WEIGHT MEDIAN FILTER USING NEURAL NETWORK FOR REDUCING IMPULSE NOISE

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Partial Requirements for the Degree of Master of Science

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Dedicated

to

My country Iraq,

Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia in fulfilment of the partial requirements for the degree of Master of Science

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March 2004

Chairman :Associate Professor Abd Rahman Ramli, Ph.D.

Faculty :Engineering

Noise is undesired information that affects an image. Noise appears in images from various sources. Noise reduction and noise removal is an important task in images processing.

The weight median filters are extension of the median filter; it belongs to the broad class of nonlinear filters. Weight median filter is more effective form of image processing, it is the removing ability of impulsive noise. Impulsive noise is a kind of image corruption where each pixel value is replaced with an extremely large or small value that is not related to the surrounding pixel values by a probability.

The design of weight coefficients of the weight median filter is considered as a difficult problem. The weight coefficients of the weight median filter learnt by the back-propagation with supervised multi-layer perceptron feed-forward networks and threshold decomposition has been presented in this thesis, which has been implemented using Turbo C++ language.

Good results have been achieved by using program package. Results show that weight median filter based on threshold decomposition removes impulsive noise with an excellent image detail-preserving capability compared to nonlinear filter and linear filter. Restored images evaluation by using mean square error and speed. The package has been implemented using the MATLAB language.

This study provides three types of filtering windows size, 3×3, 5×5 and 7×7 window size. The result shows that the mean square error of weight median filter based on threshold decomposition using 3×3 filtering window is less than 5×5, and 7×7 filtering window and the speed of weight median filter based on threshold decomposition using 3×3 is faster than 5×5, and 7×7 filtering window.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk ijazah Master Sains

PENAPIS MEDIAN PEMBERAT MENGGUNAKAN RANGKAIAN NEURAL BAGI PENGURANGAN HINGAR IMPULSIF

Oleh

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Mac 2004

Pengerusi : Profesor Madya Abd Rahman Ramli, Ph.D.

Fakulti : Kejuruteraan

Hingar merupakan maklumat yang tidak dikehendaki yang mempengaruhi suatu imej. Hingar yang wujud dalam imej datang dari pelbagai punca. Pengurangan dan penghapusan hingar merupakan suatu tugas yang amat penting dalam pemprosesan imej.

Penapis median berpemberat merupakan lanjutan daripada penapis median; dan ia tergolong dalam kelas penapis tak linear. Penapis median berpemberat merupakan pemprosesan imej yang lebih efektif; ia berkebolehan menghapuskan hingar impulsif. Hingar impulsif merupakan sejenis kerosakan imej di mana setiap nilai piksel akan

ditukarkan kepada nilai yang jauh lebih besar atau jauh lebih kecil yang tidak berkaitan dengan piksel di sekelilingnya menurut kebarangkalian.

Rekabentuk pekali pemberat untuk penapis median pemberat boleh dianggap sebagai satu perkara yang sukar. Pekali pemberat untuk penapis median pemberat yang dikaji menggunakan perambatan-belakang dengan rangkaian pegamatan penapisan-berganda suapan-kedepan dan penguraian ambang telah disampaikan di dalam tesis ini, yang mana ia telah dilaksanakan dengan menggunakan bahasa pengaturcaraan Turbo C++.

Keputusan yang memberangsangkan telah dicapai dengan menggunakan pakej program. Keputusan menunjukkan bahawa penapis median pemberat berasaskan penguraian ambang boleh menghapuskan hingar impulsif dengan kebolehan pengawetan-terperinci imej yang amat baik berbanding penapis tak linear dan penapis linear. Penilaian imej-imej yang disimpan dibuat dengan menggunakan ralat min kuasa dua dan halaju. Pakej ini telah dilaksanakan dengan menggunakan bahasa pengaturcaraan MATLAB.

Kajian ini menyediakan tiga jenis saiz tetingkap penapis tingkap iaitu 3×3, 5×5 dan tetingkap 7×7. Keputusan menunjukkan bahawa ralat min kuasa dua untuk penapis median jisim berdasarkan penguraian ambang yang menggunakan penapis tingkap bersaiz 3×3 adalah kurang daripada tetingkap penapis 5×5 dan 7×7, dan halaju bagi penapis median tetingkap berdasarkan penguraian ambang menggunakan penapis tingkap 3×3 adalah lebih cepat tetingkap penapis 5×5 dan 7×7.

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I certify that an Examination Committee met on **4/3/2004** to conduct the final examination of **Feras N. Hasoon** on his Master of Science thesis entitled "**Weight Median Filter Using Neural Network for Reducing Impulse Noise**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the supervisory committee are as follow:

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DECLARATION

I here by declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

FERAS N. HASOON

Date:

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LIST OF ABBREVIATIONS

ANN	: Artificial Neural Network
BP	: Back-Propagation
CCD	: Charge Couped Diode
DMUX	: Demultiplexor
DPCM	: Differential Pulse Code Modulation
DWC	: Difference Weight Coefficient
LTU	: Linear Threshold Unit
MF	: Median Filter
MLP	: Multi-Layer Perceptron
M-P	: McCulloch-Pitts
MSE	: Mean Square Error
NN	: Neural Network
PCA	: Perceptron Convergence Algorithm
W-H	: Widrow-Hoff
WM	: Weight Median
WMF	: Weighted Median Filter

CHAPTER I

INTRODUCTION

1.1 Background

Artificial neural networks are mathematical models, which are highly abstracted from the biological nervous systems that inspired them. They have been used in a large variety of applications. One of these applications is the optimization of image processing filter by using the neural network (Krell, *et al.*, 1996).

As any undesirable signal, noise is everywhere and thus we must learn to live with it. It gets introduced into the data via electrical systems used for storage, transmission, and/or processing. In addition, nature always plays a "noisy" trick or two with the data under observation.

Noise suppression or noise removal is an important task in images processing (Koschar and Abidi, 2001). Nonlinear filters have been successfully applied in smoothing images corrupted by impulses and substituted for linear filters because of their better edge preservation and impulse rejection capabilities (Chen and Wu, 2001). In image processing, median filtering (MF) has been proved to be a very powerful method in removing impulsive noise (Xu and Miller, 2002).

Weighted median filter (WMF) is an extension of the median filter. It introduces the concept of weight coefficient into the median filter. Weighted median filters are used to reduce impulsive noise and to preserve sharp edges in image signal efficiently (Kowalski, 2002).

Design of the WMF is believed to be a difficult problem, since there are no general methods of determining and designing the WMF. A method of determining the weight coefficients by designing the property for image features within a window has been suggested. (Akira, *et al.*, 1990)

A method of the weight coefficients design based on the back-propagation (BP) with supervised Multi-layer perceptron (MLP) feed-forward networks and the threshold decomposition algorithm has been proposed in this thesis. Learning algorithm needs a training set of a pair of images: a noisy input image and its ideal output.

1.2 Problem Statement

Noise arises as a result of unmodelled or unmodellable processes going on in the production and capture of the real signal. Noise appears in images from a variety of sources.

Salt and pepper noise common image processing problem, the noise is caused by errors in the data transmission, malfunctioning pixel elements in camera sensors, faulty memory locations, or timing errors in the digitization process and most scanned images contains noise in form of darker dots and disturbances caused by the scanning process.

If noise cannot be reduced thus, the image may mistakenly be interpreted wrong.

1.3 Objectives

The aim of this thesis is to study and investigate the effect of weight median filter in the application of images as follows:

- **To design weight coefficients of the weight median filter by using neural network based on threshold decomposition.**
- **To compare image restoration by using weight median filter and other filters.**
- **To evaluate the restored images by using mean square error (MSE) and speed.**

1.4 Scope of Work

In this thesis nonlinear filter with neural network has been presented, a novel filter to reduce impulsive noise has been developed as well as. The coefficients of the WMF have been learned by back-propagation with supervised MLP feed-forward networks and threshold decomposition algorithm. C and MATLAB have implemented this scheme.

1.5 Thesis Layout

The thesis is organized in five chapters. Introduction, which covers background of the research problem, problem statement, research objectives and the scope of research. Chapter Two contains literature review, while the third chapter contains

the methodology. The fourth chapter discusses the results obtained during the study. Finally chapter five summarizes the research findings and suggests potential future work.

CHAPTER II

LITERATURE VIEW

2.1 Noise in Digital Image

Noise is any undesired information that contaminates an image. Noise appears in images from various sources. The digital image acquisition process, which converts an optical image into a continuous electrical signal that is then sampled, is the primary process by which noise appears in digital images (Umpaugh, 1998).

There are several ways that noise can be introduced into an image, depending on how the image is created. For example:

- If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by scanner itself.
- If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a Charge Couped Diode (CCD) detector) can introduce noise.
- Electronic transmission of image data can introduce noise (Matlab Toolbox, 1997).

2.2 Type of Noise

In typical images the noise can be modeled with either a Gaussian ("normal"), uniform, or salt-and-pepper ("impulse") distribution.

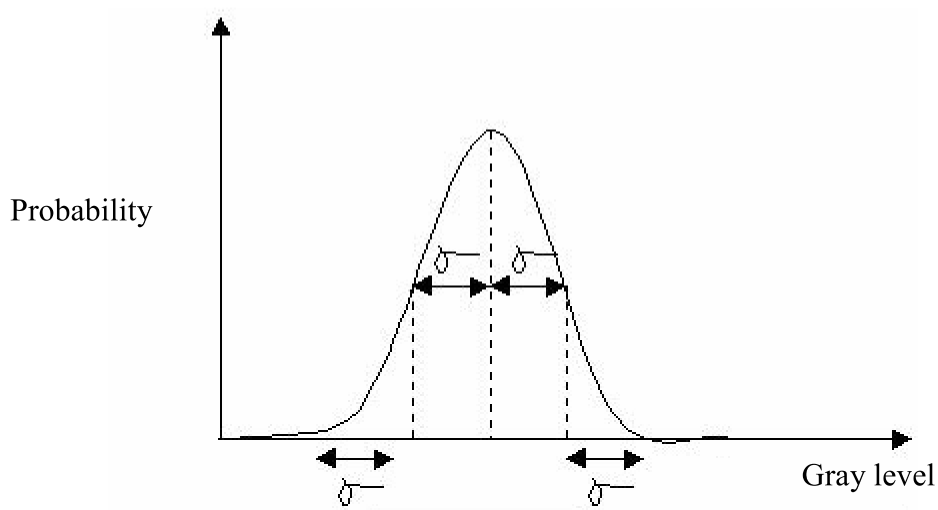
2.2.1 Gaussian Noise

The gaussian model is most often used to model natural noise processes, such as those occurring from electronic nose in the image acquisition system. Figure 2.1 shows the bell-shaped curve of the gaussian noise distribution, which can be analytically described by

$$\text{HISTOGRAM}_{\text{Gaussian}} = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2} \tag{2.1}$$

Where:

g = gray level
m = mean (average)
σ = standard deviation (σ^2 = variance)



m

Figure 2.1 Gaussian Noise Distribution

2.2.2 Uniform Noise

Uniform noise is useful because it can be used to generate any other type of noise distributed and is often used to degrade images for the evaluation of image restoration algorithms because it provides the most unbiased or neutral noise model

In the Figure 2.2 is the uniform distribution:

$$\text{HISTOGRAM}_{\text{Uniform}} = \begin{cases} \dfrac{1}{b-a} & \text{for } a \le g \le b \\ 0 & \text{elsewhere} \end{cases} \qquad (2.2)$$

$$\text{mean} = \frac{a+b}{2}$$

$$\text{variance} = \frac{(b-a)^2}{12}$$

With the uniform distribution, the gray-level of the noise are evenly distribution across a specific range, which may be the entire range (0 to 255 for 8-bits), or a smaller portion of the entire range.

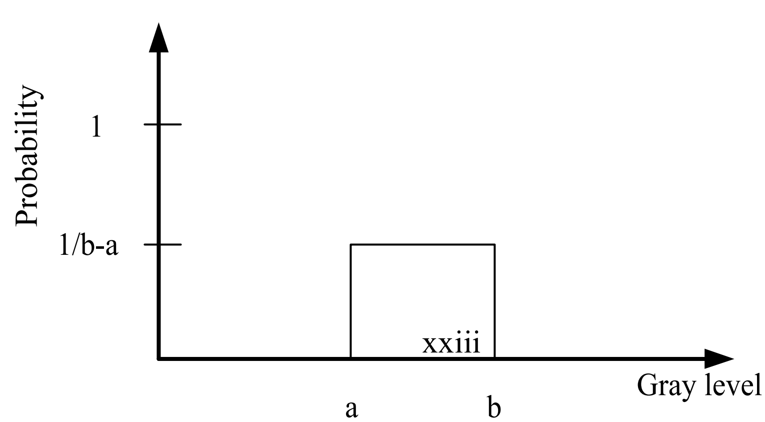


Figure 2.2: Uniform Noise Distribution

2.2.3 Salt and Pepper

The salt-and-pepper type noise is typically caused by errors in the data transmission (Fisher, *et al*, 1994), malfunctioning pixel elements in camera sensors, faulty memory locations, or timing errors in the digitization process.

The corrupted pixels are either set to the maximum value (which looks like snow in the image) or have single bits flipped over. In some cases, single pixels are set alternatively to zero or to the maximum value, giving the image a `salt and pepper' like appearance. Unaffected pixels always remain unchanged. The noise is usually quantified by the percentage of pixels, which are corrupted (Fisher, *et al.*, 2000).

In Figure 2.3 is the salt and pepper distribution:

$$\text{HISTOGRAM}_{\text{Salt \& Pepper}} = \begin{cases} A & \text{for } g = a \text{ ("pepper")} \\ B & \text{for } g = b \text{ ("salt")} \end{cases} \qquad (2.3)$$

In the salt and pepper noise model there are only two possible values, a and b, and the probability of each is typically less than 0.1 with numbers greater than this, the noise