

## **EDGE-BASED COLOUR CONSTANCY**

Colour constancy is the ability to recognize colours of objects independent of the colour of the light source. Approaches to this problem can be divided into two groups. For the first group, the aim is to represent images by features which are invariant with respect to the light source, for example within the context of image retrieval. For the second group of approaches, the aim is to correct images for deviations from a canonical light source. Contrary to methods in the first group, solutions to this problem do estimate the colour of the light source, be it explicitly or implicitly. In this paper, we look at colour constancy approaches of the second group, i.e. methods from which a light source corrected image can be computed.

### **Grey World Hypothesis and Max RGB**

The image values for a Lambertian surface are dependent on the light source, the surface reflectance and the camera sensitivity functions. We assume that the scene is illuminated by a single light source. The goal of colour constancy is to estimate the light source colour  $e(\lambda)$ , or its projection on the RGB-kernels. The hypothesis is used to derive that the average reflectance for the short-wave, middle-wave and long-wave regions is equal. Here we employ a stronger definition of the achromatic reflectance of a scene

Max-RGB is based on the assumption that the reflectance which is achieved for each of the three channels is equal. This method is sometimes explained as being derived from the white-patch hypothesis. Since a white patch reflects all the incident light, its position in the image can be found by searching for the maximum RGB values. It should be noted however that these methods does not require the maxima of the separate channels to be on the same location, hence it also obtains correct illuminant estimation results when the maximum reflectance is equal for the three channels.

### **Grey-Edge Hypothesis**

The average of the reflectance differences in a scene is achromatic. The Grey-Edge hypothesis originates from the observation that the colour derivative distribution of images forms a relatively regular, ellipsoid like shape, of which the long axis coincides with the light source colour. The colour derivatives are rotated to the opponent colour space ( $O_1$ ,  $O_2$  and  $O_3$ ) of which  $O_3$  coincides with the white light direction. Colour constancy based on the Grey-Edge assumption can be interpreted as skewing the colour derivative distribution such that the average derivative is in the  $O_3$  orientation. In contrast to existing methods which are based on zero-order structure of the image, this method is based on the higher order structure of images. The experimental results show that the newly proposed simple colour constancy algorithms obtain similar results as more complex state-of-the-art colour constancy methods. The results show that colour constancy based on the Grey-Edge hypothesis obtains better results than those obtained with the Grey-World method for real-world images.

**Difference from other techniques:** This paper is the first to propose colour constancy derived from image derivatives. This method uses higher-order image structure of images whereas methods such as Gamut mapping, neural network based colour constancy and colour by correlation are all based on the zero order structure of images. The proposed Grey-Edge algorithm can be obtained from the Grey-World algorithm by simply exchanging the RGB values for the spatial image derivatives.

**Shortcomings:** The proposed colour constancy algorithms obtain comparable results to more complex colour constancy algorithms. However, the optimal parameter setting vary for the different data sets which needs to be determined by experimentation. The zero-order image structure, which provides the building stones for the Grey-World method, is replaced by the higher-order image structure which are more computationally intense.

**Related Possible researches:** Automatic estimation of the parameters separately per image, instead of for the whole data set, will improve the colour constancy results, possibly within a learning context. It would be interesting to see how more complex methods performed once based on the derivatives of images, or based on both zero-order and higher order structure of images.

## **AN EFFICIENT DENOISING ARCHITECTURE FOR REMOVAL OF IMPULSE NOISE IN IMAGES**

According to the distribution of noisy pixel values, impulse noise can be classified into two categories: fixed valued impulse noise and random-valued impulse noise. The values of noisy pixels corrupted by random-valued impulse noise are uniformly distributed in the range of [0, 255] for grey-scale images. The random-valued impulse noise is more difficult to handle due to the random distribution of noisy pixel values. The denoising methods can be classified into two categories: lower complexity techniques and higher complexity techniques.

A novel adaptive decision-tree-based denoising method (**DTBDM**) and its VLSI architecture for removing random-valued impulse noise. The results of reconstructed pixels are adaptively written back as a part of input data. The proposed design requires simple computations and two line memory buffers only, so its hardware cost is low. Only simple arithmetic operations, such as addition and subtraction, are used in DTBDM.

### **PROPOSED METHODOLOGY-**

A 3x3 mask for image denoising is adopted. According to the input sequence of image denoising process, the other eight pixel values apart from the central pixel are divided into two sets: top\_half and lower\_half.

DTBDM consists of two components: decision-tree-based impulse detector and edge-preserving image filter. The detector determines whether  $p(i,j)$  (central pixel) is a noisy pixel by using the decision tree and the correlation between pixel  $p(i,j)$  and its neighbouring pixels. If the result is positive, edge-preserving image filter based on direction-oriented filter generates the reconstructed value. Otherwise, the value will be kept unchanged.

### **DECISION-TREE-BASED IMPULSE DETECTOR**

In order to determine whether  $p(i,j)$  is a noisy pixel, the correlations between  $p(i,j)$  and its neighbouring pixels are considered. Three concatenating decisions of the following three modules are used in making a decision-

**Isolation Module:** The pixel values in a smooth region should be close or locally slightly varying. The differences between its neighbouring pixel values are small. Therefore, we determine whether current pixel is an isolation point by observing the smoothness of its surrounding pixels.

**Fringe Module:** If  $p(i,j)$  has a great difference with neighbouring pixels, it might be a noisy pixel or just situated on an edge. How to conclude that a pixel is noisy or situated on an edge is difficult. In order to deal with this case, we define four directions. By calculating the absolute difference between  $p(i,j)$  and the other two pixel values along the same direction, respectively, we can determine whether there is an edge or not.

**Similarity Module:** The luminance values in mask  $W$  located in a noisy-free area might be close. The median is always located in the center of the variational series, while the impulse is usually located near one of its ends. Hence, if there are extreme big or small values, that implies the possibility of noisy signals.

### **EDGE-PRESERVING IMAGE FILTER**

To locate the edge existing in the current  $W$ , a simple edge preserving technique which can be realized easily with VLSI circuit is adopted. Eight directional differences are considered to reconstruct the noisy pixel value. Only those composed of noise-free pixels are taken into account to avoid possible misdetection. Directions passing through the suspected pixels are discarded to reduce misdetection.

**Benefits:** Extensive experimental results demonstrate that the proposed technique can obtain better performances in terms of both quantitative evaluation and visual quality than other lower complexity denoising methods. Moreover, the performance can be comparable to the higher complexity methods.

**Shortcomings:** The threshold used in fringe module affects the quality of denoised images of the proposed method. A more appropriate threshold contributes to achieve a better detection result. However, it is not easy to derive an optimal threshold through analytic formulation. The fixed values of thresholds make our algorithm simple and suitable for hardware implementation. Thus the method is threshold dependent and no optimal threshold is available.