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PARABOLIC DIFFUSION MODEL FOR IMAGE DENOISING IN DETECTING WELD FLAWS

SUHAILA BINTI ABD HALIM

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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Name of Student	:	Suhaila binti Abd Halim
Student I.D. No.	:	2010399299
Programme	:	Doctor of Philosophy in Information Technology and Quantitative Sciences – CS990
Faculty	:	Computer and Mathematical Sciences
Thesis Title	:	Parabolic Diffusion Model for Image Denoising in Detecting Weld Flaws
Signature of Student	:	.....
Date	:	September 2017

ABSTRACT

Image quality is an important feature in image analysis. However noise normally occurs in an image during the process of image transmission, acquisition or compression. Hence, image denoising becomes the key process in image processing. Classical filtering techniques such as Median, Gaussian and Average filters tend to blur the edge in an object's image and hence reducing the image quality. Literature shows that PDE-based models are renowned to preserve the edge in an image very well. Hence the application of the PDE models in image processing has gained a lot of attention for the past few decades because it provides better approximations in which it is able to adaptively adjust the operation of the local information in the image. In this research the two-dimensional diffusion equation in the form of nonlinear PDE of order two and order four denoising models are explored. Existing nonlinear PDE denoising models are analysed and modified with a different diffusion coefficient. The effect of the diffusion coefficient proposed in the PDE is examined on a set of welding digital radiographic images. The nonlinear mathematical model is set in the form of an IBVP and solved numerically using the finite difference approach. Two explicit (Scheme 1, Scheme 2) and two implicit finite difference schemes (Scheme 3, Scheme 4) are derived to serve as the denoising tool. The proposed schemes are tested on digital radiographic images that contain specified flaw. A flawed specimen is used as a benchmark data and an addition of 20 samples of real data are used for experimental purposes. The performances of the schemes are evaluated using Structural Similarity Index Measure (*SSIM*), Peak Signal to Noise Ratio (*PSNR*) and Mean Absolute Error (*MAE*). Results obtained show that the four schemes successfully remove noise in the image by producing high *SSIM* and *PSNR* values with Scheme 3 relatively performing the best. This is because Scheme 3 is an ADI scheme very much similar to the traditional Peaceman Rachford ADI scheme which is known to have unconditionally stability feature. Graphical results based on the Relative Error (*RE*) curve of each scheme show that each reduces and stabilizes asymptotically. All the schemes are experimentally shown to be convergence and stable. After the denoising process, the flaw detection process is adopted and successfully produces the length value of weld flaw in welding image. For automation purposes a GUI is developed using MATLAB. The GUI is very useful for the welding inspectors to analyze and evaluate radiographic data fast. This research opens room for more explorations in terms of the diffusion coefficient and its applications on other digital data types. The findings enrich research knowledge and explorations in this field.

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CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

A digital image is a representation of a two-dimensional image as a finite set of digital values, called pixels. Many digital images are often disturbed by noise that originate either from the image formation process or during the image transmission process itself. Noise can be defined as unwanted and unavoidable signals that interferes the communication and transmission or measurement of another signal. Noise is presented in various degrees in almost all environments (2008). In a digital image, noise can result in a subjective loss of information which consequently degrades the visual quality of the image. This problem is serious when the information loss in the original digital image has major or critical data. This concern results in the emergence of the digital image processing research field since the early 90's. Since then this field continues to be active globally in this digital age until today with the main mission of finding ways to improve and maintain a high visual quality of digital images.

In image processing, images undergo appropriate modifications in order to be improved. The images are enhanced with an improved visual quality that allows valuable information to be extracted which can be used for analysis purposes. High quality image gives better visualization and helps in producing more accurate evaluations. Several main processes involved in image processing are namely image denoising, segmentation and classification.

The aim of image denoising process is to remove noise in the digital images in order to form a smooth clear image. A smooth image presents an image with a smooth transition of one color pixel to the other pixels in the image. This involves replacing the intensity of the pixel in the image with its neighboring pixels. However the problem is that this often results in blurring effect and hence diminishes the object edges in the image. Since the edge information is important for image analysis and interpretation, the edge should be kept during the denoising process. This issue has raised the problem of preserving the image edge during image smoothing. Many methods have been proposed in order to remove noise and restore the quality of an image for better visualization. Amongst them are the edge-preserving methods, Median filtering method, hybrid Median