptually based method of image comparison is proposed. It is based on the colour comparison in a perceptually uniform colour space CIE Luv, and using Contrast Sensitivity Function to modify colour comparison thresholds, provided by CIE Luv space.

This method can be used to measure image distortion in case of lossy image compression, and steering image generation.

***Keywords**: Perceptually based image comparison, perceptually uniform colour space, contrast sensitivity function.*

1. INTRODUCTION

In this work we introduce new image comparison method. It is based on the perceptually based colour comparison and modelling eye perception of the non-uniform images with contrast sensitivity function.

Image comparison is widely used in many areas. It is used in image search engines, in databases in systems Query by Example. This area requires very high performance (less than 10^{-3} sec per image), but comparison can be pretty rough, and should insensitive to image shears, tilts, and rotations.

Another area is comparison in rendering systems and image quality control in compression systems. These tasks do not need so hard time restrictions, but they require much more precise comparison, that can be sensitive to shears and rotations of the image. These tasks also need detection of areas, where images look different.

The goal of my work was to create image comparison method, that could be used to control image compression quality, and to increase performance of rendering algorithms. Special requirements were following:

- this method should give correct results for any display;
- it should detect areas, where images are noticeably different;
- it should provide general characteristic of image dissimilarity.

1.1 Background

Several works were made last years in this area. In one of them, by Gaddipatti et al [1] it was proposed to select perceptually important elements of the image and to pay most attention to comparing of these elements. It was also proposed in this work to use Contrast Sensitivity Function (CSF) to compute saliency values, that could be compared using MSE metric. Also it was shown in this work, why MSE metric can't be applied for direct image comparison.

Another work, by Neumann et al. [2] proposed to compare mean colours in random rectangles. They used CIE XYZ space for mean colour computation and CIE Luv space for colour comparison. The size of rectangles was a random value, distributed according to CSF, so that common size corresponded to the maximum sensitivity of the eye. Another idea described in this paper dealt with image distortion measurement. It was proposed, that only areas, where the difference is noticeable should influence total image difference

One more article, by Rammasubramiani et al [3], describes a rendering system, that uses image comparison to increase productivity. They propose to compute maximum luminosity deviation, that still produces unnoticeable image distortion. The only drawback of this system is that it takes into account just luminosity fluctuations, and does not use colour information.

1.2 The concept of the method

The idea of the proposed method is based on the model of human visual system (HVS), that uses contrast sensitivity function for correct colour comparison, and FFT for spatial frequency computation. The model is described in part 2. Using this model, the images are compared and the Visible Error Map is generated. The element of this map shows whether colours of corresponding pixels look different. The general characteristic of image dissimilarity is obtained during processing of this map, that is described in part 3.

2. HUMAN VISUAL SYSTEM MODELLING

The goal of modelling human visual system (HVS) was to provide correct and accurate colour comparison, that should be independent from the type of display, and image uniformity.

The proposed HVS model consists of two parts. The first part provides device-independent correct colour reproduction, and the second part compensates the impact of the image non-uniformity, modifying colour comparison thresholds

2.1 Colour Reproduction

The first problem we encountered, was a problem of correct colour reproduction and colour comparison. It appeared because phosphors in different monitors have different emission spectra. Therefore one colour (defined in RGB space) can look different on different monitors. To solve this problem we used perceptually uniform colour space CIE Luv. It is derivative space from the standard colour space CIE XYZ, and therefore provides device-independent correct colour reproduction.

Since it is perceptually uniform space, the distance between colours may be obtained by formula:

$$\Delta E_{Luv} = \sqrt{\Delta L^2 + \Delta u^2 + \Delta v^2}\ , \qquad \textbf{(1)}$$

where Δ – difference between corresponding components.

There are also 2 thresholds defined in this space. They help to determine whether one can notice difference between two colours. If the distance is lower than 1, than colours look like each other. If the distance is greater than 3, than difference can be easily