Chapter 6
A Novel Approach of Restoration of Digital Images Degraded by Impulse Noise

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ABSTRACT

Restoration of digital images degraded by impulse noise is still a challenge for researchers. Various methods proposed in the literature suffer from common drawbacks: such as introduction of artifacts and blurring of the images. A novel idea is proposed in this paper where presence of impulsive pixels are detected by ANFIS (Adaptive Neuro-Fuzzy Inference System) and mean of the median of suitable window size of noisy image is taken for the removal of the detected corrupted pixels. Experimental results show the effectiveness of the proposed restoration method both by qualitative and quantitative analysis.

INTRODUCTION

Degradation of images usually occurs due to addition of noise during image acquisition and transmission. Each element in the imaging chain such as lenses, film, digitizer, etc. is responsible for introducing noises and causing degradation. Hence, some noise reduction technique is essential to suppress the noise by retaining important features of the images according to different applications. Noise occurs in the images when the pixels are randomly failed and replaced by other values in an image. The image model containing impulse noise can be described as:

$$X_{ij} = \begin{cases} N_{ij}, & \text{with probability } p \\ S_{ij}, & \text{with probability } 1-p \end{cases}$$

where, S_{ij} represents the noiseless image pixel and N_{ij} represents the noise substituting for the original pixel. The fixed and random-valued impulse noise have been discussed in a variety of impulse noise models for images. Fixed-valued impulse noise, known as the "salt-and-pepper" noise, is made up of corrupted pixels whose values are replaced with values equal to the maximum or minimum (255 or 0) of the allowable range with equal probability (*p*/2). The random-valued impulse noise is made up of corrupted pixels, the values are replaced by random values, uniformly distributed in the range [0, 255]. Several modifications have been applied on conventional filtering techniques in order to remove noise as nonlinear filtering techniques tend to blur fine details and destroy edges while removing corrupted pixels. (Lee, Kuo & Yu, 1997);(Lee & Kuo, 2000);(Xu, Zhu & Wang, 2004); (Sheng & Runato, 2000); (Boo, Ibrahim & Toh, 2009).

In recent years, research is being carried out in the field of digital image processing with conjunction of soft computing technique. Fusion of Adaptive Neural Network (ANN) and Fuzzy Inference System (FIS) is frequently applied by researchers in various scientific and engineering research areas to tackle real world issues. When the classic techniques are not sufficient to produce an easy and accurate solution, neural networks and fuzzy logic are applied together to a variety of problems in digital image processing (Yuksel & Bas, 2003); (Yuksel & Bas, 2005); (Yuksel & Yildirim, 2004). As both paradigms have their own advantages, it becomes imperative to combine their features and make a strong tool to solve complex problems.

Suo et al. (2010) have discussed the advantages of neural network technology, such as parallel calculating abilities, nonlinear mapping and adaptive ability for visual image processing. Monireh (2012) has reviewed the application of ANFIS as a classifier in medical image classification. Training procedure of neural network for resolving problems related to medical imaging is analysed by Jiang and all (2010). Saenko et al. (2012) has used fuzzy technique for image enhancement and image quality analysis. A new soft-switching hybrid filter based on a neuro-fuzzy network for impulsive noisy environments has been proposed by Saban and Hasan (2011), which combines an adaptive finite impulse response (FIR) filter, an adaptive weighted myriad (WMy) filter, and a soft-switching mechanism based on a neuro-fuzzy (NF) network. Zhenghao and Lifeng (2010) have reviewed the application of artificial neural networks in medical image pre-processing, in medical image object detection and recognition. A novel Adaptive Neuro Fuzzy Inference System (ANFIS) filter to remove impulse, Guassian as well as mixed noise has been proposed by C. Hemalatha et al. (2012), which preserves the small fine details like edges and textures of the image. Hao Qin et al. (2007) have presented the ANFIS approach for nonlinear noise cancellation for images. The mean filter is normally used to reduce Gaussian noise, but it is not so effective on the impulse noise. Median filter is good for reducing the impulse noise but it does not work well on Gaussian noise. Based on the idea of fuzzy logic, Zhang et. Al (2011) have proposed the fuzzy filter, which could deal with these two types of noise to some extent. The role of the fused neuro-fuzzy system is attracting researchers due to the significant enhancement in results over traditional methods.

A combinational neuro-fuzzy filter is proposed in this paper, where fused NF logic is used to detect the impulse noise and a mean of the median of the window size is used to restore the noisy image. The paper has been organized in four sections. The section II describes the working of neuro-fuzzy model, section III gives the description of the proposed model. Experimental results are shown in section IV which reflects all the significant improvement over the traditional method.

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