NOISY IMAGE QUALITY IMPROVEMENT USING COMBINATIONAL FILTER MODELS AND SHARPENING

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Dedicated to my beloved parents, thank you

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ABSTRACT

Image is one of the prominent mediums used to illustrate or express a message in daily communication. Image is used in a variety of applications nowadays, such as in security systems, communication systems and medical systems. The feature of an image is its vast data capacity, particularly for high- resolution images. In today's world, noisy image is one worry in developing countries like Pakistan. When working with noisy images, existing methods remove the noise but also the details of the image edges, resulting in a blurred final image. There is no distinction between the image's edges and background. To overcome this problem, combination filter models have been developed so that they can be used to solve various types of noise problems. In this research the noise is introduced to produce a noisy image sample. Then, Mean filters, Median filters, and Wiener filters are used to eliminate noise from the image samples. Next, to detect the edges in the image, the Sobel, Prewitt, Laplacian of Gaussian and Canny edge detection techniques are used. Meanwhile, the Laplacian Operator is applied which, sharpens the blurred edges of an image. All the proposed models were tested using eight sample images. The experimental findings show that Combination Model 1 with Laplacian Operator is effective at removing Salt and Pepper noise with Peak Signal to Noise Ratio value of 40.66. Combinational Model 2 with Laplacian Operator shows good results for Salt and Pepper noise with a 38.89 Peak Signal to Noise Ratio value. While Combinational Model 3 with Laplacian Operator reveals a 36.60 Peak Signal to Noise Ratio value for Poisson noise. Combinational Model 1 and 3 equally give good value for Speckle noise with 34.79 and 34.02 Peak Signal to Noise Ratio. These models give the best value for portrait, landscape and standard-size images. The findings show that the proposed models outperform previously proposed methods in terms of Peak Signal to Noise Ratio quality.

ABSTRAK

Imej merupakan salah satu medium yang digunakan untuk menggambarkan sesuatu mesej dalam komunikasi harian. Imej digunakan dalam pelbagai aplikasi pada masa kini, seperti dalam sistem keselamatan, sistem komunikasi dan sistem perubatan. Imej yang berkualiti tinggi adalah imej yang mempunyai kapasiti data yang besar dan beresolusi tinggi. Hingar dalam imej adalah salah satu permasalahan yang wujud di negara membangun seperti Pakistan. Dalam kajian yang terdahulu, kaedah sedia ada berjaya menghilangkan hingar pada imej, namun, pada masa yang sama ia juga turut menghilangkan butiran tepi imej. Justeru, ia menghasilkan imej akhir yang kabur dan tiada perbezaan yang jelas antara tepi imej dan latar belakang imej. Untuk mengatasi masalah ini, model penapis gabungan telah dibangunkan supaya ia boleh digunakan untuk menyelesaikan pelbagai jenis masalah hingar. Dalam penyelidikan ini hingar dimasukkan ke dalam sampel imej bagi menghasilkan sampel imej berhingar. Kemudian, penapis *Min, Median dan Wiener* digunakan untuk menghapuskan hingar daripada sampel imej tersebut. Seterusnya, bagi mengesan tepi dalam imej, teknik pengesanan tepi *Sobel, Prewitt, LoG* dan *Canny* digunakan. Sementara *Laplacian Operator* digunakan untuk menajamkan tepi imej yang kabur. Semua model yang dicadangkan telah diuji menggunakan lapan imej sampel. Dapatan eksperimen menunjukkan penapis hingar Model Gabungan 1 dengan *Laplacian Operator* berkesan untuk menghilangkan hingar *Salt and Pepper* dengan nilai Nisbah Isyarat Puncak kepada Bunyi (PSNR) 40.66. Penapis hingar Model Gabungan 2 dengan *Laplacian Operator* menunjukkan hasil yang baik untuk hingar *Salt and Pepper* dengan nilai PSNR 38.89. Manakala penapis hingar Model Gabungan 3 dengan *Laplacian Operator* menghasilkan nilai PSNR 36.60 untuk hingar *Poisson*. Model Kombinasi 1 dan 3 sama-sama memberikan nilai yang baik untuk hingar *Speckle* dengan nilai PSNR 34.79 dan 34.02. Model gabungan yang dicadangkan juga didapati memberikan nilai PSNR yang baik terutama pada imej potret, landskap dan imej bersaiz standard. Kajian ini juga telah menhasilkan model gabungan penapis yang mengatasi prestasi kaedah yang dicadangkan sebelum ini dari segi kualiti PSNR.

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LIST OF ABBREVIATIONS

ADD	-	Advanced Dual Domain
AM	-	Amplitude Modulation
ASRMM	-	Adaptively Sparse Reconstruction Method for Mixed
ASTM	-	American Society for Testing and Materials
BDND	-	Boundary Discriminative Noise Detection
CGI	-	Computer Generated Imagery
CM	-	Combinational Model
CT	-	Computed Tomography
DAMF	-	Different Applied Median Filter
DCxWT	-	Daubechies Complex Wavelet Transform
DIP	-	Digital Image Processing
DOTA	-	Dataset of Object deTection in Aerial images
EM	-	Electron Micrograph
EMF	-	Elastic Median Filter
FIR	-	Finite Impulse Response
FOTV	-	Fractional Order Total Variation
GGL	-	Grid Guided Localization
HBG	-	High Boost Gaussian
HMM	-	Hidden Markov Model
HPB	-	High Pass Butterworth
HPG	-	High Pass Gaussian
HSV	-	Hue Saturation Value
ICA	-	Independent Component Analysis
IN	-	Impulse Noise
ITM	-	Improved Tree Markov
JSR	-	Joint Sparse Representation
LBP	-	Local Binary Pattern
LOG	-	Laplacian of Gaussian

LPG	-	Low Pass Gaussian
LRA	-	Low Rank Approximation
MAP	-	Mean Average Precision
MATLAB	-	Matrix Laboratory
MF	-	Membership Function
MRI	-	Magnetic Resonance Imaging
MSE	-	Mean Square Error
OCR	-	Optical Character Recognition
OD	-	Object Detection
OTSU	-	Oral Tracheal Stylet Unit
PA	-	Proposed Algorithm
PET	-	Positron Emission Tomography
PRBF	-	Poisson Reducing Bilateral Filter
PSNR	-	Peak Signal to Noise Ratio
RGB	-	Red Green Blue
RS	-	Remote Sensing
SAP	-	Salt and Pepper
SAR	-	Synthetic Aperture Radar
SBEM	-	Serial Block-face Electron Micrograph
SIWPD	-	Shift Invariant Wavelet Packet Decomposition
SMF	-	Standard Median Filter
SNR	-	Signal to Noise Ratio
SPDA	-	Sparse Poisson De-noising Algorithm
SSIM	-	Structural Similarity Index Measure
SURE	-	Stein’s Unbiased Risk Estimator
SVD	-	Singular Value Decomposition
TAF	-	Tamper Assessment Function
UDWT	-	Undecimated Discrete Wavelet Transform
VISU	-	Visualization
VST	-	Variance Stabilizing Transforms
WJSR	-	Weighted Joint Sparse Representation
WMF	-	Weighted Median Filter
ZM	-	Zernike Moment

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

Digital images play an important role both in daily life applications such as satellite television, magnetic resonance imaging, and computed tomography as well as in areas of research and technology such as geographical information systems and astronomy. Data sets collected by image sensors are generally contaminated by noise. Imperfect instruments, problems with the data acquisition process, and interfering natural phenomena can all degrade the data of interest. Furthermore, noise can be introduced by transmission errors or compression. Thus, de-noising is often a necessary and the first step to be taken before the image's data is analysed. It is necessary to apply an efficient de-noising technique to compensate for such data corruption [1].

Image de-noising still remains a challenge for researchers because noise removal introduces artefacts and causes blurring of the images. The previous research describes many different methodologies for noise reduction giving an insight as to which algorithm should be used to produce a better image quality [2].

Noise in images is greatly affected by the accuracy of capturing instruments, data transmission media, image quantization, and discrete sources of radiation. Different algorithms are used depending on the noise model. Most of the natural images are assumed to have additive random noise such as a Gaussian. Speckle noise [3] is observed in ultrasound images whereas Rician noise [4] affects MRI images.

Salt-and-pepper noise, also known as impulse noise, is a type of noise that can be seen on digital images from time to time. This noise can be caused by sharp and sudden disturbances in the image signal. It appears as sparsely distributed white and black pixels [5].

Due to the statistical nature of electromagnetic waves like x-rays, visible light, and gamma rays, Poisson noise can be seen [6].

Image de-noising has remained a fundamental task in image processing. Wavelets give a superior performance in image de-noising due to properties such as sparsely and multi-resolution structure. Wavelet transformation has gained popularity in the last two decades, and various algorithms for de-noising in the wavelet domain were introduced. The focus was shifted from the spatial and Fourier domain to the wavelet transform domain. Ever since Donoho's wavelet-based thresholding approach was published in 1995, there was a surge in the de-noising papers being published. Although Donoho's concept was not revolutionary, his methods did not require tracking or correlation of the wavelet maxima and minima across the different scales as proposed by Mallat [7]. Thus, there was a renewed interest in wavelet based de-noising techniques since Donoho [8] demonstrated a simple approach to a difficult problem.

1.2 Problem statement

Captured images may be imposed with noise that can lead to image corruption or image blurring. Current denoising techniques remove important image features while extracting noise. Despite the fact that deblurring filters were used, the final image did not have a high PSNR.

Images also face hardware limitation problems and hurdles while transmitting the data that can corrupt the pixels of the image [9-12].This problem mostly can be seen in undeveloped countries such as Pakistan in which most of the mobile phone used has only low-resolution camera. Due to low purchasing power, most of the Pakistani population cannot afford a smartphone. People from the lower middle class make up the majority. For safety reasons, most Pakistani carry a low-cost mobile phone [13].

Pakistan ranks 20th in the world in terms of mobile phone usage. Pakistan's total population is 220.89 million, with only 40.59 million, or 18% of it being mobile phone users. More than that, only 20% of the mobile phone user carry the smartphone [14].

Besides, based on Global System for Mobile Communication (GSMA) report in 2021, it states that Pakistan will be at close to the tail end in terms of smartphone user amongst several Asia Pacific countries by the year 2025 [15].

Low-cost phones, such as Qmobile, does not have a high-resolution camera [13]. Thus, the image produced by this type of low-cost phone is low quality with some noise in it. A high-resolution camera can give you an image with more clear detail than a low-resolution camera. Some of the past researchers have done some research on image de-noising [16 – 19] but some of the proposed methods still lacks in preserving the image quality. It can be seen in their empirical testing where the obtained Peak Signal to Noise Ratio (PSNR) value is quite low.

Thus, in this research, a combination of various types of image filters with edge detection and image sharpening is proposed to improve the image quality.

1.3 Objective of research

The objective of this research are as follows:

1. To develop a combinational noise removal model for de-noising method to remove the noise from image.
2. To improve the quality of the de-noised image through sharpening technique to preserve the edges in an image.
3. To evaluate the performance of the proposed method in terms of PSNR, SSIM, MSE and SNR.

1.4 Scope of research

The study scope of this research is:

4. The sample images used are Lena, Cameraman, Jungle, Sky, Crow, Sea, Rose and Walima.
5. The noises inserted into the image samples are Salt and Pepper, Speckle, and Poisson.
6. Technique used for image de-noising are Mean, Median and Wiener filters.
7. Technique used for edge detection are Canny, Sobel, Prewitt and LoG and for

sharpening Laplacian technique is used.

8. The performance evaluation matrices are PSNR (Peak Signal to Noise Ratio), SSIM (Structural Similarity Index Measure), MSE (Mean Square Error) and SNR (Signal to Noise Ratio).
9. The proposed technique will be developed on MATLAB.

1.5 Thesis outline

There are five chapters in this thesis. The first chapter, Chapter 1, introduces digital image processing and noisy images. The objectives, scope, and problem statement are further items in this chapter's content.

The specifics of the literature study on prior research projects are detailed in Chapter 2. The notion of image processing and an overview of image processing types are covered at the beginning of this chapter. The details of several digital image processing techniques and categories follow. Also, describe the many sorts of noise and how de-noising procedures can clean the image. Techniques for edge identification and sharpening are available at the final edge.

With the use of diagrams and figures from the study flowchart, Chapter 3 demonstrates the methodology of this research project. This research's methodology is divided. The chapter begins by describing the noisy model of an image and then goes on to explain how noise can be eliminated using filters. The chapter then discusses edge detection and sharpening techniques. Finally, evaluation matrices are used to represent how well the system performs.

After that, every result, including the analysis of study is presented in Chapter 4. The quality of an image is assessed using the results in terms of MSE, PSNR, and SSIM. Combinational models of filtering were employed to take out the noise before highlighting the edges with approaches for edge identification and sharpening. In addition, a summary of all outcomes is provided, and it is improved compared to earlier research.

The overview of the research is concluded in Chapter 5, along with the accomplishment of the research goals. Future research recommendations are also discussed and compiled.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter includes algorithms, methods, approaches, techniques, detectors, models, and filters, as well as all of the historical research in which their links were used as evolutionary and provided the optimized form of solutions for noise and de-noising issues. This chapter includes noise types and corrupted image backgrounds, as well as a brief description of the improvement of filters or their types. To begin, this chapter describes the noise issue, such as how many different types of noise could one encounter in this world while sending data in the form of an image. Second, this chapter demonstrates how noise can degrade and corrupt image structure during data transmission. Third, there are numerous techniques for removing noise from an image. The fourth section describes which filter completely and efficiently removes noise from an image. The fifth section discusses the issues that arise after removing noise from an image, such as the de-noise image having blurred edges and so on.

2.2 Mobile Phone Usage and Trend in Pakistan

Pakistan has the lowest smartphone penetration rate in the Asia-Pacific region as a whole and only 41% of the community can afford to spend more than Rs 500 on a phone [13].

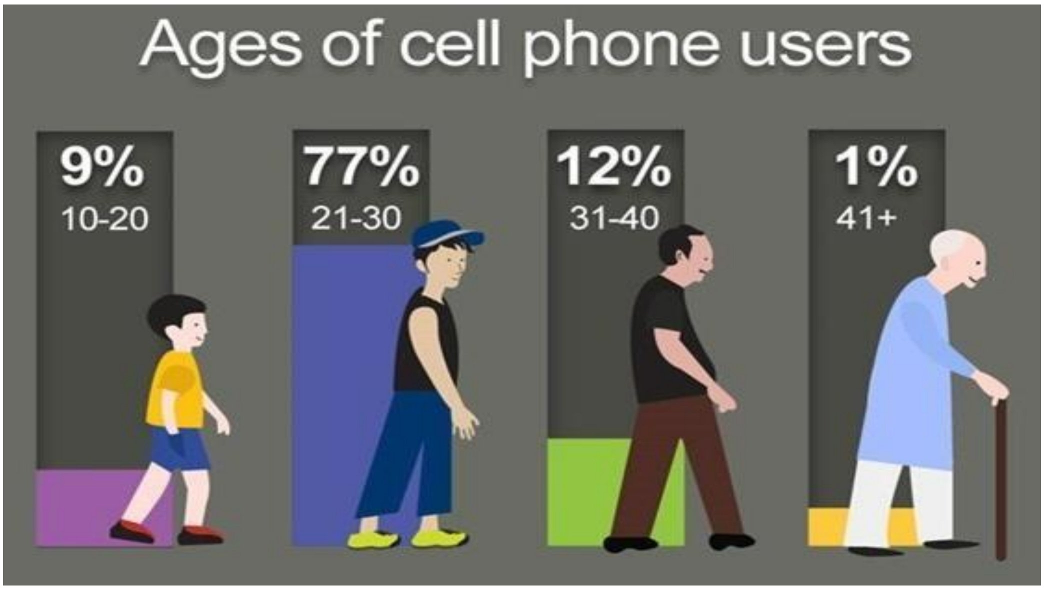

Figure 2.1: Ages of cell phone users [13]

Some people can afford high-quality phones, but due to security and robbery concerns, they do not purchase expensive mobile phones. One of the concerns for low-quality mobile phone usage is about safety [13].

Figure 2.2: The reason for low-cost phones [13]

According to the GSMA, which represents 750 mobile operators worldwide, Pakistan will rank last in the Asia-Pacific continent in terms of smartphone users and 5G reportage by the year of 2025 [15].

GSMA also believed that, markets with higher tax ambiguity score lower on infrastructure provision, whereas an equitable and balanced approach to revenue collection via taxes and fees has the ability to foster favourable investment conditions and improve affordability [15].

2.3 Image Processing

Image processing is an umbrella term that encompasses a variety of functions that analyse images or convert one image representation to another. Although some analogue processing was done in the past, most image processing today is done in the virtual world. Surveillance, medical imaging, machine vision, robotics, computer-generated imagery (CGI), video conferencing, and satellite data analysis are just a few of the applications. Digital signal processing includes image processing. The goal of image processing is to convert an image into electronic information and perform some process on it in order to obtain a better image or to extract information from it. It is a method that is being developed to convert images into digital form and perform some activities on them in order to obtain specific models or extract useful information from them. This method takes as input a video segment or an image, such as a portrait. The abilities in order to select or draw attention to the preferred or attention-grabbing portion of the image [20]. When using pre-determined signal processing methods, image processing systems generally treat images as two-dimensional signals.

Image processing basically includes the following three steps:

- Importing the image using image acquisition software;
- Analysing and modifying the image;
- Output, which can be an altered image or a report based on image analysis.

2.4 Types of Image Processing

There are two types of image processing techniques: analogue and digital image processing. Analogue image analysis can be used for hard copies such as printouts and photographs. While using these visual elements, image analysis employs various fundamentals of interpretation. Digital image processing techniques aid in the manipulation of digital images using computers. Pre-processing, enhancement, and knowledge discovery are three general phases that all types of data must go through when using digital techniques [21].

The intervention of images using computer terminals is known as digital image processing. Its popularity has skyrocketed over the last few decades. Its various applications ranging from medicine to entertainment, with geological computation and remote sensing is also on the list. One of the cornerstones of the modern information society is multimedia systems, which rely heavily on digital image processing [22].

2.5 Categories of Digital Image Processing

Generally, there are four types of images [23]:

- Binary images
- Multi-spectral images
- Colour images
- Grey-scale images

2.5.1 Binary Images

Binary images can have two values: 0 and 1, or black and white. Binary images use only one binary digit to represent each pixel, so they are also known as 1-bit images. For instance, optical character recognition (OCR) [24]. Binary images are made by performing a threshold operation on grayscale images. Every pixel above the threshold level is turned white (1), while those below the threshold start turning black (0).

2.5.2 Multi-Spectral Images

This kind of image contains data that is beyond the normal range of human perception. The human system cannot see the information represented. As a result, these are not photographed in the traditional sense. The data is pictured visually by mapping the various spectral bands to RGB components. Ultraviolet, infrared, X-ray, radar, and acoustic data are examples of multi-spectral images [24].

2.5.3 Colour Images

Colour images are generated as three-band monochromatic image data, with each band representing a different colour. There is grey-level information in each

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APPENDIX B

LIST OF PUBLICATIONS

1. Khan, S. U., Abbasi, W., Nawi, N. M., Khan, Z., & Khan, S. N. (2020). " A New Biometric Matching Fingerprints System for Personal Authentication Using R305". Academia of Information Computing Research, 1(1).
2. Samra Urooj Khan, N.S.A.M Taujuddin, , Husin, Z.H, Tara Othman Qadir, Sami Ud Din , Zoya Khan, Sundas Naqeeb Khan, "Control Motor Speed Through Variable Frequency Drive By Using Arduino," International Conference on Electrical and Electronic Engineering 2021 (Icon3E 2021).
3. Samra Urooj Khan, N.S.A.M Taujuddin, Sundas Naqeeb Khan, Zoya Khan, Tara Othman Qadir, "Iris Recognition through Feature Extraction Methods: A Biometric Approach," 19th IEEE Student Conference on Research and Development (SCOReD 2021).
4. Hasnat, A., Khan, S. N., Khan, S. U., Ahmed, M. H., & Abid, I. (2022). "A Case Study Based Quantitative Approach in Determination of Workplace Incivility Towards Adaptation Effects". Quantum Journal of Social Sciences and Humanities, 3(6), 17-28.

APPENDIX C

VITA

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