Image Denoising in Wavelet and Spatial Domain

by

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وَلَسَوْفَ يُعْطِيكَ رَبُّكَ فَتَرْضَىٰ

And your Lord is going to give you, and you will be satisfied (93:5)

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LIST OF ABBREVIATIONS

BF	Bilateral filter
CWT	Continuous wavelet thresholding
DWT	Digital wavelet thresholding
LM	Local Means
MF	Mean Filter
MSE	Mean Square Error
Non LM	Non Local Means
RMSE	Root Mean Square Error
RPSNR	Root Peak signal noise ratio
PSNR	Peak signal noise ratio
Db	Daubechies
WT	Wavelet threshold
RGB	Red Green Blue
RMSE	Root Mean Square Error
SNR	Signal-to-Noise Ratio

LIST OF SYMBOLS

F(g)	Gaussian noise
m	Mean or average
g, α	Denotes the gray level
σ	Standard deviation of the noise
D(U,I)	Soft thresholding function or Hard
W(x,y)	Noise signal
S(x,y)	Original signal
S	Second
N(x,y)	Noise

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ABSTRAK

Matlamat teknik denoising adalah untuk menghapus hingar dari imej dan ia merupakan langkah pertama dalam mana-mana pemprosesan imej. Kaedah penyingkiran hingar harus diterapkan dengan cara berjaga-jaga jika tidak,menyebabkan pewujudan artifak yang dapat mengaburkan imej. Dalam karya ini, tiga tahap hingar Gaussian digunakan untuk menambahkan hingar pada imej asal ($\sigma = 10$, $\sigma = 50$, $\sigma = 100$) dan juga ($\sigma = 15$, $\sigma = 20$, $\sigma = 25$) untuk bandingan dengan kerja terdahulu. Analisis dengannya untuk menguji sistem tertanam dengan penapis median. Penilaian prestasi penapis median, teknik pemberian ambang wavelet Teknik yang digunakan nyahhingar berdasarkan penapis median dan ambang wavelet untuk menghilangkan bunyi bising berdasarkan raspberry pi Python 2.7.9 dengan Open CV 3.1.1. Empat kaedah untuk menghapuskan imej bunyi digunakan. Kaedah pertama median tempatan (LM) yang digunakan secara meluas kerana ia sangat berkesan untuk menghilangkan bunyi bising sambil memelihara imej tepi dan kurang bunyi, dan kaedah kedua adalah ambang. Wavelet Haar digunakan, di mana nisbah puncak isyarat-ke-bunyi (PSNR) adalah nilai yang tinggi. Kaedah ketiga median sebelum ambang wavelet dan keempat ialah median selepas ambang wavelet. Keputusan untuk setiap kaedah diperkenalkan sebagai jadual untuk Sepuluh imej yang berbeza. Keputusan menunjukkan Teknik nyahhingar menggunakan penuras median menunjukkan hasil yang lebih baik dari Teknik menggunakan ambang “wavele”.

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ABSTRACT

The goal of any de-noising technique is to remove noise from an image which is the first step in any image processing. The noise removal method should be applied watchful manner otherwise artefacts can be introduced which may blur the image. In this work, three levels of Gaussian noise are used for adding noise on the original image (σ=10, σ=50, σ=100) and also (σ=15, σ=20, σ=25) to compare with previous work and analysis with it to test embedded system with median filter. Performance evaluation of the median filter, wavelet threshold de-noising techniques is provided. The techniques used are namely the median filter and wavelet threshold is used to remove noise based on raspberry pi using Python 2.7.9 with Open CV 3.2. Four methods to remove noise image are used. The first method local median (LM) which it is widely used as it is very effective at removing noise while preserving edges images and less noise, and the second method is wavelet hard threshold. The wavelet Haar is used, where the Peak signal-to-noise ratio (PSNR) is high value. The third method median before wavelet threshold and the fourth is median after wavelet threshold. The results for each method are introduced as a table for different ten images. The image camera was better than other after applying four methods for the Gaussian noise σ=10. In other hand the other images were better than image of camera for the Gaussian level 50 and 100. The results were good in median filter in wavelet threshold based on Raspberry Pi.

CHAPTER 1 : INTRODUCTION

1.1 Research Background

Image processing is an area that continues to increase, with new applications being developed at an ever growing speed. It is considered an attractive and exciting area with many applications ranging from the recreation industry to the space program. The information should be send and received complex data that exceeds ordinary written text. The visible information, transferred in the form of digital images, has become main technique of communication for the 21st century. Image processing is a format of signal addressing that the input represents an image, such as pictures or frames of video and the output of image processing can be either an image or properties or parameters associated with the image. The techniques of image processing includes addressing the image as a two-dimensional signal and applying standard signal-processing method (Kalavathy, 2012).

The applications of digital images are: magnetic resonance imaging, satellite television, computer tomography, also in different fields of research and technology. The information in many applications is considered the Images as the prime sources. Images produced by combination from various imaging systems leads to undergo wastage of information. A noise that can be modelled as white Gaussian most of the time considered to be key limitations in image precision (Motwani M C, 2004). Image denoising is a reversion process during many trying that depends on methods and modelling algorithms and using previous information of the degradation process (Kalavathy, 2012).

The main goal of image de-noising is to decrease the noise scale and retrieve meaningful information from noisy images. As well as, the main performance of wavelet-based de-noising is closely attached to its ability to adjust naturally to image cut out. Discrete wavelet transforms (DWT) of an image tends to be scattered and the noise is uniformly distributed during the coefficients, while maximum of the image information is massive in the few largest ones. Which coincide to the original image details at various resolution scales. Thus, a simple thresholding wavelet coefficients can be repressed the additive noise effectively (Benabdelkader, 2015).

1.2 Problem Statement

Noise removal considered to be the reason why image denoising remains as a challenge for researchers. It is introduced artifactual causes blurring of the images, noise modelling in images which is affected by capturing devices or data transmission media, high cost, complexity (Sirisha, B., Dhilli, K., & Govinda, E., 2017). Ramadhan. et al, (2017) produced Lena, Camera, Fruits, Coarse and Texture images using median filter and adaptive wavelet threshold applied on two stages; First- three images, Second- two images. As well as, the data transfer was unreliable and inefficient. Embedded system is important, and previous work does not implement on embedded system

The mentioned disadvantages will be solved with embedded systems such as Raspberry Pi which it is fast, cheap, high reliable, general platform and efficient using Python language, such as: Open CV, NumPy, and SciPy which can get the same results in one stage only. The image denoising by median filter in wavelet domain can be modified by using more accurate estimation function and other kinds of threshold

methods. Furthermore, should be able properly and precisely filter out each pixel on a particular window size. The value of Peak signal noise ratio (PSNR) in final image has to approximate original image.

1.3 The Objectives of the Study

The objectives of the work to denoise image are: -

1- To design a local median filter in wavelet threshold for noise removal.

2- To implement local median filter in wavelet threshold image de-noising in Raspberry Pi platform.

3- To analyse the performance image in term of (PSNR and MSE) in PC and Raspberry Pi platform.

1.4 Contributions

The contributions of this work are summarized as follows: A local median filter in wavelet threshold will be designed, and implemented a Raspberry Pi based system to analyse the performance of the algorithm on embedded system. The performance PSNR and MSE using a PYTHON language with the Open CV 3.2 will be measured.

1.5 Research Scope/limitation

1- Original image will be noised by Gaussian.

2- Wavelet threshold and Median Filter will be designed to reduce the noise and implemented in Raspberry Pi.

3- PSNR and MSE based on equations are used in python programming language with the Open CV 3.2.

1.6 Expected outcomes

PSNR is used for comparison the local Median filter and wavelet analysis techniques by implementing in Raspberry Pi using PYTHON program with the Open CV 3.2 in PC and compare the results with previous work to test the work based on embedded system. In this project, we will analyse the PSNR value when comparing the performance of PSNR analysis measures an objective difference between two images by using a standard mathematical model. It estimates the quality of reconstructed image with respect to the original image. The basic idea is to compute a single number that reflects the quality of reconstructed image. Reconstructed images with lower MSE and higher PSNR are judged better.

1.7 Structure of the Report

This report consists of five chapters. Chapter one includes the research background, problem statement, objective of the study, contributions, Research questions, research scope, and expected outcomes. For chapter two, it presents the details of literature review for the techniques that relate with image denoising, advantage and disadvantage for related works and explains the parameters for image denoising. Finally, chapter three presents research methodology, research design, data source and data collection techniques, issues reliability and validity, sampling, modelling and experimental techniques, data analysis and interpretation approaches. All results are presented in

Chapter 4. The images extracted using the local median filter and the thresholding techniques by assessing the image quality by measuring the PSNR values are introduced. In Chapter 5, the conclusions of this study based on the platform used are introduced. Also, future work for improving the research is introduced.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

Digital image is a numeric representation, normally binary, of a two-dimensional image. Depending on whether the image resolution is fixed. Digital image processing is known as a process which uses algorithm on digital image. It can bring some advantages as following: Many algorithms are used to the input data and Remove noise and signal distortion during processing.

In order to recover image, image denoising is the best choice to select. It needs the usage of previous knowledge and working with methods that relate with image processing. The main purposes of using image denoising are to eliminate of noise, the retain of edges and another detailed feature. This noise gets introduced during acquisition, transmission & reception and storage & retrieval processes. In this study, Additive Gaussian Noise was used. For the role of the multi resolution structure and property of sparsely, wavelets are mainly anticipated in image denoising. Wavelet Thresholding considered to be one of the important techniques in wavelet domain filtering. In this study, some spatial-domain and transform-domain image filtering algorithms and wavelet thresholding algorithm have been developed to suppress Gaussian noise.

The performances of the developed algorithms/methods in this study were compared with the existing methods in terms of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) (Jaiswal, Upadhyay, & Somkuwar, 2014).

There are a wide range of techniques used for image processing such as digital image processing, or digital picture processing. These techniques developed in the 1960's and were mainly used for applications of wire photo, medical image and character recognition (Jain, S., & Chadokar, 2015, Jansen, 2012). However, these techniques were very costly and were seen as a disadvantage. Then in 1970s, cheaper means in the form of computers and dedicated hardware became available. Images were processed in real time and the only limitation detected was television standards conversion. Finally, in the 2000's, the discoveries of speedy generation of computers and signal processors, it helped digital image processing to become the most common form of image processing mainly. Because, it is not only the most multilateral method, but also the most inexpensive (Jain, S., & Chadokar, 2015, Jansen, 2012). More methods were eventually introduced. For instance, Kovesi (1999) proposed a new method of calculating the phase congruency through the use of wavelets. 1D signal is extended to allow the calculation of phase congruency in 2D images. High pass filter is used to obtain image information at different scales. Raheem (2018) proposed wavelet based on image denoising using raspberry pi. Mean filter is used in the proposed work. Also, an adaptive median filter technique to reduce low complexity is presented by to remove noise based on embedded system using FPGA (Matsubara, Moshnyaga, & Hashimoto, 2010).

2.2 Embedded system

In our daily life, many electrical and electronic circuits or equipment are used which are designing utilizing embedded systems technology. The computers, cell phones, laptops, tablets, digital electronic systems, and other electrical and electronic tools are designing utilizing embedded systems. (Shibu . KV., 2009).

Embedded systems are an electronic system which integrates both the hardware circuitry and the software programming techniques(Berger, 2017). In order to provide project solutions. The use of embedded system technology not only greatly decreases the complexity of the circuits but also the price and small size, which reduced project circuitry's size and weight. In other words, embedded system is a programmed or non-programmed electronic system that is been used for operating, organizing, and performing single or multi tasks depending on the particular application. The program or group of principles or code which are established into the microcontroller are developed in order to all the assembled units can work together in the real time embedded systems. However, as pointed out by Shibu (2009), these microcontroller programming techniques are only able to solve a limited range of problems as shown in Figure 2.1 (Shibu. KV., 2009).

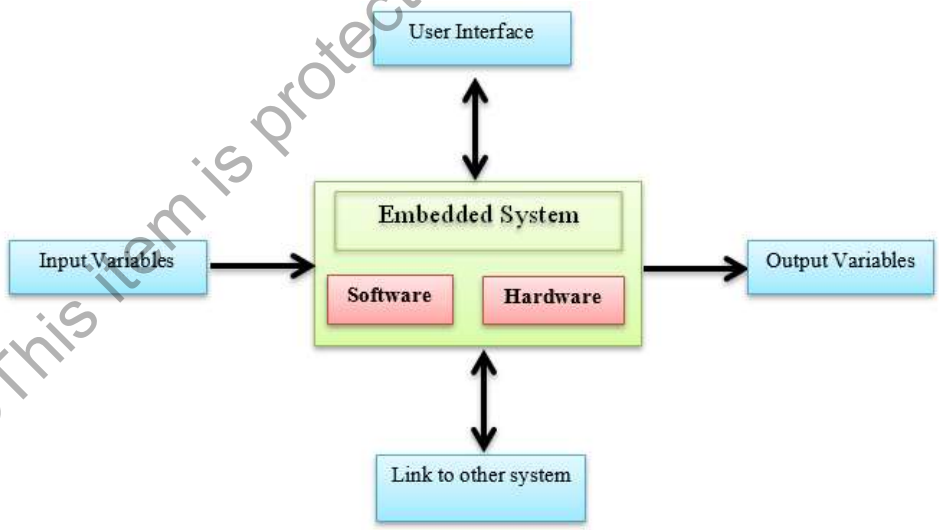

Figure 2.1:Embedded System

2.2.1 Embedded Systems Hardware

This kind of system is similar to any electronic system for containing central processing unit (CPU), power supply equipment, memory device, output circuits, timers, serial communication ports and system application specific circuit components and circuits (Steve. H., 2003).

2.2.2 Embedded Systems Software

Hardware and software are integrated by embedded system. the software represents a group of steps which contains instructions which are named as a program. the hardware circuits represent the microprocessors or microcontrollers. It programmed to achieve tasks by steps of instructions. The programs are high level language which is written with it. For example, languages like C++ or C or embedded C are used in Proteus or Lab-view. Then, the program is casted into the microcontrollers or microprocessors that are applied in the circuits of the embedded system, as illustrated in figure 2.2 (Steve. H., 2003).

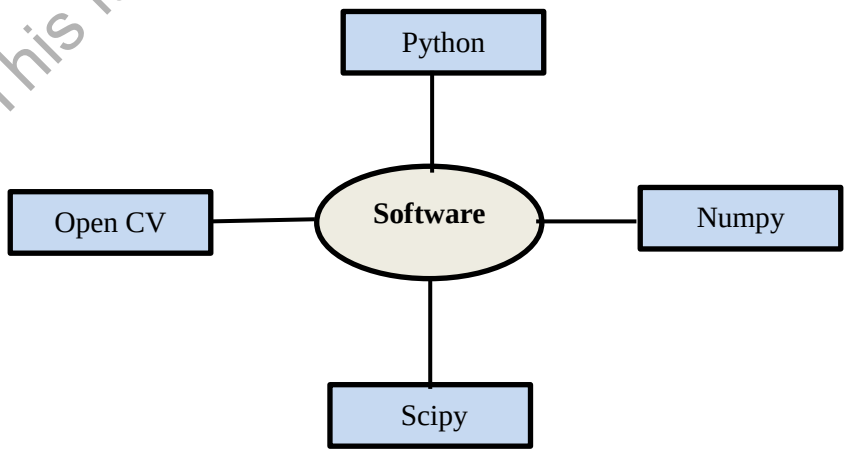

Figure 2.2: Embedded System Software

2.2.3 Embedded System Classification

This type of systems has been categorized into several kinds depending on the complexity of hardware, software, and microcontroller (8 or 16 or 32-bit) as demonstrated in Figure 2.3. Therefore, there are three categories of embedded systems based on the performance of the microcontroller as following: (Steve. H., 2003 & Shibu . KV., 2009):

- Small scale embedded systems
- Medium scale embedded systems
- Sophisticated embedded systems

The embedded system can further be categorized into four more types based on their implantation and functional requirements of the system:

- Real time embedded systems
- Standalone embedded systems
- Networked embedded systems
- Mobile embedded systems

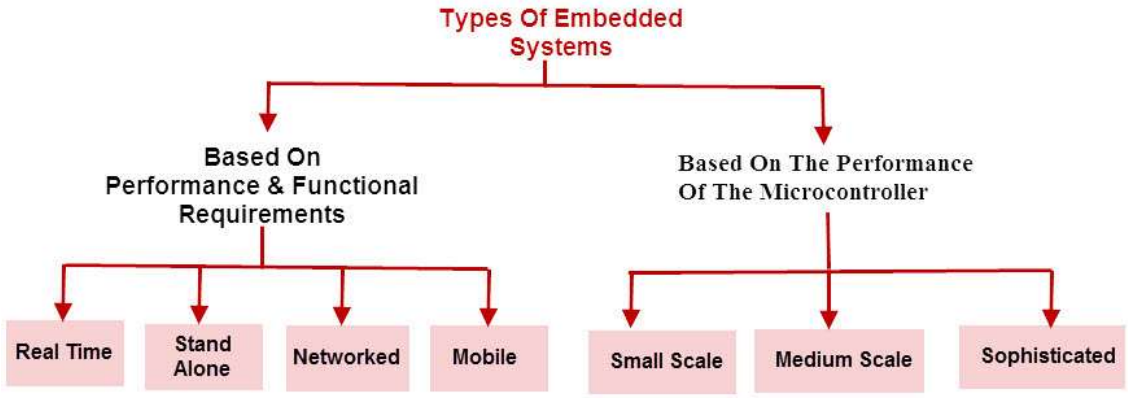

Figure 2.3: Classification of Embedded Systems

2.2.4 Applications of Embedded Systems

There are various applications using embedded system. Mainly in telecommunications, digital electronics, computing network, satellite systems, smart cards, military defence system equipment, satellite systems, and research system equipment. Some of these applications are used practically in designing embedded projects for the studied of this final year engineering electronics project. These applications contain digital consumer electronics, smart cards, computer networking, satellites, telecommunications, missiles, etc. Figure 2.4 demonstrates the application of embedded system (Kamal, 2011).

Figure 2.4: Embedded System Applications

2.2.5 Raspberry Pi

A set of small single board computers is considered as equipment of the Raspberry Pi. It has been developed by the United Kingdom by the Raspberry Pi Foundation to support education of basic computer science in schools and in enhancing countries. The original model became far more popular than unexpected, selling outside its objective market for utilizes like robotics. It does not comprise peripherals (such as keyboards, mice and cases) (Getting started with raspberry PI., 2012).

Gong (2012) on the other hand, introduced a new Bayesian image de-noising technique with two complementary discontinuity measures. The spatial-gradient, and the other which is a continuity measure detects contextual discontinuities for feature preservation as shown in his findings whereby a clear high peak signal to noise ratio (PSNR) is gained from noisy images, and the noise is successfully decreased while preserving edge components. Till now, most methods have exhibited limitations namely high costs, complexity, and blurring image losing details. Therefore, this study proposes