HYBRID FILTERS FOR EDGE DETECTION AND ITS NEW FUZZY PERFORMANCE EVALUATION TECHNIQUE

by

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LIST OF ABBREVIATIONS

MSE	Mean square error
EDI	Edge Detection Index
AVE	Average
MIN	Minimum
MAX	Maximum
PSNR	Peak signal to noise ratio

LIST OF SYMBOLS

Gy	Vertical Direction
Gx	Horizontal Direction
θ	Angle

Penapis-penapis Hibrid untuk Pengesanan Pinggir dan Kaedah Penilaian Prestasi Kabur Barunya

ABSTRAK

Pengesanan pinggir merupakan operasi penting dalam pemprosesan imej digital dan juga sangat penting dalam bidang komputer visual, segmentasi imej dan pengecaman objek. Pinggir ialah garisan antara dua sudut atau permukaan yang juga merupakan peralihan ketara warna dalam suatu imej. Ianya juga boleh ditakrifkan sebagai perubahan mendadak dalam keamatan piksel-piksel dan ketakselanjaran dalam kecerahan imej. Objektif utama kaedah pengesanan pinggir ini adalah untuk mengeluarkan ciri-ciri atau maklumat penting dalam sesebuah imej. Dalam kajian ini tujuh teknik yang berbeza telah digunakan untuk mengekstrak titik-titik pinggir bagi dua imej yang berbeza. Tujuh teknik yang terlibat adalah pengesan pinggir klasik dan juga penapis-penapis hibrid seperti Sobel, Prewitt, Freichen, Robert, Sobel-Prewitt, Sobel-Freichen dan Robert-Freichen. Faktor keupayaan penapis telah dianalisa dalam aspek kualitatif dan kuantitatif. Taburan frekuensi digunakan untuk mengukur bilangan piksel-piksel yang aktif dalam imej yang dikesan pinggirnya. Taburan frekuensi ialah pengukuran kuantitatif berdasarkan kepada pemetaan pinggir-pinggir sesama mereka melalui penilaian berstatistik. Proses penilaian telah ditambah dengan aspek kualitatif melalui analisis visual iaitu melalui aspek kebagusan penyetempatan menggunakan Logik Kabur. Satu set peraturan berdasarkan kepada keamatan pinggir seperti penilaian bagi 'hilang pinggir', 'pinggir tebal' dan 'pinggir pecah-pecah' telah ditakrifkan. Kaedah konvensional memerlukan penterjemahan manusia untuk menentukan pengecaman. Akhirnya, penilaian keupayaan dibandingkan menggunakan indeks pengesanan pinggir. Indeks yang digunakan dalam Indeks Pengesanan pinggir adalah merupakan jumlah nilai yang ditambah daripada taburan frekuensi dan skala persepsi visual bagi sesuatu imej yang diperolehi melalui logik kabur. Nilai yang tinggi bagi indeks pengesanan pinggir mencerminkan kebagusan sesuatu penapis. Secara keseluruhannya penemuan telah menunjukkan bahawa penapis hibrid Robert Freichen mengatasi kesemua penapis-penapis klasik dan kombinasi penapis-penapis hibrid yang lainnya dengan nilai 2.73 dalam indeks pengesanan pinggir bagi imej 1 (Lena) dan 2.65 bagi imej 2 (Bahagian Mekanikal).

Hybrid Filters for Edge Detection and Its New Fuzzy Performance Evaluation Technique

ABSTRACT

Edge detection is an important operation in digital image processing and also very important in field of computer vision, image segmentation and object recognition. Edge is line between two corners or surface which also a significant colour transition in an image. It also can be defined as an abrupt change in intensity of pixels and discontinuity in image brightness. The primary goal of edge detection methods is to extract the important feature or information in an image. In this study seven different techniques are used to extract the edge points for two different images. The seven techniques are involved the classical edge detectors as well the hybrid of the filters such as Sobel, Prewitt, Freichen, Robert, Sobel-Prewitt, Sobel-Freichen and Robert-Freichen. Performance factors are analysed in term of qualitative and quantitative aspect. Frequency distribution is used to measure the number active pixels in edge detected images. Frequency distribution is a measurement of quantitative based on the edge maps to each other relatively through statistical evaluation. The evaluation process is all added with qualitative aspect by visual analysis in term of good localization using fuzzy logic. A set of rules based on intensity of edges such as rate of 'missing edges','thick edges' and 'broken edges' defined. The conventional method required the human interpretation to decide upon the detection. Finally, performance evaluation is compared using Edge detection index. The indices used in Edge Detection Index are the sum of frequency distribution and visual perception scale of an image which will be obtained from fuzzy logic. The higher value of edge detection index indicates the better the filter. Overall findings indicated hybrid of Robert Freichen outperformed other combination of gradient filters with value of 2.73 in edge detection index for image 1(Lena) and 2.65 for image 2(Mechanical parts).

CHAPTER 1: INTRODUCTION

1.1 Background

An image which means a visual form of an object can be digitized in order to store in any form of storage media. Once the image has been digitized, it can be operated upon by using various image processing operations. An edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity which is stated by Juneja and Sandhu (2013). Edge detection is one of the most important tasks in the image processing, computer vision and pattern recognition by Sun, Liu, Liu, Ji, and Li (2007). The primary goal of edge detection methods is to extract the edge features and important information in an image. The edges occur on the boundaries between two different regions which are significant local changes in the intensity of an image. The conventional methods to detect edge features usually involve convolving an image with 2-D (filter) or operator to be sensitive to large gradients in the digital images. There are various ways to detect edges in digital images however the majority of methods are grouped into two main groups namely the Grradient and Laplacian techniques by Igbinosa (2013).

The primary goal of this study is to analyse the visual comparison in term of good localization and to make quantitative comparison of hybrid algorithm and finally to evaluate using edge detection index for obtaining ideal edge detection filters. The purpose of this study is to improve the edge detection process to get better results in term of good detection and good localization. This will be done by employing two or more filters that will be used together to perform the edge detection and to evaluate using edge detection index. Hybrid edge detection combines more than one filter. By combining more than

one filter, the advantages of every filter also combines to work together. A. Kaur and Kaur (2012) states that combination of operators not only increase the number of pixel but also precisely find the clear boundaries of an image.

1.2 Problem Statement

In real world of recognition and interpretation of a system, issues such as noise and variable scene illumination make the edges difficult to be identified. Effective edge detection technique is required for many important areas and widely used in medical imaging (Choi, Trevor, & Christensen, 2013). There is absence of edge detectors that works under all condition. Sobel, Prewitt, Robert and Freichen which are known as traditional detectors commonly extract edges by adopting specific template. However traditional edge detectors often results in some drawbacks such as broken edges, false edges or thick edges. Other than that, tools to evaluate the edge detection also play a vital role to justify a filter. Therefore, evaluation should be done in multiple ways to test the effectiveness of an edge detector. Edge detection continues to be active research area thus there is a substantial need to conduct such a study to find a method to define and improve the detection method of edge features in digital images in order to use effectively in many application. Thus, a hybrid technique is used in order to overcome some drawbacks of traditional operator.

1.3 Objectives

The specific research objectives of this study are summarized in the following sentences:

i) To explore the application of hybrid technique, fusion of traditional edge detectors such as Sobel, Prewitt, Robert and Freichen

ii) To determine qualitative value of hybrid algorithm performance using fuzzy logic based technique

iii) To determine quantitative value of hybrid algorithm by frequency distribution

iv) To compare the performance of edge detection using edge detection index

1.4 Scopes

The scope of this study is applying hybrid approach for improving edge detection in digital images. The scopes generally can be summarized as follow:

i. Pre-processed digital image made as the input by assuming the employed pictures at least have some noise.

ii. Gradient filters made as the operators

1.5 Research significance

The overall contribution of this study can be summarized as to explore hybrid technique of edge detectors. Instead of using a traditional operator, this study is to modify

the algorithm to fuse a filter with another filter and work in respect with their advantages. Detection of edges is essential to extract important feature from an image. In short, this study aims to compare performance of edge detection using edge detection index which comprises qualitative and quantitative value of edge detection where this technique of evaluation has never been explored in previous researches.

1.6 Outline

This thesis comprises of FIVE chapters, which are illustrated as follows:

- **Chapter 1** is to introduce the background and motivation of image processing. Consequently, problem statement, objectives, scopes, and research significance are described in this chapter.

- **Chapter 2** presents the significant literature related to the edge detection and the usage of hybrid approach as well as mathematical methods to evaluate the edge detection filter. Specified characteristic and features of image processing operator also discussed in this chapter.

- **Chapter 3** explains overall framework to utilize the method of hybrid in detecting edges. It also highlights the flow of this study.

- **Chapter 4** will be about the expected results or findings of this study.

- **Chapter 5** is the final chapter where it brings out the conclusion of the study by discussing about the achievement of objectives and as well as recommendations, suggestions for the future work.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Sufficient related work discussed in this chapter to bring about the aim of identifying edges in a digital image which is called as edge detection. Edge detection is an important operation in the field of image processing that includes mathematical method to identify the sharp points of an image. This chapter is also to study on type of images, fundamental tool, edge detection process in image processing and various techniques that have been used in order to enhance the edges. The scope of this literature is limited to the studies related to the edge detection features in image processing and application of hybrid technique to retain required information from an image.

2.2 Definition of Edge

Edge is line between two corners or surface which also a significant transitions in an image. It also can be defined as an abrupt change in intensity of pixels and discontinuity in image brightness. Generally, there are three derivatives of edges an image can be convolved which are horizontal edges, vertical edges and diagonal edges as shown in Figure 2.1. An important edge feature of an image involves corners, lines as well as curves.

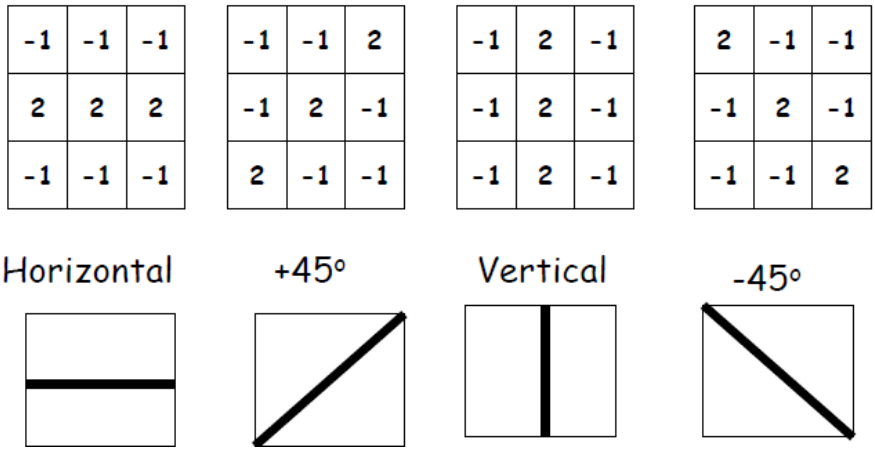

Figure 2.1: Derivatives of edges

2.3 Definition of Noise

Noise is unwanted electrical energy that degrades quality of a signals and data. In image processing noise is said to be a distortion in an image as in the figure below. The common salt- pepper noise presents itself as sparsely occurring white and black pixels which can be caused by sharp and sudden disturbances in image signal. Gaussian noise which is a statistical noise having a probability density function and Poisson noise is a noise originated from electric charge which in another word is a type of electronic noise.

Original Image

Poisson Noise

Salt-pepper noise

Figure 2.2:Different type of image noise (Rohit & Ali, 2013)

2.4 Representation of images

i. **Binary Image:** Binary image is the simplest type of image that takes only on two values, 0 and 1. Every pixel value represents their respective colour which means 0 here represents black and 1 represent white or vice versa as shown in Figure 2.3

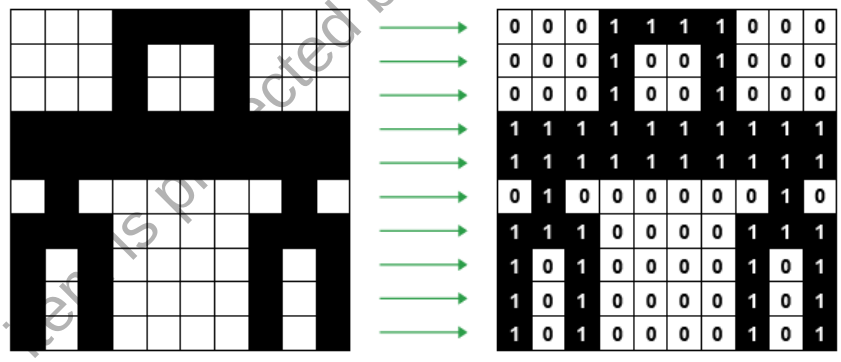

Figure 2.3: Binary image that involves 0 and 1

ii. **Grayscale Image:** A grayscale image is an image that contains shades of gray which is an intermediate color between black and white. Grayscale images (as photographs) are commonly stored with 8 bits per sampled pixel, which allows 256 different intensities. Medical images typically contain 12-16bit/pixel which have lowered available of gray shades in order to obtain higher display quality (Padmavathi & Thangadurai, 2016).

iii. **Digital images:** Digital images also known as color images that contains color information. A digital image $a[m,n]$ is a representation of 2D image derived from an analog image $a(x,y)$ through digitization (Nabi al.,2008). Color images can be classified into 8-bit color format, a common model that also known as grayscale images, 16-bit color format it has 65,536 different colour which also known as high colour format followed by 24 bit and 32-bit colour format also known as true colour format. For illustration purpose, Figure 2.4 below shows anatomy of a digital image. Pixel count of an image can defined as $height \times width$.

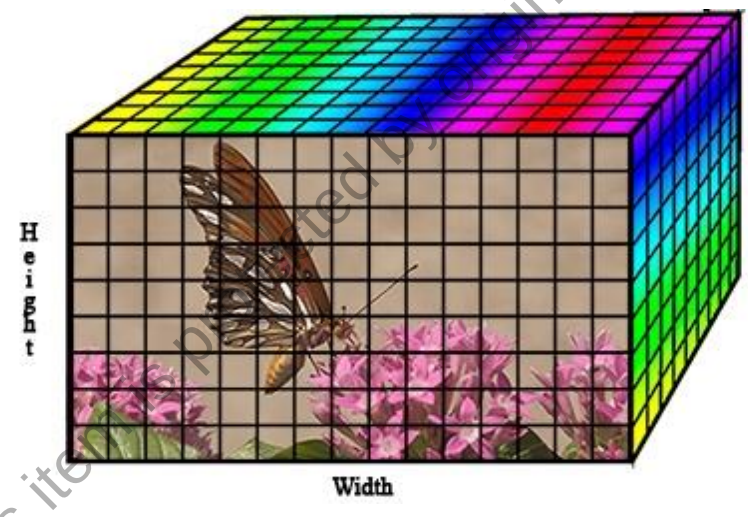

Figure 2.4: True colour images

2.5 Image processing

Once an image has been digitized, it can be stored in any form of storage media and can be operated upon by various images processing technique. Image processing is the process of manipulating an image in order to either extract information from the image or to produce alternative possible representations of the image. There are plentiful specific goals for image processing however majority fall into one or both of the following categories:

(i) To eliminate or reduce artifacts which are the unwanted signals or components that usually corrupt the images.

(ii) To extract useful information from an image.

2.6 Digital image processing

The importance and necessity of digital processing can be seen in two main aspects which are:

i. Improvement of pictorial information to extract for human interpretation

ii. Improvement of pictorial to eliminate the unwanted signals on image

Digital image processing has a broad range of applications such as remote sensing, acoustic imaging, machine or robot vision, and medical imaging. Medical applications can be seen widely in processing of X-rays and Ultrasonic scanning as in Figure 2.5.

Figure 2.5: Illustration of Ultrasonic scanning

2.7 Concept of Edge Detection

Edge detection is an important process to identify significant characteristic of an image. The process involves, identifying sharp discontinuities in digital images where it can be done in vertical, horizontal and diagonal edges. In edge detection, there are two types of operators namely gradient based edge detection and laplacian based edge detection. The detection of edges in the gradient method is the first order approach that can be done through the close observation of the minimum and maximum first derivatives of a particular image. Among the examples of the gradient images are Robert operator, Sobel operator and Prewitt operator. Laplacian and Gaussian are two examples of the Laplacian edge detection methods which is the second order approach. This operator is considered a 2-D isotropic measure of the 2nd spatial derivatives for any image in which the regions of rapid intensity change are highlighted. Different types of edge detection methods and its result shown in Figure 2.6.

a) Original image

b) Zero cross

c) Canny edge detector

d) Log edge detector

Figure 2.6: Different type of edge detection methods

2.7.1 Gradient Operator for Edge Detection

The gradient is a generalization of the usual concept of the derivative of a function in one dimension to a function in several dimensions that done through the close observation of the minimum and maximum first derivatives of a particular image. According to Hussain and Agarwal (Hussain & Agarwal, 2015)**,** gradient based operator is simple and easy to execute**.** The following operators come under Gradient Based Edge Detection like Robert Operator, Sobel Operator, Prewitt Operator and Freichen Operator.