WAVELET BASED IMAGE DENOISING USING RASPBERRY PI

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بِسْمِ اللهِ الرَّحْمنِ الرَّحِيم

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صَدَقَ اللهُ الْعَظِيم

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LIST OF ABBREVIATIONS

ASIPs	Application-Specific Processor
AWGN	Additive White Gaussian Noise
CM	Compute Module
CM3L	Compute Module 3 Lite
CPU	Central Processing Unit
DCT	Discrete Cosine Transform
DWT	Discrete Wavelet transforms
DSP	Digital Signal Processor
DB	Daubechies
EMMC	Embedded Multi Media Card
GPIO	General Purpose Input / Output
HWT	Haar Wavelet Transform
IP	Internet Protocol
IDE	Integrated Development Environment
LAN	local area network
MSE	Mean Square Error
MR	Magnetic Resonance
MCLA	Monte-Carlo-based linear aggregation

NLM	Non Local Means
PNG	Portable Network Graphics
PSNR	Peak Signal-to-Noise Ratio
PLAs	Programming Languages and Systems
RAM	Read Access Memory
RGB	Red Green Blue
RMSE	Root Mean Square Error
SNR	Signal-to-Noise Ratio
SURE	Stein's Unbiased Risk Estimate
ST	Soft Threshold
SoMs	System on Modules
SSIM	Structural Similarity
SD	Secure Digital
TCP	Transmission Control Protocol
WT	Wavelet Transform
WAN	Wide Area Network

Penggunaan Raspberry pi Dapat Menghasilkan Wavelet Imej Kurang Bunyi Bising

ABSTRAK

Teknik permulihan imej yang efektif telah menjadi permintaan tinggi seiring dengan peningkatan di dalam bidang perfileman digital dan gambar, dimana telah ditangkap dalam kondisi yang tidak baik.Tidak kira bagaimana hebat sesebuah kamera, penambahbaikan imej selalu diutamakan untuk meningkatkan sifat dan pandangan imej. Dalam pemprosesan imej, pengambilan imej yang tepat amat penting. Kualiti imej yang rendah menjadi penghalang kepada ciri pengekstrakan yang berkesan. Oleh itu, pengurangan bunyi memainkan peranan asas daripada imej. Teknik semasa dalam mengurangkan bunyi bising adalah efisien namun lebih tertumpu kepada PC atau pemprosesan berasaskan desktop. Kelemahannya adalah kos pengiraan yang agak tinggi. Pengubahsuaian ini dilakukan ke atas algoritma asing yang membawa kepada peningkatan ketepatan dan prestasi pengiraan. Ia membentangkan analisis terhadap ketepatan kaedah sebagai fungsi kedimensian sub ruang unjuran dan menunjukkan ketepatan puncak pengurangan bunyi di dimensi yang rendah. Terdapat beberapa modality pengimejan yang digunakan pada masa ini bagi kajian pemprosesan imej. Tujuan pengurangan bunyi adalah untuk menyahkankan butiran yang tidak dikehendaki kepada imej bising, dan melaksanakan pengurangan bising algoritma imej yang berkesan dengan bantuan pengaturcaraan Bahasa Phyton. Kaedah menganalisis pemprosesan dilaksanakan dengan cara asing mpat dan pengambangan keras wavelet. Dengan membentuk satu system berdasarkan Pi Raspberry bagi mengurangkan imej bising. Sistem berasaskan Pi Raspberry digunakan untuk melaksanakan pengurangan bunyi dalam imej. Dalam kajian ini, bunyi Gaussian digunakan, kerana bunyi serupa dengan taburan normal. Kedua-dua kaedah telah dilaksanakan dalam persekitaran Pi Raspberry menggunakan Python 2.7.9 dengan terbuka CV 3.1.1. Dengan menggunakan kedua-dua kaedah, terdapat hasil yang berbeza dilihat daripada output.Non-Local Means (NLM) mengemukakan imej lembut dan bunyi yang kurang, manakala pengambangan keras wavelet mempunyai kurang ralat berbanding NLM. Purata perbezaan antara PSNR oleh NLM saripada imej yang diambil sebagai contoh Lena imej berturut-turut mengikut penggunaan sigma 25 adalah 1,4711, lada imej 2,2303, dalam bot imej 2,0481. Dari segi masa pemprosesan, NLM adalah lebih cepat daripada pengambangan keras wavelet. Kedua-dua algoritma ini berfungsi dengan baik dalam Pi Raspberry.

Wavelet Based Image Denoising Using Raspberry pi

ABSTRACT

There has been a huge demand for effective image restoration techniques since the increase in the production of the digital movies and images. No matter how good cameras are, an image improvement is always desirable to extend the image property and view. In image processing, it is very important to obtain precise images. Low image quality is an obstacle for effective feature extraction. Therefore, there is a fundamental need of noise reduction from images. current technique in reducing noise is efficient however focus on pc or desktop based processing. The drawback is the relatively high computational cost. This modification is done to non-local means algorithm results in improved accuracy and computational performance. There are currently a number of imaging modalities that are used for study of image processing. The aim of image de-noising in image processing is to clear the unwanted noise from the noisy image and implement an effective image denoising algorithm with the help of the Python programming language. Improve the processing methods by implementation of Non-local means and wavelet hard thresholding. Raspberry Pi-based system is used to implement image denoising. In this research, Gaussian noise is used, because noise property similar to a normal distribution. Both method has been implemented in Raspberry pi environment using Python 2.7.9 with Open CV 3.1.1. By used on both methods there are different result seen from the output. Non-local means (NLM) produce smoothen image and less noise, while wavelet hard thresholding have less error compared to Non-local means. The average difference between the PSNR by the hard threshold method and the PSNR by the NLM method of the images taken as an example of the image Lena the difference in succession according to the use of sigma 25 is 1.4711, in image Pepper 2.2303, in image Boat 2.0481. In term of processing time NLM is faster than wavelet hard thresholding. Both algorithm perform well in Raspberry Pi

CHAPTER 1

INTRODUCTION

1.1 Overview

There has been a huge demand for effective image restoration techniques since the increase in the production of the digital movies and images, which are shot in bad conditions. Despite the fact that the cameras used could be very good, there is always a requirement for the image restoration for improving the range of their action. For image processing, precise and accurate images have to be obtained for facilitating the proper observation of the images for the specific application. Often, low-quality images prove to be a hindrance for efficient feature-extraction processes, recognition, analysis and quantitative estimations. Hence, the noise has to be decreased form the images. Currently, several imaging modalities are being used for studying the image processing parameters (Yousuf & Nobi, 2010); (Sulam, Romano, & Elad, 2016).

The digital image is often encoded as the matrix containing grey or coloured values, along with the red, green or blue components in the picture. This study focuses on the .png or .jpg image formats. The denoising of the images was carried out using the following techniques – initially, the image was transformed into a domain where the noise could be identified easily. Thereafter, a thresholding operation for noise elimination have been applied, and then, transformation was inverted for reconstructing an effective denoised image (Kovesi, 1999).

The noise and signal components of any signal are made more distinct with the help of the wavelet transform. The wavelet denoising makes use of the orthogonal or the bi-orthogonal wavelets due to their reconstructive qualities. Despite these techniques, no single wavelet was considered as 'best' for eliminating noise. Many studies agree that the wavelets with a linear or a near-linear phase and response are more desirable, leading to the application of the wavelets or bi-orthogonal wavelets with the 'symlet' feature (Jaiswal, Upadhyay, & Somkuwar, 2014a).

The embedded systems are considered to be a reactive system, i.e., generally such systems react to their environment continuously and a majority of such systems possess the real-time response characteristics. The current developmental trend in such embedded systems has undergone a shift from being confined to only one particular function whereas the alternative trends allow flexibility for adding, modifying or deleting the sub-functionality units of such embedded system. Several changes are still occurring in the global embedded systems and the final objective was to make such systems as small and as fast as possible. One application of the embedded systems involves the mission-critical wherein the noise in the image is removed using the wavelet transformation feature (Rajwade, Rangarajan, & Banerjee, 2012).

In recent times, the Raspberry Pi is used as it has a higher flexibility, ensures a faster development, better reliability, easier upgrade and is cost-effective. Hence, the Raspberry Pi for designing and implementing the functional units have been applied, which resulted in a better throughput and an improved performance.

The denoising of the image removes the noise in the image, which improved the image quality. the salt and pepper and the Gaussian noises for the images have been used and applied the non-local wavelet threshold as a filtering technique. Other studies have applied filtering methods like the mean filtering and the interquartile range filtering methods. Many different types of noises can be used for comparing the noisy and the denoised images, however, Gaussian and the salt-and-pepper noises were the major noises used in this study (Buades et al., n.d.).

1.2 Problem Statement

In the past few years, there has been a huge development of the systems, especially those related to human life. Hence, it became imperative to grant these systems with an ability to process the real-time data and make precise decisions for solving the problems. Furthermore, it was important that these systems should be simple and not complex. For improving the efficacy and the accuracy of these systems, they consist of the noise removal systems.

Data-driven descriptions of structure are becoming increasingly important in image processing applications such as denoising, regularization and segmentation. One strategy is to use collections of nearby pixels, i.e. image neighborhoods, as a feature vector for representing local structure. Image neighborhoods are rich enough to capture the local structures of real images, but do not impose an explicit model. This representation has been used as a basis for image denoising and for texture image segmentation. For denoising, it has been demonstrated that the accuracy of this strategy is on the same level as state-of-the-art methods in general and exceeds them in particular types of images such as those that have significant texture patterns. The drawback is the relatively high computational cost. This modification to the non-local means algorithm results in improved accuracy and computational performance.

As mentioned above, the algorithm used for noise removal should be accurate and not affect the image edges. Furthermore, it should be able to properly and precisely filter out each pixel on a particular window size. Therefore, the techniques and the algorithms used for noise processing have to be very accurate (Viola & Jones, 2004).

When using a particular algorithm, generally compares the final image with the images generated by using other algorithms. In this way, a better image can be determined by comparing the PSNR values of the generated images.

1.3 Objective

The three objectives studied in this report include:

1. Implement an effective image denoising algorithm with the help of the Python programming language.
2. Analyzing the processing methods by implementing Non-local means and wavelet hard thresholding.
3. Designing a Raspberry Pi-based system for denoising the images.

1.5 Research Scopes

In this study, this project has considered the various aspects which need to be improved for increasing the throughput and the performance of the noise removal systems using the characteristics that are embedded in a single-board computer (Raspberry Pi). This work also explained the various designed systems which were implemented on a Raspberry Pi board. The implementation of the wavelet principle in the proposed algorithm helped in processing multiple data.

1.6 Project Organization

This study is divided into five chapters, where in every chapter addressed a different feature.

Chapter 1 presents the background, objectives, research questions and research scope.

The Chapter 2 has investigated this topic and presents the literature review. This review has uncovered the data and the referrals published previously in journals, websites etc. This chapter has explained the hypothesis for the processes like thresholding, non-local means etc. Furthermore, the method used for executing the proposed technique has also been described.

Chapter 3 describes the research methodology, architecture along with the platform characteristics used here. This chapter also presents the methodology and the general techniques used for completing the basic tasks.

All results have been presented in Chapter 4 .compared the images extracted using the NLM and the thresholding techniques by assessing the image quality by measuring the PSNR values.

In Chapter 5, the conclusions of this study based on the platform used has presented. They have also provided future recommendations for improving the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the related literature and studies after the thorough and in depth search has been done. This will also present the synthesis, theoretical and conceptual framework to fully understand the research to be done and lastly the definition of terms for better comprehension of the study.

The main objective of using the optimization processes involves manipulation of a specific image to generate a better result than the primary image. The digital image improvement methods can be divided into two classes, i.e., the spatial domain and the frequency domain. The spatial domain technique consists of methods belonging to a similar image level and all these methods are dependent on the processing of all image elements. On the other hand, the second class consists of methods based on the modification of the Fourier transform for the processed image (Gonzalez and Wintz, 1987).

Image smoothing is applied for two basic reasons, firstly, in order to provide the image components with some special effects and secondly, for eliminating the noise present in an image. Also, the smoothing processes decrease the false effects present in a digital image because of an inaccuracy or a poor review system (Kam et al., 2003).

Since the main objective of applying the smoothing process is decreasing the noise in the images, one must understand the different kinds of noise that can be present in the image and the method for dealing with such noises. Noise in a digital image is undesirable and can appear from various sources. For instance, the noise occurring due to the errors in the camera usage, which is often stored as a pattern and regularly appears in an image, is known as the regular noise. Also, random noises that occur due to the errors in the data transmission (sending) process, leading to the emergence of randomly scattered points or patches within an image and can be light or dark are known as the salt and pepper noises. Furthermore, noise resulting due to the erroneous image acquisition system is called as Gaussian noise. Thus, such noises or distortions can negatively affect the data extraction process and have to be removed before diagnosing any information in the image (Chen and Thanh, 2006). Here, the Haar algorithm in the Raspberry Pi using the Python 2.7.9 program with the Open CV 3.1.1 has been applied.

2.2 Mathematical formula for the image (matrix)

The images generated are generally stored in the 2-D matrices, and consist of 2 composite (X- and Y-) elements. Every element present in a matrix represents the colour and the pixel location provides detailed information about the image type in the MATLAB and includes the binary, RGB and the grey images. The images having fewer colours tend to get processed rapidly and hence, many of the applications prefer the binary images. The example shown below describes the binary image matrix for the triangle:

$$\begin{matrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix}$$

The accurate image dimensions are 7 * 5 and the storage in every location of the memory is 1 bit; hence, the size required for storing the image in the memory is 7 * 5 * 1 bits, whereas, for the grey images of the triangle, 8 bits are needed for each element within the image matrix instead of 1 in a binary matrix as follows: