IMPROVING IMAGE LUMINOSITY AND CONTRAST VARIATION USING HYBRID STATISTICAL STRATEGY

WAN AZANI BIN WAN MUSTAFA

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by

WAN AZANI BIN WAN MUSTAFA
(1340611113)

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THESIS DECLARATIONS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AD	Average Difference
AMBE	Absolute Mean Brightness Error
DCT	Discrete Cosine Transform
DoG	Difference of Gaussian
DWT	Discrete Wavelet Transform
GCF	Global Contrast Factor
HBF	Homomorphic Butterworth Filter
H-DIBCO	Handwritten Document Image Binarization Contest
HE	Histogram Equalization
HSE	Hybrid Statistical Enhancement
ME	Misclassification Error
MPM	Misclassification Penalty Metric
MQI	Morphological Quotient Image
NAE	Normalized Absolute Error
PSNR	Peak Signal Noise Ratio
SNR	Signal Noise Ratio

Penambahbaikan Kilauan dan Variasi Kontras Imej Menggunakan Strategik Statistik Hibrid

ABSTRAK

Masalah kilauan dan variasi kontras adalah salah satu tugas yang mencabar dalam bidang pemprosesan gambar terutamanya untuk meningkatkan kualiti gambar. Peningkatan dilakukan dengan melaksanakan penyelarasan keamatan gelap atau cerah untuk meningkatkan kualiti gambar dan menambahkan prestasi segmentasi. Baru-baru ini, banyak kaedah telah dicadangkan untuk menormalkan variasi kilauan dan kontras. Dalam kajian ini, satu kaedah baru dicadangkan berdasarkan teknik secara langsung dengan menggunakan data statistik dikenali sebagai 'Hybrid Statistical Enhancement' (HSE). Kaedah HSE ini menggunakan purata dan sisihan piawai berdasarkan kawasan kecil dan keseluruhan dan dikelaskan kepada tiga kumpulan; objek, sempadan, dan rantau bermasalah (kontrast & kilauan). Dua set data iaitu gambar dokumen dan gambar kecacatan kimpalan diuji untuk menunjukan keberkesanan kaedah HSE. Keputusan dari aspek visual dan objektif menunjukkan bahawa kaedah HSE mampu menormalkan kilauan dan mengatasi masalah variasi kontras dengan berkesan berbanding dengan kaedah-kaedah peningkatan yang lain. Kemudian, proses peruasan dilakukan dengan menggunakan gambar yang terhasil daripada kaedah HSE. Bagi membuktikan keberkesanan HSE, beberapa penilaian kualiti gambar dibentangkan dan hasilnya dibincangkan. Kaedah HSE mencapai keputusan tertinggi berbanding dengan kaedah-kaedah lain iaitu (Ratio Isyarat Hingar = 9.32) bagi set data dokumen dan (Ratio Isyarat Hingar = 8.92) untuk set data kecacatan kimpalan. Pada peringkat peruasan, kaedah Otsu memperolehi peningkatan purata tertinggi, iaitu 41% untuk set data dokumen dan 82% untuk set data kecacatan kimpalan. Kesimpulannya, pelaksanaan kaedah HSE yang dihasilkan berkesan dan cekap untuk pembetulan latar belakang, meningkatkan kualiti gambar dan meningkatkan kualiti hasil peruasan berdasarkan ketepatan dan Ratio Puncak Isyarat Hingar (PSNR).

Improving Image Luminosity and Contrast Variation Using Hybrid Statistical Strategy

ABSTRACT

Luminosity and contrast variation problems are among the most challenging tasks in the image processing field especially to improve the image quality. Enhancement is implemented by performing an adjustment of the dark or bright intensity in order to improve the quality of the images and to increase the segmentation performance. Recently, numerous methods had been proposed to normalize the luminosity and contrast variation. In this study, a new method based on a direct technique using a statistical data that is known as Hybrid Statistical Enhancement (HSE) is proposed. The HSE method used the mean and standard deviation of a local and global neighbourhood and classified the pixel into three groups; the foreground, border, and problematic region (contrast & luminosity). Two datasets namely document image and weld defect image were utilized to demonstrate the effectiveness of the HSE method. The results from the visual and objective aspects showed that the HSE method can normalize the luminosity and enhance the contrast variation problem effectively, compared to the other enhancement methods such as Homomorphic Filter and Discrete Cosine Transforms (DCT). Then, the segmentation process was done using the resulting image from the HSE method. In order to prove the HSE effectiveness, a few image quality assessments were presented and the results were discussed. The HSE method achieved the highest result compared to the other methods which are (Signal Noise Ratio = 9.32) for document dataset and (Signal Noise Ratio = 8.92) for weld defect dataset. In segmentation stage, the Otsu method obtained the highest average increment, which is 41% for document dataset and 82% for weld defect dataset. In conclusion, the implementation of the HSE method has produced an effective and efficient result for background correction, quality images improvement and increase the quality of segmentation result in term of Accuracy and Peak Signal Noise Ratio (PSNR)

CHAPTER 1

INTRODUCTION

1.1 Background of Image Enhancement

Image analysis refers to the process of analysing an image using a computer with the objective of extracting meaningful information from the image. A human vision system can perceive and understand the environment easily. However, developing a computer program that can mimic the ability of the human visual system to perform image analysis is a difficult task. Image enhancement is an important topic in image analysis in order to help humans and computer vision algorithms to obtain an accuracy information for analysis. The visual quality and certain image properties, such as brightness, contrast, signal to noise ratio, resolution, edge sharpness, and colour accuracy were improved through the enhancement process (Gonzalez & Woods, 2008; S. Sharma, 2013). Recently, many image enhancement methods have been developed based on various digital image processing techniques and applications. They can be developed in the spatial domain or spatial-frequency domain. The enhanced image provides useful information for post-processing, especially in segmentation stage. Several survey papers on image normalization and segmentation methods have been presented in the literature and can be found in (Jain & Arya, 2014; Reza Ghabousian & Nooshin Allahbakhshi, 2015; S. Singh & Sharma, 2014).

Many researchers have studied contrast enhancement techniques in order to improve the image quality. Contrast enhancement can be categorized into two types; (1) direct method and (2) indirect method (Kotkar & Gharde, 2013; Saleem, Beghdadi, & Boashash, 2012). The direct methods enhance the details by defining or detecting the contrast, while indirect methods improve the contrast without defining a specific contrast region. The indirect methods are not efficient and effective since it just extends the global distribution of the intensity compared to the direct method (Gonzalez & Woods, 2008).

Besides that, image enhancement methods also can be divided into global and local methods. Global methods process the entire image using one technique. On the other hand, local methods use local image information in order to process a given area in the image. Often image characteristics differ from region to region, it is reasonable to use context-sensitive approaches when enhancing the contrast. In conclusion, global contrast enhancement techniques enhance the overall contrast by dependencies on the global content of the image. Local enhancement methods improve image details, but it can produce block discontinuities, noise amplification and unnatural image modifications (Saleem et al., 2012).

1.2 Problem Statement

Illumination (luminosity and contrast) is described as a non-uniform intensity which appears as a darkest or brightest region on the original image. Recently, illumination variation is still a tough problem in enhancement research area. When the lighting condition is changed, the intensity appears variously. More specifically, the changes caused by the variation of lighting could be larger than the difference between of the appearance individuals. Reflections and shadows are two main categories of

appearance variation due to illumination variation (Emadi, Khalid, Yusof, & Navabifar, 2012). The direction of the light source may cause the image too bright or too dark.

One of the most significant current discussions in image processing is a contrast enhancement since the contrast problem is a crucial factor need to be considered before the segmentation process (C. Chen, Wang, & Sarem, 2011; Mandeep Kaur, Jain, & Lather, 2013; Moghaddam & Cheriet, 2009). Many researchers agreed that pre-processing is an important stage in image analyses (Kopilović & Szirányi, 2005; Sharif, Mohsin, Jamal, & Raza, 2010; Zhoa, Lin, Ou, & Yang, 2015). Contrast variation and luminosity problem commonly affected by occlusion, pose, lighting and caused the difficulties in the segmentation process (An, Wu, & Ruan, 2010; Drira, Amor, Srivastava, & Member, 2013; Megherbi & Rastogi, 2005). Contrast and luminosity enhancement are important, however, it is a very challenging task and is impossible to construct a perfect mathematical model especially for extreme illumination (J. Liu et al., 2014). Usually, the researcher proposed approaches to eliminate uneven illumination in an image (Gonzalez & Woods, 2008; J. Liu et al., 2014; Yi, Mao, Chen, & Rovetta, 2016). However, the proposed methods are unsuccessful if the images have both luminosity and contrast problems.

Many researchers suggest a filtering based method in order to eliminate uneven illumination such as Homomorphic filtering (HF) (Delac, Grgic, & Kos, 2006; C. N. Fan & Zhang, 2011; Shahamat & Pouyan, 2014). The main function of Homomorphic filtering is used to eliminate uneven illumination, compress dynamic range, and enhance contrast, thereby strengthening the high frequency and weakening the low frequency by separating the reflection components. However, this filter has two drawbacks: it does not provide an indication of the cut-off frequency and introduces other illumination artefacts

on the edges of the foreground (Ardizzone, Pirrone, & Gambino, 2006; Grigoryan, Dougherty, & Agaian, 2016).

Another familiar method of contrast enhancement is the Histogram Equalization (HE). This technique is popular because it is easy to implement and fast processing (Garg, Mittal, & Garg, 2011; Sengee, Sengee, & Choi, 2010; K. Singh & Kapoor, 2014). However, this technique produces many drawbacks such as it adds noise to the output image, increasing the contrast of its background and the signal gets distorted (Longkumer, Kumar, & Saxena, 2014). The HE may produce over enhancement result and saturation artefacts due to the stretching of the grey levels over the full grey level range. In addition, many types of HE are based on the global technique. However, these global processing techniques are found to be insufficient to overcome variations due to illumination changes (Carneiro & Cámara-Chávez, 2012; Y. Li, Liu, & Gao, 2014; Virendra P Vishwakarma, Pandey, & Gupta, 2009).

In the recent decades, Fourier Transform (Discrete Cosine Transforms (DCT) & Discrete Wavelet Transforms (DWT)) has been one of the major interesting research to enhance the images (Fu, Wang, Zeng, Huang, & Ding, 2015; Rubel et al., 2016). The methods can analyse an image in multi-resolution and detect small fluctuations at the multi-levels, they are a good technique for contrast enhancement. However, the approaches based on DWT show a slow processing time and complex implementation (A. Kaur & Kaur, 2012; Parmar, 2014; Ramaraj & Raghavan, 2011). In addition, the DWT has a problem to deal with higher noise and badly non-uniform image. Besides, the DCT has a high computational cost and complicated in term of selecting suitable transfer functions or parameters (J. Liu et al., 2014). A serious drawback of this Fourier transform approach is the algorithm does not perform perfectly to enhance the image in an extreme illumination and has a problem to deal with the high noise level.

Based on the literature, many enhancement methods have been developed in the last few decades for specific types of images and applications but there is no single method applicable to solve the contrast variation and luminosity at the same time. This was the motivation behind the present study. According to the previous research, the main limitation is to find a separating point to differentiate between the bright and the dark area before applying the contrast enhancement method. Second, the main problem when considering the filtering method (such as homomorphic filtering) is the cut-off value. According to the literature, the researchers obtained the cut-off and other parameters by manual testing (C.-N. Fan & Zhang, 2011; Shahamat & Pouyan, 2014). The value of the parameter is not efficient and accurate for all types of non-uniform original images.

Although, a lot of review investigation concentrated on the contrast enhancement, to the best of author knowledge and many references in the literature systematically describe the effect of contrast variation before the segmentation process (Bakhshali, Shamsi, & Golzarfar, 2011; Bakhshali, 2016; L. C. Chen, Chien, & Nguyen, 2013; Dhinagar & Celenk, 2012; Schaefer, Rajab, Emre Celebi, & Iyatomi, 2011; Youssif, Ghalwash, & Ghoneim, 2006). In the segmentation process, the contrast and illumination effect are important to be considered since the non-uniform contrast images will reduce the effectiveness of the segmentation result. According to the study by (Ikhsan, Hussain, Zulkifley, Tahir, & Mustapha, 2014), the uneven illumination and contrast variability throughout the image significantly affect the vertebral bone segmentation process. The paper presented a comprehensive review of three contrast enhancement techniques, namely histogram equalization (HE), gamma correction (GC), contrast limited adaptive histogram equalization (CLAHE) and the effect on the segmentation performance. Research finding by (Schaefer et al., 2011) also points towards the effect of non-uniform skin images on the segmentation accuracy. Similarly,

a low-contrast is important to be solved before applying the segmentation process. The enhancement methods were proposed in order to normalize the low contrast effect and automatically improved the image quality (L. C. Chen et al., 2013; Sharif, Mohsin, Jamal, et al., 2010; Sharif, Mohsin, & Raza, 2010; Zhoa et al., 2015).

In conclusion, an automatic computer-based screening and detection systems are difficult to analyse images with large luminosity and contrast variation problem. Based on the literature, many different properties of various image processing techniques were proposed. Each method has its own speciality compared to other methods in terms of capability, performance, robustness, computation load, and algorithm complexity. Thus, it is impossible to investigate all different image processing techniques in order to develop a new enhancement method. In this study, a few literatures gave a strong motivation in order to propose a new enhancement method are;

1. A good contrast enhancement should consider both global and local information (Hasikin & Mat Isa, 2012; S. Zhou, Wang, Zhang, Liang, & Gong, 2016).
2. Contrast and luminosity enhancement are important, however, it is a very challenging task and is impossible to construct a perfect mathematical model especially for badly illumination (J. Liu et al., 2014).
3. The luminosity and the contrast problem contributed a high effect on the segmentation performance (Bakhshali, 2016; Dhinagar & Celenk, 2012; Schaefer et al., 2011).
4. Mean value can represent the luminosity and standard deviation can represent contrast variation (Foracchia, Grisan, & Ruggeri, 2005).

1.3 Objective

According to the literature review, it can be concluded that the objective of image enhancement is to improve the image quality for analyses, especially for segmentation stage. This study is dedicated to develop an innovative image enhancement technique, especially for contrast and luminosity normalization to improve the visibility of low-quality digital images caused by various reasons such as high dynamic range scene irradiance, poor contrast due to the very narrow dynamic range of the captured scene, very low illumination (low light conditions), non-uniform illumination or the spectral characteristics of the illumination, and the limited resolution of the imaging devices. In summary, the objectives are;

1. To develop a direct enhancement method using the statistical information.

This method based on the statistical information such as mean, variance and standard deviation. The target is to solve the luminosity and contrast problem on the non-uniform image.

2. To evaluate the efficiency of the proposed method in non-uniform dataset images.

In order to prove the effectiveness of proposed method, two datasets were applied which are document images and weld defect images. A few image quality assessments such as Signal Noise Ratio (SNR), Peak Signal Noise Ratio (PSNR) and Global Contrast Factor (GCF) were utilized.

3. To demonstrate the performance of the enhanced image on the segmentation stage.

Based on the literature, the enhancement process will influence the result of the segmentation. In this study, a few suitable segmentation such as Otsu method, Niblack

method and Bernsen method were selected in order to apply on the proposed image. The increment performance between the original image and proposed image was obtained.

1.4 Scope

The scope of this study is to normalize the contrast and luminosity effect in the non-uniform images. The proposed method was constructed based on the statistical information. The pixels in the original image were classified into three groups; foreground, border, and problematic region. The problematic intensity was enhanced using the proposed algorithm, meanwhile intensity for the other regions was remained unchanged. The proposed method was tested on non-uniform images such as document images and weld defect images. The document images were obtained from the online database while weld defect images is a real application provided by the Malaysia Nuclear Agency. A few quality assessment techniques were utilized in order to prove the effectiveness such as Signal Noise Ratio (SNR), F-measure, and Average Mean Brightness Error (AMBE). Then, the result of the experiments in term of normalization and segmentation was compared to the other methods.

1.5 Thesis Outline

Chapter 2: A literature review of common approaches for image enhancement is presented. This is followed by a discussion on some image quality assessment techniques. This chapter intends to give some review to the readers about the scope of research that has been conducted.

Chapter 3: Discuss details of the new direct enhancement method are given. The steps used to construct the enhancement process and perform the segmentation are elaborated. The experimental results of the enhanced images using the proposed method are also presented. This chapter also will explain the quality assessment method and performance to be achieved in this project.

Chapter 4: This stage presents the results obtained and discussion of the findings, mainly focusing on normalization and segmentation. Also, it presents a case study where the proposed method is used. Two sets of databases are utilized to test the efficiency of the method, namely the document image and weld defect images. The ability of the proposed method to enhance the image and improve the segmentation is compared to the other approaches. The performance of the results was verified by quality assessment such as Signal Noise Ratio (SNR), Signal Noise Ratio (PSNR), F-measure, and Misclassification Error (ME).

Chapter 5: This chapter provides the conclusion of the present work by highlighting the achievement, objectives and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Image enhancement can be considered as one of the fundamental processes in image analyses. The goal of contrast enhancement is to improve the quality of an image to become more suitable for a particular application. Till today, numerous image enhancement methods have been proposed for various applications and efforts have been directed to further increase the quality of the enhancement results and minimize the computational complexity and memory usage. In this chapter, an overview of the main categories of image enhancement methods is presented. Samples of methods belonging to each category are introduced and elaborated. Then the focus to quality image assessment and segmentation methods.

2.2 Enhancement Category

Contrast enhancement is one of the most important issues in image processing and analyses. The commonly used techniques for contrast enhancement fall into two categories: (1) direct method and (2) indirect method. Besides, the contrast can be measured globally and locally. A good contrast enhancement should consider both global and local information. It should be noted however that there are many methods that cannot be assigned to one of the two categories since they utilized a combination of steps associated