Chapter 55
An Efficient Random Valued Impulse Noise Suppression Technique Using Artificial Neural Network and Non-Local Mean Filter

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ABSTRACT

A new technique for suppression of Random valued impulse noise from the contaminated digital image using Back Propagation Neural Network is proposed in this paper. The algorithms consist of two stages i.e. Detection of Impulse noise and Filtering of identified noisy pixels. To classify between noisy and non-noisy element present in the image a feed-forward neural network has been trained with well-known back propagation algorithm in the first stage. To make the detection method more accurate, Emphasis has been given on selection of proper input and generation of training patterns. The corrupted pixels are undergoing non-local mean filtering employed in the second stage. The effectiveness of the proposed technique is evaluated using well known standard digital images at different level of impulse noise. Experiments show that the method proposed here has excellent impulse noise suppression capability.

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INTRODUCTION

Image denoising is one of the widely studied unsolved problems and plays a significant role in the research area of image processing and computer vision. Most of the time images are contaminated by impulse noise during the process of image acquisition or at the time of transmission due to malfunctioning image pixels in the camera sensors, channel transmission errors or faulty storage hardware. Therefore, a pre-processing stage is always required before processing an image for any application. Noise filtering is one of the important parts of this stage. The objectives of image denoising algorithms are to detect and suppress the unhealthy pixel elements in the test image without harming the fine details of the image. Impulse noise found in digital images is a spark that disturbs the information contain in the images. It distorts the pixels of a digital image by replacing the original value either by fixed value or any random value within the available dynamic range. So there are two categories of impulse noise as per the distribution of noise in an image: salt and pepper noise (SPN) and Random valued impulse noise (RVIN) (Dey, Ashour, Beagum et al., 2015) (Ikeda, Gupta, Dey et al., 2015). Impulse noises can be mathematically described by the following model (Patel, Jena, Majhi & Tripathy, 2012):

$$s\left(u,v\right)=\begin{cases}\gamma\left(u,v\right) & \text{with probability } P\\ x\left(u,v\right) & \text{with probability } 1-P\end{cases} \tag{1}$$

where, $s(i,j)$ specifies a certain location of a pixel in the test noisy image, $x(i,j)$ indicates an original healthy image pixel element and γ(u,v) represents a location where a pixel element is contaminated by impulse noise. In salt-and-pepper noise(SPN), the corrupted pixels either obtain the minimum value or the maximum value of the available dynamic range i.e. η(i,j)$\hat{I}${Sm$i_{n,S}$m$a_{x\},}$ and in random-valued impulse noise(RVIN), the corrupted pixel element can attain any possible value of the available dynamic range i.e. y(i,j)$\hat{I}${Sm$i_{n,S}$m$a_{x\}}$ where, Sm$i_{n,S}$m$a_{x\ d}$enote the minimum and the maximum pixel intensity within the available dynamic range of the image respectively. Therefore, the detection and suppression of presence of RVIN in an image is a challenging work (Gonzalez & Wood, 2002; Chanda & Majumder, 2002; Kang & Wang, 2009). Figure 1 shows the result of image corrupted by RVIN and SPN noise. Most of the existing algorithm performs very well for suppression of salt and pepper noise (SPN), whereas the performance towards random valued impulse noise (RVIN) is quite miserable (Jena, Patel &Majhi, 2014).

Noise removal from images is a prominent field of research and many authors have proposed a large number of methods and explained their effectiveness with other methods. The main thrust on all such methods is to detect and suppress unhealthy pixels present in the image while keeping the image details unaffected. Initially the most common and popular filters used for impulse noise suppression is the simple median filter as in Chanda and Majumder (2002) Jena, Patel, Majhi, and Tripathy (2013) and its modifications. But it could not differentiate between noisy and noise free pixels. Due to the above case, all the pixels i.e. both healthy and unhealthy are allowed in taking part in the filtering stage which causes absence of fine details in the restored images and producing blotches. To avoid such problem an impulse noise detection stage must be included in the algorithm before filtering process, which can only allow the identified corrupted pixels only to be filtered. In last few year some improved noise removal process with advanced noise detection algorithm have been proposed, such as: Space Variant Median Filters for the Restoration of Impulse Noise Corrupted Images (Kang & Wang, 2009), Adaptive Im-