UNIVERSITI PUTRA MALAYSIA

ENHANCEMENT OF OVER-EXPOSED AND UNDER-EXPOSED IMAGES USING HYBRID GAMMA ERROR CORRECTION SIGMOID FUNCTION

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By

MOHD AZRIN BIN MOHD AZAU

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

July 2007

For my mother Puan Mahanom Bt Talip
and my late father Mohd Azau B. Abd Aziz
whose soul lives within me

For my sisters and youngest brother.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: **Associate Professor Ishak bin Aris, PhD**

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The demands to improve the visibility quality of the captured images in extremes lighting conditions have emerged increasingly important in digital image processing. The extremes conditions are when there is lack of reasonable lightings termed as underexposed and too much of light termed as overexposed. The popular enhancement technique currently used is the contrast enhancement through contrast stretching, histogram equalization, homomorphic filtering and contrast adjustment. The adjustments are to transform the less useful images to more meaningful images when the post image processing operations are carried out. This thesis is motivated to deal with the problems concerning image capturing in these two extremes conditions.

The sigmoid function is used to adjust the contrast with two controlling parameters. The parameters adjust the contrast locally and globally. The gamma function is commonly used to correct the non-linear error in the images due to the camera

lenses. This thesis combines the functions' properties and developed a hybrid algorithm to improve the quality of the poorly captured images by adjusting the contrast and compensating the gamma error. The sigmoid and gamma function are coded in MATLAB 6.0 in which testes are made over the selected images. The sample images are taken using different type of cameras transformed to grayscaled input images. The luminosities of the surroundings are also measured using a light meter.

The derivations of the parameters' ranges are done by calculating the root mean square error or the standard deviation. The suggested ranges are used in the hybrid system which has two variants, Variant I and Variant II. The first variant, combines the sigmoid function inside the gamma compensation function while the second variant combines the gamma compensation function inside the sigmoid function.

Based on the test results, the proposed algorithm significantly improves the contrast of the images. For the underexposed image samples, the percentages of the intensity lesser than 0.1 decreases as more of the intensities reside at higher values. For the overexposed image samples, the percentages of intensity greater than 0.9 decreases as more of the intensities reside at lower values. With the suggested range deduced, the images are contrast enhanced with the reduction of percentage of pixels residing he intensity less than 0.1 and greater than 0.9.

The comparative analyses are made by comparing the suggested hybrid system with the existing adaptive homomorphic filtering, adaptive histogram equalization and adaptive contrast enhancement.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGUKUHAN IMEJ DEDAHAN-RENDAH DAN DEDAHAN-LAMPAU MENGGUNAKAN FUNGSI TERGABUNG PEMBETULAN RALAT GAMMA SIGMOID

Oleh

MOHD AZRIN BIN MOHD AZAU

Julai 2007

Pengerusi : **Professor Madya Ishak bin Aris, PhD**

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Permintaan untuk menambah baik kualiti penglihatan imej yang ditangkap pada keadaan yang ekstrim telah muncul dan mendapat tempat dalam pemprosesan imej digital. Keadaan ekstrim yang dimaksudkan ialah apabila suatu keadaan persekitaran yang kurang pencahayaan iaitu yang dikenali sebagai dedahan-rendah dan keadaan yang dilimpahi lebihan cahaya yang dikenali sebagai dedahan-lampau. Tenik pengukuhan imej yang terkenal sedang digunakan sekarang ialah melalui pengukuhan kontras yang mana pengukuhan itu dilakukan melalui regangan kontras, penyamaan histogram, penapisan homomorfik dan ubahan kontras. Kaedah-kaedah pengukuhan ini adalah penting supaya informasi yang gagal dikesan oleh mata kasar seseorang pemerhati dapat dikukuhkan dan diubah. Transformasi ini adalah untuk mengubah imej-imej yang kurang berguna akibat infromasi terlindung, menjadi imej-imej yang lebih bererti supaya pasca-pemprosesan imej dapat dilakukan dengan lebih

baik. Tesis ini digerakan melalui motivasi untuk mengatasi masalah mengambil gambar di dalam keadaan ekstrim yang disebutkan.

Fungsi matematik sigmoid digunakan untuk ubahan kontras dengan dua parameter yang mengawal. Parameter tersebut akan digunakan untuk ubahan kontras secara setempat dan secara keseluruhan. Fungsi gamma pula terkenal digunakan dalam membetulkan ralat tidak linear akibat lensa kemera. Tesis ini menggabungkan sifat-sifat fungsi yang disebutkan dan algoritma tergabung dibangunkan untuk memperbaiki kualiti imej yang kurang bagus. Fungsi sigmoid serta gamma yang digabungkan dikodkan menggunakan MATLAB 6.0 dan simulasi dijalankan ke atas imej-imej yang terpilih. Imej imej tersebut ditangkap menggunakan kemera yang berlainan dan diubah kepada imej masukan skala-kelabu. Kecerahan sekitaran diukur menggunakan meter cahaya.

Terbitan had parameter-parameter yang mengawal fungsi matematik ini dicadangkan berdasarkan kepada pengiraan punca purata kuasa dua ralat atau sisihan piawai. Had yang dicadangkan akan digunakan dalam sistem tergabung yang mempunyai dua varian, Varian I dan Varian II. Kombinasi pertama menggabungkan fungsi sigmoid ke dalam fungsi kompensasi gamma dan kombinasi kedua menggabungkan fungsi kompensasi gamma ke dalam fungsi sigmoid.

Dari keputusan ujikaji, algoritma tergabung yang dicadangkan menambah baik kontras imej dengan lebih ketara. Untuk imej dedahan-rendah, peratusan kecerahan kurang dari 0.1 berkurangan kerana lebih banyak mendiami di nilai yang tinggi. Untul imej dedahan-lampau, peratusan intensiti yang melebihi 0.9 berkurangan

kerana lebih banyak mendiami di kawasan yang mempunyai nilai yang lebih rendah. Dengan had yang dicadangkan, kontras imej ini dikukuhkan dengan pengurangan peratusan piksel yang mendiami nilaian kurang dari 0.1 dan yang melebihi 0.9.

Proses bagi penanda aras dibuat dengan membandingkan sistem tergabung yang dicadangkan oleh tesis ini dengan sistem adaptif penapisan homomorphic, sistem adaptif penyamaan histogram dan sistem adaptif pengukuhan kontras.

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I certify that an Examination Committee has met on 12 July 2007 to conduct the final examination of Mohd Azrin Bin Mohd Azau on his Master of Science thesis entitled "Enhancement of Over-Exposed and Under-Exposed Images Using Hybrid Gamma Error Correction Sigmoid Function" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.

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Date: 13 December 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM other institutions.

MOHD AZRIN BIN MOHD AZAU

Date: 19 October 2007

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LIST OF ABBREVIATIONS

Symbols

`Ig`	grayscaled image intensity
`Igd`	grayscaled and doubled image intensity
`Ice`	contrast enhanced image intensity
`Igc`	gamma compensated image intensity
`Igs`	gamma-hybrid-sigmoid intensity
`Isg`	sigmoid-hybrid-gamma intensity
`G`	gain
`Co`	cutoff
Appdx	Appendix
RMSE	Root Mean Square Error
UM	Unsharp Masking

CHAPTER 1

INTRODUCTION

1.1 Background

The demands to improve the quality of the captured images with the absence of reasonable lighting (underexposed) and with the presence of overwhelming lighting (overexposed) have motivated many researchers to develop enhancement techniques using contrast adjustment and gamma compensation. Capturing images in these two extreme conditions somehow are at disadvantages since the quality are degraded. Some of the information are failed to be identified and recognized by one's eyes and thus these images are laterally meaningless.

Wu has highlighted the importance of image enhancement in biomedical pattern recognition (Wu, 2002). The studies of image processing's impact in biomedical are made on the chromosome classification. From the results obtained, with a proper image enhancement technique, it will lead to significantly improved recognition accuracy. The quantification of performance improvement could be used as a mean to measure the success of the various technique implementations.

With the availability and affordability of imaging technology, there are interests to develop more robust, faster and reliability system in medical imaging applications, monitoring and surveillance systems, driving assistance and lane/pedestrian

detections, (Frosio, 2006), (Wong, 2005), (Stern, 2001). There are issues in processing the poor digital images that fall in the category of underexposed and overexposed. The major concerns are to deliver out the details that the images have. With regards to this issue there are also concerns to develop algorithms to counter the problem to name a few are, the contrast adjustment, gamma compensation, noise suppression, filtering development and image restoration. Image preprocessing processes the images before they become meaningful images to the viewers with the details are made visible. Methodology is drawn from the fundamental studies and approaches are realized with the tool. The system or algorithm developed is simulated with various conditions to test its reliability, efficiency and correctness. Having that done, the system is embedded onto applications of interest.

The 2-D images are not merely lines, shapes and colors; instead they can be translated to matrices and mathematically represented. If an image is of size $M \times N$, and the pixel intensity is mapped on the Cartesian coordinate, then f is the vector function where f(x,y) indicates the brightness of an image has. x and y is the point at the corresponding intensity, (Petrou, 2002), (Davies, 2005). Transforming the images into matrices the options of operations could be expanded to adjust, enhance and correct the input images. This can be done by applying the arithmetic and logical mathematics operators. Literally, an image enhancement is a process by which improvement of the details of an image has, so that it is subjectively looks better.

A conventional simple gray-scale image processing technique is illustrated as in the block diagram shown in Figure 1.1. The emergence of color image processing has

getting a place in the research field. However two main important factors that have become the principle in deciding to go for color image processing or gray-scale are,

a) the fundamental value of color image processing
b) additional storage and processing penalty it might bring,

(Davies, 2005)

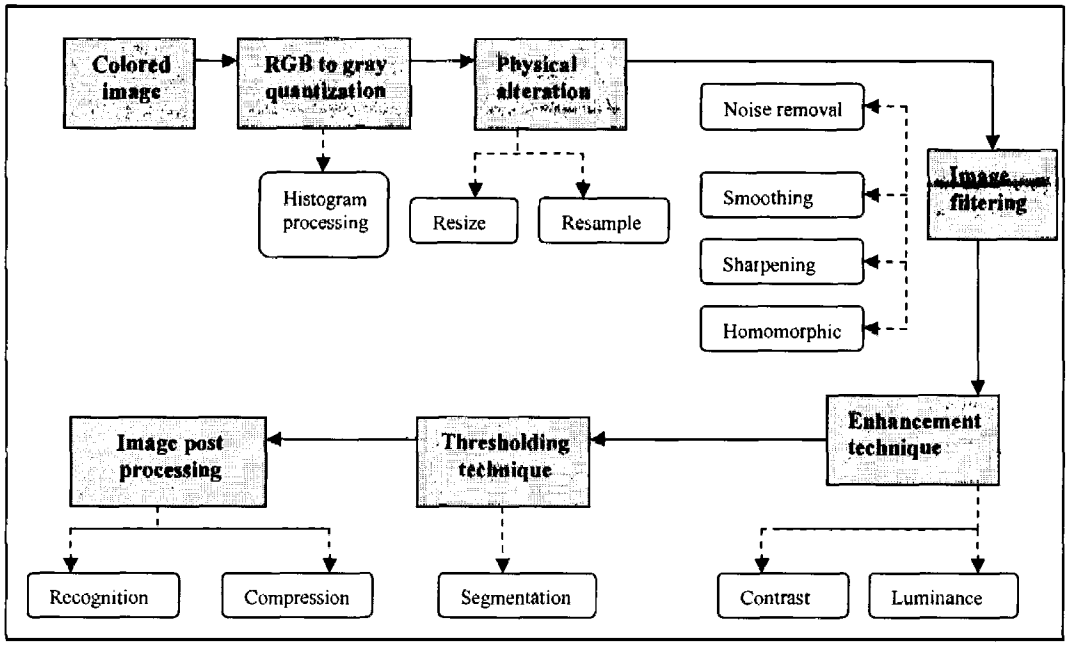

Figure 1.1: Simple image processing technique

Humans' sight ranges are limited by the fact of the existence of cones and rods in the retina. These cones and rods are receptors in which the cones dominantly functional over the rods. With well-held vision theory, these rods are for vision under dim levels of illumination (scotopic vision) and cones are functioning at higher illumination level (photopic vision). Photopic vision provides the capability for

seeing color and resolving fine details (20/20 of better) but it functions only in good illumination. Scotopic vision is of poorer quality in which it is limited by reduced resolution (20/200 or less) and offers the ability to discriminate only between shades of black and white. Therefore in many night vision applications colors has become a secondary argument, since decreases in illumination will result loss in color vision where the blue-green lights will appear brighter whereas the reds will appear dimmer (Umbaugh, 1998).

1.2 Image Enhancements For Underexposed and Overexposed Images

Observations to the nature of the nocturnal animals have motivated man to start developing electronic gadgets to counter balance the lacking capabilities of seeing in the dark. The researches conducted are to produce night-vision goggles and cameras that to intensify the visibility and the quality of the sight as well as the images captured. These night-vision cameras are specifically equipped with pre-filtering hardware mounted on them and the systems themselves are complicated for individuals to operate. The initial set up cost sometimes is unbearable even for simple application like home security monitoring system. However, instead of having these bulky, expensive specially made gadgets, the development of robust algorithm to enhance the captured images is one of the solutions. One way to potentially realize the development of these algorithms is, by using the mathematical functions (Rumar, 2002).