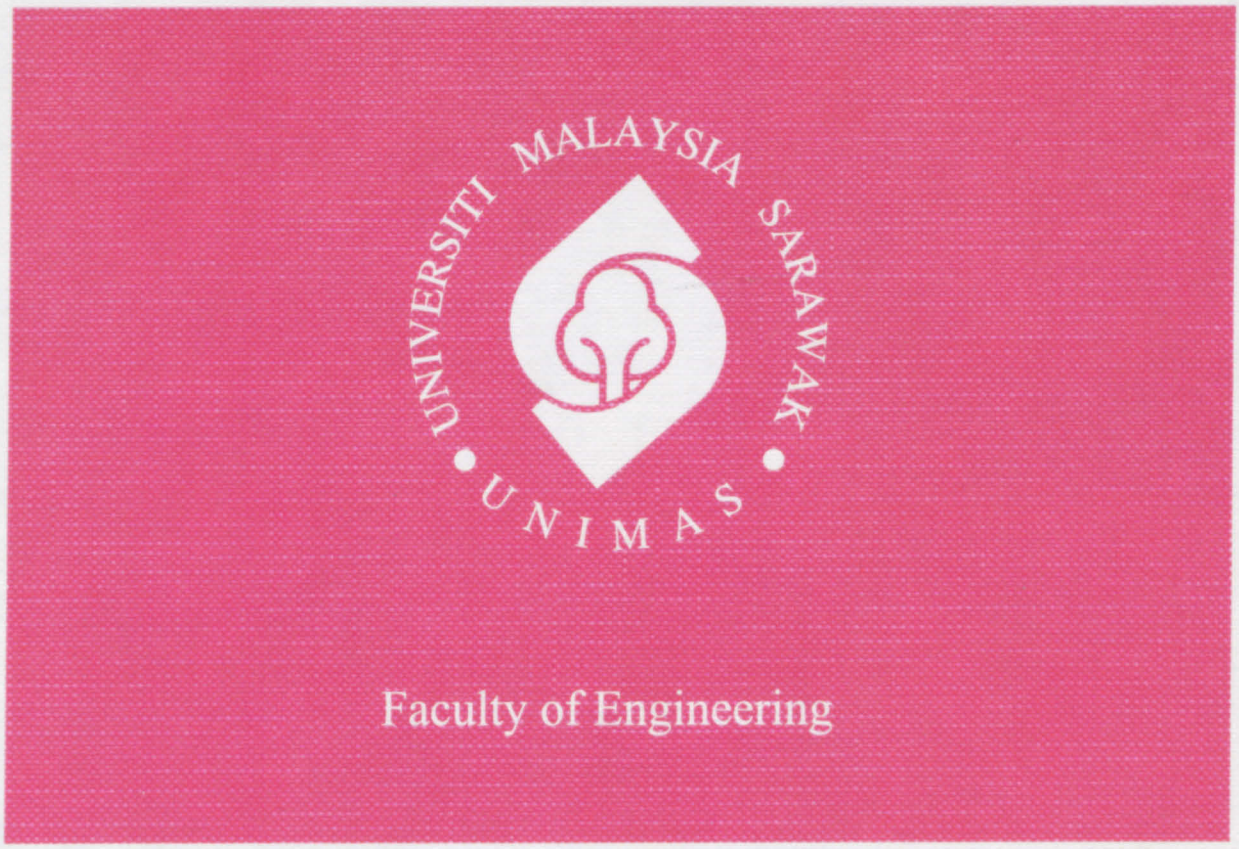

THE EFFECT OF INPUT LIMITING ON NONLINEAR FILTER FOR THE REMOVAL OF IMPULSIVE NOISE

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Bachelor of Engineering with Honours
(Electronics and Computer Engineering)
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This project is submitted in partial fulfillment of

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Dedicated to my beloved family, lecturers and friends.

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"In the name of Allah most gracious and most merciful"

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ABSTRAK

Isyarat sering rosak disebabkan oleh bendasing. Isyarat yang rosak ini kebiasaannya tajam atau memercik secara tiba-tiba berdasarkan pemerhatian berbanding isyarat normal. Ini akan memberi kesan kepada fungsi kepadatan yang mana menjadi lebih teruk berbanding dengan kepadatan fungsi Gaussian. Walaubagaimana pun, penapis tidak linear menawarkan cara yang sesuai dan paling baik untuk mengatasi isyarat yang bercampur dengan bendasing ini. Jadi, matlamat projek adalah untuk menyiasat kesan menghadkan isyarat masuk ke atas penapis 2 dimensi (2-D) jenis "median" apabila isyarat masuk bercampur dengar bendasing. Projek ini memfokuskan kepada penapis jenis "median" untuk tujuan penapisan dan bendasing di dalam isyarat dimodelkan oleh proses rawak "α-stable". Untuk tujuan simulasi, projek ini menggunakan perisian MATLAB. Hasil simulasi menunjukkan bahawa isyarat keluar yang melalui penapis jenis 'median' yang dihadkan ini adalah lebih baik dari perspektif kualitinya.

ABSTRACT

Signals are always corrupted by impulsive noise. These corrupted signals are likely to have accidental burst of outlying observations than one would expect from normally distributed signals. This will affect their density functions which are decay in the tails less than Gaussian density function. However, the nonlinear filters provide a useful and flexible approach to face the signals which are contaminated with the impulsive noise. Thus, the aim of this project is to investigate the effects of input limiting on the performance of two-dimensional (2-D) nonlinear filters when the input signal is contaminated by impulsive noise. This project is focused on median filter for filtering purpose and the impulsive noise is modeled as α – stable random process. For simulation purpose, this project was used MATLAB software. The result of simulations showed that the output signal that passed through limited median filter is better in term of their quality.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

Noise is defined as any unwanted signals that interferes with the communication and corrupt the signal. Noise can cause transmission error and distortion in signal and this can consider as the factors limiting the capacity of data transmission in telecommunications and accuracy in signal measurement system. A noise itself is a signal that conveys information regarding the source of the noise. For example, the noise from a car conveys information regarding the state of the engine and how smoothly it is running. The sources of noise are many and varied and include thermal noise intrinsic to electric conductors, shot noise inherent in electric current flows, audio frequency acoustic noise emanating from moving, vibrating or colliding sources such as revolving machines, moving vehicle, computer fans, keyboard clicks, wind, rain and radio-frequency electromagnetic noise that can interfere with the transmission and reception of voice, image and data over the radio-frequency spectrum. Signal distortion is the term

often used to describe a systematic undesirable change in a signal and refers to a changes in a signal due to the non-ideal characteristics of the communication channel, reverberations, echo, multipath reflections and missing samples [1].

The main limiting factors in communication and measurement systems are noise and distortions. Therefore, noise reduction and distortion removal are essential in the theory and practice of all signal processing applications. Linear filtering technique can be used in order to solve the problem regarding digital image processing. However, this technique has limitation while dealing with signals contaminated by impulsive noise. Linear filters fail to remove the impulsive noise and tend to blur the image [2]. Therefore, there has been a great interest to study about nonlinear filtering technique especially in digital image processing.

Nowadays, it was suggested that the family of alpha-stable (α-stable) random variables provide useful model for impulsive phenomenon [2]. Two main factors why this model proposed for impulsive phenomenon are; its stability property and it satisfies the generalized central theorem [3]. The explanation regarding these two factors will be explained further in Chapter 2.

1.2 Project Objectives

The most important objectives of this project is to investigate the effects of input limiting on the performance of two-dimensional (2-D) nonlinear filters when the input signal is contaminated by impulsive noise. Other objectives that will cover under this project are:

i. To study the characteristics of Gaussian and non-Gaussian (impulsive) noise.

ii. To learn the concept of α-stable noise distribution for modeling noise.

iii. To develop a filtering technique which can restore various images embedded in a variety of α-stable noise.

iv. To analyze the performance of nonlinear filter for the impulsive noise reduction.

v. To investigate the performance of the median filter in terms of edge preservation and noise suppression.

1.3 Report Structure

This report has been arranged systematically in order to give a full view about the whole development of this project. By developing this project, this report was divided into two stages. The first stage includes Chapters 1, 2, and 3 and the second stage includes Chapters 4 and 5, which have been completed in Semester 2.

Chapter 1 describes the overview of the project, a brief introduction and the objectives of this project.

Chapter 2 is about the literature review which provides the explanation of noise; Gaussian and non-Gaussian noise, filter; linear and non-linear filter, and α-stable noise distribution.

Chapter 3 is research methodology which describes the flow, design and the implementation of noise modeling, generating noise model, input signal and filtering operation by using MATLAB.

Chapter 4 presents the results for all simulations that have been done in this project. This chapter also evaluates the performance of the median filter on reducing impulsive noise focusing on 2-D signals.

Finally, Chapter 5 consists of the conclusions regarding to this project and recommendations on how to improve this project in future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Noise

As mentioned in the previous chapter, noise may be defined as any unwanted signal that interferes with the communication, measurement, perception or processing of an information – bearing signal. Noise is present in various degrees in almost all environments. For example, in a digital cellular mobile telephone system, there may be several varieties of noise that could not degrade the quality of communication, such as acoustic background noise, thermal noise, shot noise, electromagnetic radio-frequency noise, co-channel radio interference, radio channel distortion, acoustics and line echoes, multipath reflection, fading and signal processing noise [1]. The presence of noise in signal will reduce the quality of the signal and the signal could be corrupted. This chapter introduces two types of common noise; Gaussian and Non-Gaussian noise. The explanations are discussed in the following sections.

2.1.1 Gaussian Noise

The Gaussian distribution has an important property: to estimate the mean of a stationary Gaussian random variable, one cannot do any better than the linear average. This makes Gaussian noise a worst-case scenario for nonlinear image restoration filters in the sense that the improvement over linear filters is least for Gaussian noise. The Gaussian function with mean, m and standard deviation, s is defined by Equation (2.1) [5]:

$$f(x) = \frac{1}{s\sqrt{2\pi}} e^{-\frac{1}{2}\left[\frac{x-m}{s}\right]^2} \tag{2.1}$$

2.1.2 Non-Gaussian Noise

Non-Gaussian (impulsive) noise is a result of a randomly process placed on the signal. The noise could be positive (maximum), negative (minimum) or a mixture (salt and pepper) [5]. Impulsive noise caused by a variety of sources. In communication system, an impulsive noise originates at the some point in time and space and then propagates through the channel to the receiver [1]. The channel will shaped the receive signal and can be considered as a channel impulse response. For 2-D signal, that is image, the received signal contaminated with impulsive noise will encounter problem in acquisition, transmission and processing of images.

2.2 Noise Modeling

The Gaussian process has always been the main noise model in communications and signal processing literature, mostly because of the *central limit theorem*. This important theorem explains with purely theoretical arguments, the appearance of Gaussian statistics in real life.

Nowadays, it has a great interest and suggested that α-stable random variables provide useful models for impulsive phenomenon. Stable distribution share defining characteristics with the Gaussian distribution, such as the stability property and central limit theorems [5]. Further explanation regarding this α-stable distribution is discussed in the following section.

2.2.1 Alpha-Stable (α-Stable) Distribution Modeling

Alpha stable (α-stable) distribution is one type of distribution that exhibit heavier tails compare to the Gaussian distribution [3]. This type of distribution capable to model diverse phenomenon such as random fluctuation of gravitational fields, economics market indexes and radar clutter [3]. This group of α-stable distribution provide useful model for impulsive phenomena because of two main properties that are [5]: