AN APPROXIMATE ARITHMETIC PROGRESSION APPROACH FOR IMAGE FILTERING TECHNIQUE

by

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DECLARATION OF THESIS

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LIST OF ABBREVIATIONS

PDEs	Partial Differential Equations
RGB	Red, Green, Blue
RV	Random Values
FV	Fixed Values
AWGN	Additive White Gaussian Noise
AP	Arithmetic Progression
CD	Common Difference
SNR	Signal to Noise Ratio
PSNR	Peak Signal to Noise Ratio
MSE	Mean Squared Error
TV	Total Variation
YNF	Yaroslavsky's Neighborhood Filter
BF	Bilateral Filter
NLM	Non Local Means
MF	Median Filter
SMF	Standard Median Filter
WMF	Weighted Median Filters
CWMF	Center Weighted Median Filters
DWMF	Directional Weighted Median Filters
SMF	Switching Median Filter
RWMF	Recursive Weighted Median Filters
AMF	Adaptive Median Filter
AWMF	Adaptive Weighted Median Filters
AWFM	Adaptive Weighted Fuzzy Mean Filter
AFSF	Adaptive Fuzzy Switching Filter
FBF	Fuzzy Bilateral Filtering
FRINRM	Fuzzy Random Impulse Noise Reduction Method
FSF	Fuzzy Similarity Filter

LIST OF SYMBOLS

$I\ (x, y)$	Two-Dimensional Function
I	Function of Luminance Intensity and Color
(x, y)	The Spatial Coordinates of Point In The Image
u	Noise Free Image
n	Noise
v	Noisy Image
σ	Standard Deviation
N	Number of Pixels in Image
$\hat{I}$	Estimator of I
N_{RV}	Image Corrupted By Random Value Noise
N_{FV}	Image Corrupted By Fixed Value Noise
P	Probability
e	Error
c	Constant

Pendekatan Penganggaran Perkembangan Aritmetik Untuk Teknik Penapisan Imej

ABSTRAK

Imej mempunyai kepentingan besar dalam banyak bidang dalam kehidupan manusia seperti dalam bidang perubatan, fotografi, biologi, astronomi dan juga pertahanan. Oleh itu ianya menarik perhatian banyak penyelidik untuk menarik minat mereka dalam mengekalkan ciri-ciri imej daripada apa-apa faktor yang boleh mengurangkan kualiti imej. Pembuangan kekotoran daripada imej dengan mengekalkan ciri-ciri imej yang ditangani telah menjadi cabaran hebat untuk para penyelidik dalam bidang pemprosesan imej. Oleh itu, kajian ini telah dijalankan untuk mencadangkan dan mengaplikasikan satu teknik penapisan baru untuk menghilangkan kekotoran jenis Garam & Lada Hitam daripada imej digital. Teknik ini membolehkan pengecilan perbezaan antara imej asli dan imej yang diubah secara visual dan kuantitatif dengan menggunakan konsep bermatematik (perkembangan aritmetik) disebabkan oleh kebolehupayaannya dalam permodelan variasi bagi keamatan piksel dalam imej. Prinsip bagi teknik penapisan yang dicadangkan bergantung kepada ketepatan, yang mana ianya mengekalkan piksel-piksel yang tidak dikotori dengan menggunakan pengesanan kekotoran yang berkesan dan menukarkan piksel-piksel yang dikotori dengan menggantikan mereka dengan piksel-piksel terdekat daripada imej asli pada kos yang rendah dan lebih ringkas. Keputusan yang diperolehi menunjukkan bahawa teknik penapisan yang dicadangkan memberikan prestasi yang boleh diterima jika dibandingkan kepada kaedah-kaedah sedia ada samada secara visual ataupun kuantitatif dengan menggunakan Nisbah Puncak Isyarat kepada Kekotoran (NPIK) dan Ralat Min Kuasa Dua (RMKD).

An Approximate Arithmetic Progression Approach for Image Filtering Technique

ABSTRACT

Image have a significant importance in many fields in human life such as, in medicine, photography, biology, astronomy, industry and defense. Thus, it attracts the attention of large number of researchers, among them those interested in preserving the image features from any factors that may reduce the image quality. Removing noise from the image by retaining the features of this treated image remains a standing challenge for the researchers in image processing field. Therefore, this study is carried out to propose and implement a new filtering technique for removing Salt & Pepper noise from the digital image. This technique permits the narrowing of the gap between the original and the restored images, visually and quantitatively by adopting the mathematical concept (arithmetic progression) due to its ability in modelling the variation of pixels intensity in the image. The principle of the proposed filtering technique relies on the precision, where it keeps the uncorrupted pixels by using effective noise detection and converts the corrupted pixels by replacing them with other closest pixels from the original image at lower cost and with more simplicity. The results illustrate that the proposed filtering technique gives an acceptable performance compared to the existing methods whether visually or quantitatively with peak signal-to-noise ratio (PSNR) and mean squared error (MSE).

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Image is considered as a powerful platform to carry and to transmit information between peoples. It is very important in a lot of fields such as biology, astronomy, industrial, medical and surveillance (Kumar & Shaik, 2015). Thus, it attracts the attention of many researchers in restoring the unknown original image from the degraded image caused by any factors that may degrade or reduce the image quality such as blur.

One of these factors is the noise that may be introduced in the image with many forms (additive, multiplicative and impulsive), through one of these phases : image acquisition, transmission or storage (Li, 2012). The noise is a parasitic or weird information affect the visual aspect of the image by changing the pixel's values and make the other subsequent image processing more difficult such as segmentation, compression, classification, analyses, extraction of information. Figure 1.1, illustrate how the noise affect the visual aspect of image.

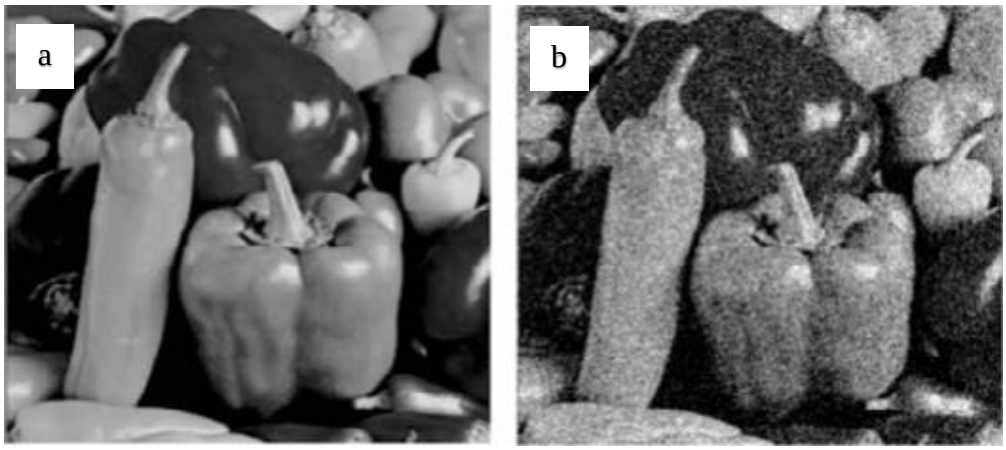

Figure 1.1: (a) Noise Free Image, (b) Noisy Image

It should be noted that, the image restoration concept varies according to the degradation factor where it might be deblurring (Kundur & Hatzinakos, 1996), inpainting (Li, 2011) and so on. In the case of degradation caused by the noise, the image restoration can be also called as image denoising, noise removal, or noise reduction, where it was firstly introduced by Wiener and Kolmogorov in the 1940s (Li, 2012).

Hence, denoising image is a critical and primary phase in the image processing, aims to remove or reduce the noise from the noisy image by preserving the image features, using the various techniques such as median filtering, fuzzy filtering and adaptive filtering. The observed image such as photograph and chart, is initially digitized and stored in digital memory as a matrix of binary numbers, where this digital image can be processed (Jain, 1989).

Further, many number of image filtering techniques have been introduced in order to remove noise from the image by considering the image's features and details like edges. In other words, to obtain the best similarity by comparing the noised image to the original

image. These methods adopt several mathematical concepts of filtering process such as linear/non-linear, statistics, probabilities, modeling, PDEs, wavelet, and fuzzy logic.

The performance of the filtering techniques vary from one filter to another filters, and it can be evaluated according to various criteria, which are: a) The noised image (input): the type of noise (additive, multiplicative, impulse noise, mixed noise), level of noise (high, low), structure of image (texture, smooth, edge), pixels intensity. b) Filter (filtering tool): computational cost (acceptable, high), filter implementation (simple, complex). c) Restored image (output): measurement of noise (SNR, MSE, PSNR), visual quality (blur, artifacts, information loss and so on).

1.2 Problem Statement

Beside the researches and studies which aim to achieve the optimal filtering techniques performance, that give the closest restored image to the original version (noise free image) and make the detection towards the difference between the two (original and restored) images unattainable, taking into account the evaluation criteria cited in the previous section such as the computational cost and the simplicity of the filter implementation. In other words, removing noise from the image by retaining the details and features of this treated image. However, the findings proved to be inconclusive yet and the above goal has not yet been achieved, thus the noise removal remains a standing challenge for the researchers in this field (Buades, Coll, & Morel, 2010; Chatterjee & Milanfar, 2010; Li, 2012; Quan, 2013).

This work is interested by proposing and implementing a new filtering technique that permits to narrow the gap between the original and the restored image, visually and

quantitatively in order to achieve the objective, by adopting the mathematical concept (arithmetic progression) due to its ability in modelling the variation of pixels' intensity in the image. The principle of proposed filtering technique relies on the precision, where it keeps the uncorrupted pixels by using effective noise detection and changes the corrupted pixels by replacing with other closest pixels from the original image with lower cost and more simple.

1.3 Research Objectives

Based on the above problem statement, the objectives in this study are summarized as follows:

i. To develop the noise detection phase in the filtering process, which aims only to treats the corrupted pixels in the noisy image and keeps others uncorrupted pixels with same values.

ii. To develop the noise suppression phase by changing the corrupted pixels by the most correct values. In order to reduce the difference between the restored image and the original image, visually and quantitatively.

iii. To compare the performance of the proposed filtering technique with the performance of exciting techniques.

1.4 Scope of the Study

The scope of this research includes the process of removing the noise from the digital images. The noise appears in the image through three forms which are additive, multiplicative and impulse noise, many studies and researches have been done to handle these types, where this study focus on treating the last type which is the impulse noise with fixed values (Salt & Pepper noise), due to its structure that makes the adoption of the proposed mathematical concept (arithmetic progression) more able in successfully solving this kind of problems. In addition, this study is interested in processing the digital image, which is come from the digitization of the captured image.

1.5 Significance of the Study

This study adopts the restoration of the image, which considered as an important tool of communication and sharing information between peoples. This process make other subsequent image processing attainable, such as segmentation, compression, classification, analysis, extraction of information. Furthermore, it has a quite eminent role in the development and progression in many fields in our life such as in the medicine, photography, biology, astronomy, industry and defense. Thus, the significance of this research is merged follow to above significance.

1.6 Thesis Organization

The first chapter of this thesis is Introduction, which present the general information of this research, starting by the background. Then, the problem statement of

this research is described in the second section of this chapter. Where, others informations are presented under the following titles, objectives, scopes, and significance of the study.

The second chapter of this thesis is the literature review of the previous researches and studies that are related to the treated subject in the image filtering. The noise in the image, the filtering methods and the evaluation of those methods are discussed in this chapter.

Chapter 3 of this study is about the methodology involved in this research, explanation about the process, phases, tools that are adopted to treat this problem of noise in the image.

Chapter 4 present the results of the research. A comparison of these results with others filtering techniques is presented in this section, with detailed discussion.

Chapter 5 is the conclusion. In this section, the summary of the research and the recommendation for future research are presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Among the different tools of communication between people, there is the image, which carries a large amount of information. However unfortunately sometimes this image will be corrupted by parasitic information, which is called: noise, an alteration of image, which may be caused by the image acquisition process, transmission (Yan, 2013; Zhu, 2014), or storage (Li, 2012).

More specifically, the main concern of the researchers in this subject is to succeed in solving this problem by removing noise from the noisy image and achieve the best restoration of the original one. To achieve the desired aim, they need ample and necessary knowledge, concepts and definitions, which are inspired from the review of relevant literature. Further, image processing is a quite wide field of knowledge due to its importance, and decisive attendance in several fields like, biology, astronomy, industrial, medical and defense. Thus, a huge amount of researches and studies was been done about this point.

In brief, this section provides the necessary information restricted in the primary phase of image processing (image pre-processing), which called image filtering, particularly the fundamental approaches of image filtering. We seek to gather and introduce these approaches and concepts smoothly, with good arrangement, where the readers can go gently in the subject's depth, in order to facilitate the path that leads to the

goal, by making this study as a starting point of others studies concerning the image filtering. Thus, image, digital image, noise, noise types, evaluation criteria, image filtering, approaches for image filtering, methods comparison, are presented in the rest of the literature review.

2.2 Image Definition

The image is a scene representation through painting, sculptures, drawing, photography, and so on. It is also a structured set of information that gives meaning to human after the display on screen. It may be defined as a two-dimensional function $I(x, y)$ analog brightness continuous, defined in a bounded domain x and y as the spatial coordinates of a point of the image and I is a function of luminance intensity and color. In this aspect, the image is unusable by the machine, which requires digitization (Ander, 1987).

2.3 Digital Image Definition

The digital image, in its broadest sense, refers to any image acquired, processed and stored in a coded form that may be represented by numbers (numerical values). Digitization is the process which permits the image to move from the physical state (optical image) represented by continuous signal (an infinity of intensity value), to the digital image state which is characterized by the discrete aspect (intensity take their values in a finite number of points). This is the digital form, which permits a further exploitation by computer software tools.

Figure 2.1 shows the image digitization process. Thus, the digital image is a bounded set of elements, each one of them determined by location coordinate and value. These elements are called image elements, picture elements, pixels, and pels. The most widely used term to denote the digital image elements is pixel. According to the luminance intensity value, digital image is classified into three types (color-coding): black and white gray scales and colored.

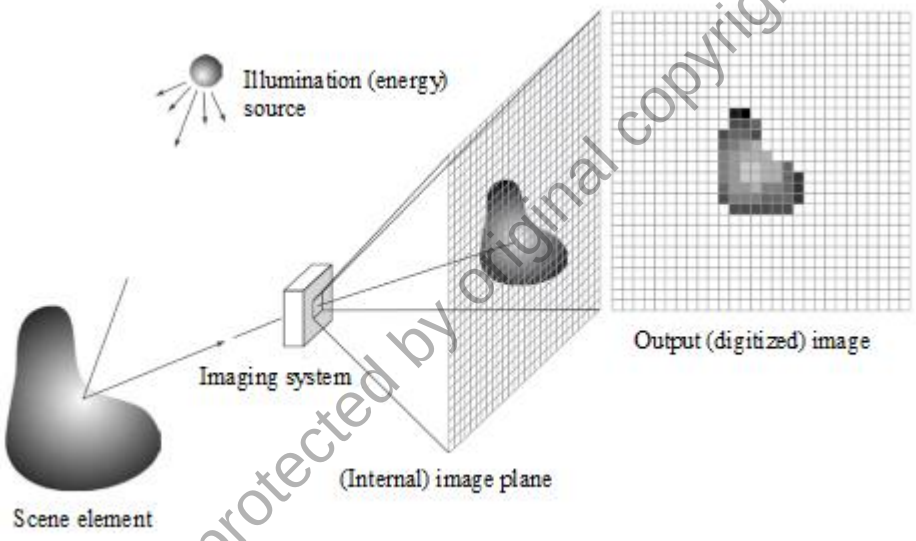

Figure 2.1: Display of the Digital Image Acquisition Process

Source: (Gonzalez & Woods, 2008)

2.3.1 Binary Images

The binary images are an array of integers ($k = 1$ bit), pixel that can take one of the values: 0 or 1. White is denoted by 0 and Black by 1. This is the simplest types of images and usually this kind is used to scan texts when the latter is composed of one color as shown in Figure 2.2.

2.3.2 Gray Scale Images

The gray level is the value of the luminance intensity at one point. As shown in Figure 2.2. These images consist of only 8 bits, and the pixel color can take values ranging from black to white through various levels of brightness $[0,1,2,..,255]$.

2.3.3 Full-Color Images

Figure 2.2 presents full-color images. Color images are usually based on three primary colors: Red, Green and Blue (RGB), and typically they use 8 bits for each color component, so each pixel requires $3\times 8 = 24$ bits to encode three components, and each color component can be one of the values of the range $[0,1,2,..,255]$. Thus, possible colors may actually appear in the image.

Figure 2.2: Color Coding of Digital Image

2.4 Noise

Noise is an alteration of image (parasites information), there may be created in one of these phases, during the acquisition process (conversion operation from optical signals to the electrical then from electrical to digital signal) through the transmission,

sensor status and environmental conditions (Liu, Tai, Huang, & Huan, 2013; Zhu, 2014). The noise has different origins, but it causes similar effects such as the loss of sharpness in the details or the appearance of grains, where the number of corrupted pixels assigns the amount of noise in noisy image.

In terms of removing this noise from the corrupted image, the researchers of this field have made some in-depth studies to know the nature and types of noise. The image is corrupted due to the fact that there are various types of noise such as the Gaussian noise, Poisson noise, Speckle noise, Salt and Pepper noise and many more fundamental noise types in the case of digital images (Boyat & Joshi, 2015).

(a) (b) (c)

Figure 2.3: (a) Original Image, (b) Noisy Image, (c) Restored Image

2.5 Noise Models

Noise is integrated in the image $u(x, y)$ through three forms of noise $n(x, y)$, namely additive, multiplicative, and impulse noise (Saeedi, Moradi & Faez, 2010; Schulte, De Witte, & Kerre, 2007), to give a noisy image denoted by $v(x, y)$.