Applied Soft Computing 21 (2014) 107–118

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Color differences based fuzzy filter for extremely corrupted color images

Sohail Masood [c], Ayyaz Hussain [a,b], M. Arfan Jaffar [c,d,*], Tae-Sun Choi [a]

[a] Gwangju Institute of Science and Technology, South Korea
[b] International Islamic University, Islamabad, Pakistan
[c] National University of Computer and Emerging Sciences, Islamabad, Pakistan
[d] College of Computer and Information Sciences, Al-Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia

ARTICLE INFO

Article history:
Received 3 August 2011
Received in revised form
12 November 2013
Accepted 7 March 2014
Available online 25 March 2014

Keywords:
Color image restoration
Impulse noise
Fuzzy filter

ABSTRACT

In this paper, a color difference based fuzzy filter is presented for fix and random-valued impulse noise. Noise detection scheme of two stages was applied to detect noise efficiently whereas for noise removal an improved Histogram based Fuzzy Color Filter (HFC) is presented. Pixels detected as noisy by the noise detection scheme are deliberated as candidate for the removal of noise. Candidate noisy pixels are then processed using a modified Histogram based Fuzzy Color Filter to estimate their non-noisy values. The idea of using multiple fuzzy membership functions is presented, so that best suitable membership function for local image statistics can be used automatically. In the proposed technique we have used three different types of fuzzy membership functions (bell-shaped, trapezoidal-shaped, and triangular-shaped) and their fuzzy number construction algorithms are proposed. Experimentation is also performed with three, five, and seven membership functions. Type and number of suitable fuzzy membership functions are then identified to remove noise. Comparison with the existing filtering techniques is established on the basis of objective quantitative measures including structural similarity index measure (SSIM) and peak-signal-to-noise-ratio (PSNR). Simulations show that this filter is superior to that of the existing state-of-the-art filtering techniques in removing fix and random-valued impulse noise whereas retaining the details of the image contents.

1. Introduction

Image restoration has been used in so many applications in the last few years. They range from exploration of space to as for the medical diagnosis. Various effectual and refined techniques for image restoration have been proposed in both the spatial and transformed domains [16]. Image restoration may be defined as "the process of restoring the original image from corrupted one with or without having prior knowledge about the degradation procedure. Pre-processing, transmission, compression, acquisition, storage and/or reproduction phases of processing leads to image degradation. [7]. Restoring the image, removal of such degradation is considered as an important issue in image processing, for example, an important task is to remove the impulse noise without destroying the image details. Smoothing a region of the degraded image may lead to blurrier edges while sharpening edges can cause amplification of unnecessary noise. Standard impulse noise filtering procedures are generally based on median modifications [17]. Most of the filters are subjected to be applied on the image as a whole, apart from applying on the noisy pixels, pixels that are not altered and are noise free are also changed that is the key contributing factor for destroying the image specifics. Switching scheme concept is an important strategy to improve the impulse noise removal without destroying the image details [18]. The concept suggests that we should detect the noisy pixels first and then we should proceed to the process of noise removal. Noise free pixels should remain unchanged during the filtering process. Most of the newly proposed filters are based on this approach. Since only the selected pixels are estimated during the filtering process, therefore most of the image details can be maintained in this case by not estimating the noise-free pixels present in the degraded image. In these filter, the core is the efficient and accurate noise

* Corresponding author at: College of Computer and Information Sciences, Al-Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia. Tel.: +966 553605730.
E-mail addresses: rsmbhatti@gmail.com (S. Masood), ayyaz.hussain@iiu.edu.pk (A. Hussain), arfan.jaffar@ccis.imamu.edu.sa, arfanjaffar@gist.ac.kr (M.A. Jaffar), tschoi@gist.ac.kr (T.-S. Choi).

http://dx.doi.org/10.1016/j.asoc.2014.03.006
1568-4946/

detection process. Since degradation can occur on smooth regions as well as on edges, therefore, estimation of noisy pixels can still lead to distortion of edges. So we need a correct noise detection process as well as an effective detail preserving filter to restore the degraded image. Color image restoration is a difficult task as compared to the gray-scale image restoration but it is a logical step in the study of image restoration [35,37,38]. The major problem in color image restoration is that restoration algorithm must take care of correlation between different color components. Majority of the methods, proposed for color image restoration, apply the filtering mechanism to each color channel, say Red, Green and Blue in RGB model, independently. The images restoration techniques discussed in paper 2 are mainly used for grayscale images but they can also be applied to color images by applying them to each color component independently. This procedure leads to the introduction of many artifacts especially on edge or texture elements. As these techniques are applied on each component separately, each color component is restored by a different amount of noise. As a

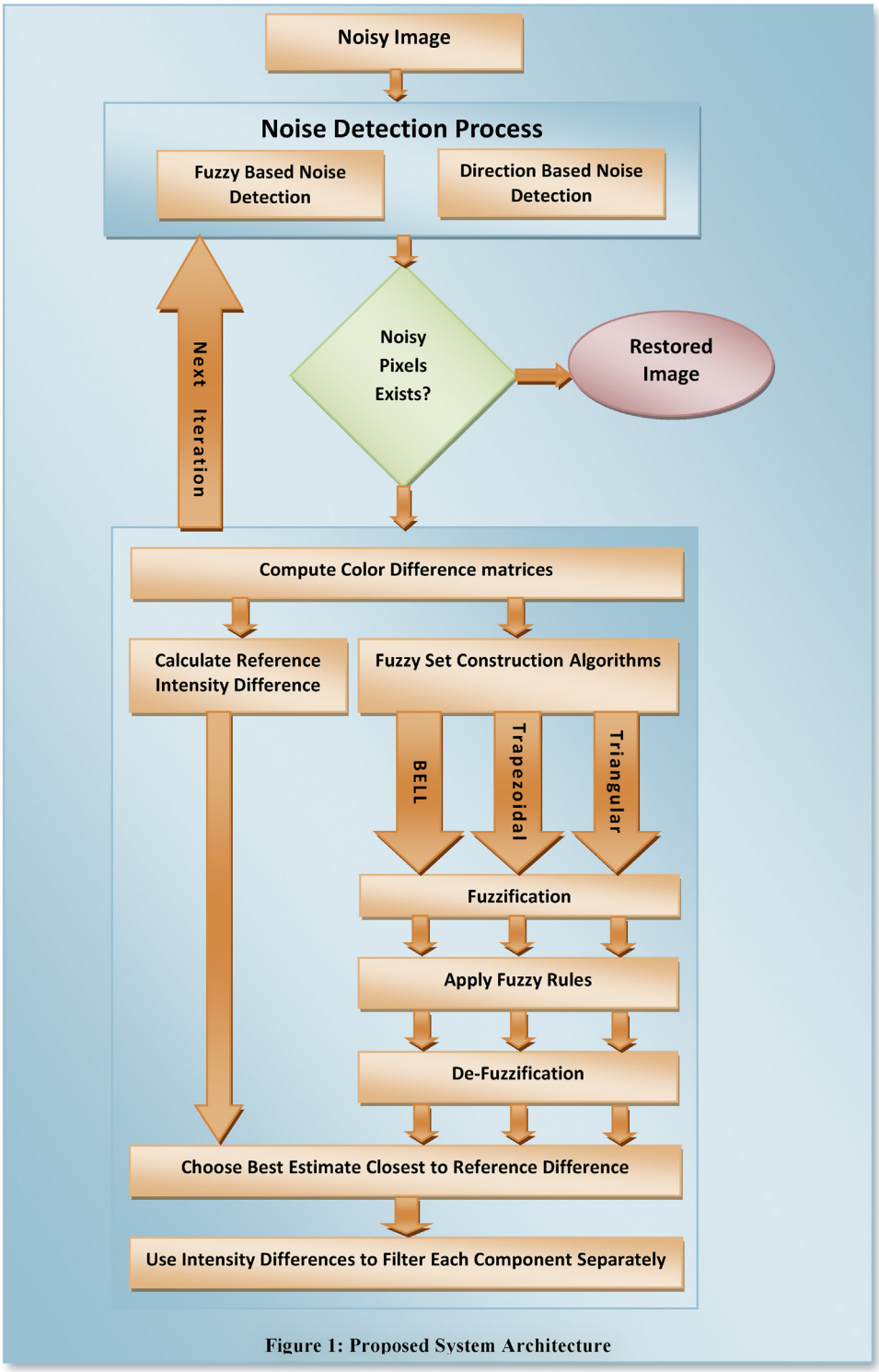

Fig. 1. Proposed system architecture.