Frankle-McCann Retinex by Shuffling

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Abstract. In this paper, our aim is to present an alternative to the ratio-product term of Frankle-McCann Retinex by manipulating shifting directions and the number of iterations, which is a major obstacle in applications, keeping the quality of the result images. For this, we focus on replacing the shifting mechanism with a symmetrical shuffling method that partitions all given regions in each channel image into two parts per region and then exchanges each other in two pre-determined directions. This processing has the advantage in that there is no need to consider shifting directions at a step, so the complexity of the algorithm is reduced, except for the shuffling cost. From the experiments on Barnard’s four datasets, the results showed that our expectation can be met by the proposed method.

Keywords: Recursive Retinex, Frankle-McCann Retinex, Color Constancy, Image Enhancement.

1 Introduction

Light enables us to see the rich and colorful world. Even so, as the interaction between incident light and object surfaces sometimes causes ambiguity of object color in the images acquired by digital cameras, the removal of this ambiguity is important in the computer or machine vision. Also, in HDR (High Dynamic Range) images, details in dark regions are poorly represented due to the linear responses of digital cameras’ sensors. However, it can be solved if we obtain the color of the scene illuminant or the reflectance of surface patches. As a solution to such problems, Retinex algorithms were formulated and have still been employed for image sharpening, color constancy or dynamic range compression.

After the Retinex by Land and McCann[1], many variants have been proposed with various aims. But these algorithms are roughly classified into five classes: path-based models have random paths[1] or a random spray function[3] when determining lightness at a position; center/surround models consider its neighbors together[4-7]; PDE (Partial Differential Equation) models find a solution to the Poisson equation[8,9]; variational models are formulated as a Quadratic Programming optimization problem[10][11]; finally, recursive models[12-19] are focused on estimating the scene illuminant or the object reflectance through iteration.
The recursive Retinex was first introduced in 1983 by Frankle and McCann\cite{12}, which is U.S. patented and was eventually called the Frankle-McCann Retinex (FMR), and described again by McCann\cite{13}, as McCann-Sobel Retinex (MSR). In these methods, the path computation was replaced by a recursive matrix comparison. As follow-up work, Ciurea and Funt \cite{15} tuned the parameters of FMR such as the shift distance and the number of iterations, and these two algorithms were programmed with the MATLAB\textsuperscript{TM} code by Funt et al. \cite{16}. To adopt FSR for HDR images, Cooper \cite{16} incorporated a Ratio Modification Operator (RMO). In recent studies, the algorithms have frequently been adopted for rendering high dynamic range photographs \cite{18}\cite{19} and for color constancy in stereo images \cite{17}.

In this paper, by reconsidering the iteration pattern and the shifting direction, we present an alternative that replaces the existing ratio-product operation in FMR, with the quality of its result image being maintained. Iterative Retinex algorithms are effective in revealing details of dark images and slowly removing changing illumination. In these, the iteration pattern and the number of iterations are important parameters in making good quality images resulting from the algorithms. But a large number of iterations cause us to hesitate to adopt them in the applications. In addition, too strict constraints on the size of input images— especially in MSR— cause us to lose interest. A clue for solving these deficiencies will be discussed in this paper.

### 2 Previous Iterative Retinex Algorithms

The basis of recursive algorithms is FMR, but MSR also is a main part of the plot. Later, these two algorithms were implemented with the MATLAB\textsuperscript{TM} code by Funt et al., in which MSR was named McCann99. FMR and MSR have in common with each other in shifting, subtracting and accumulating; some differences in the iteration pattern, the reset operation and the mean of their result images. The most outstanding difference can be found in their iteration patterns as shown in Fig. 1, where we must see the reducing ratio of shift distances from the center to a point and the progressing direction in one step. In FMR of Fig. 1, one step consists of two directions, and then the shifting distance is reduced by half, and another step is performed. But in MSR on the right of Fig. 1, one step consists of four directions and two iterations per direction. The reducing ratio is the same as FMR.

![Iteration Patterns: the left for FMR and the right for MSR](image_url)