



UNIVERSITI PUTRA MALAYSIA

**AUTOMATIC ESTIMATION OF NOISE TO SIGNAL POWERSPECTRUM
RATIO IN WIENER FILTERING TECHNIQUE FOR COMPUTED
TOMOGRAPHY IMAGES**

MOHAMAD NAEEM BIN HUSSIEN

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By

MOHAMAD NAEEM BIN HUSSIEN

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

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To my late mother



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

AUTOMATIC ESTIMATION OF NOISE TO SIGNAL POWERSPECTRUM RATIO (NSR) IN WIENER FILTERING TECHNIQUE FOR COMPUTED TOMOGRAPHY IMAGES

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November 2013

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One of the most common medical imaging modalities used in examining internal structure of human body nowadays is Computed Tomography (CT). The main concept of CT imaging is to produce cross sectional images of interior anatomical structure inside the body. Furthermore CT image is very useful in determining the extent of bone destruction and it is also an essential tool in evaluating the severity of diseases especially around specific location of the body. In various applications particularly medical imaging, degradation process normally occurred due to noise and degradation phenomena. The degradation phenomena, also known as Point Spread Function (PSF) may be caused by several factors, for instance, from out-of-focus blur, 2D Gaussian Blur, turbulence blur, motion blur and electronic noises.

In practice, image restoration is a process that tries to recover or reconstruct a degraded image by applying knowledge that causes the degradation phenomenon. Prior knowledge of the degradation phenomenon and inverse filter must be obtained or estimated in order to restore back the image. Therefore restoration method is concerned toward mathematically modelling the degradation PSF and applying the inverse process to recover the undegraded image.

In this research, the best possible restoration technique for CT image is presented. The whole research is concerned about Wiener filter and its parameters, which are power spectrum of noise and signal, PSF and noise to signal ratio (NSR). The main objective of this study is to offer a method which is able to approximate a desirable value of noise to signal power spectrum ratio (NSR) via frequency domain where it will be applied into the Wiener filter equation. Another parameter of Wiener filter that has been considerate is PSF in which three typical types of PSF are compared. Furthermore an analytical comparison had been done regarding the competence of specific PSF in

restoring these particular CT images. All those procedures utilized the information of the CT image itself. Quality of CT images are measured by using two types of mathematical evaluation assessments, which are Blur Metric and Blind Image Quality Assessment through Anisotropy (BIQAA). Therefore, a standard value of good quality image can be define in terms of blur and contrast.

Ultimately the proposed method provided an automatic estimation for NSR value compared to the previously or commonly technique. The previously or typically method in obtaining the value of NSR usually by treating the value as constant and further proceed with utilize try and error method. The iteration process will halt when it achieved the conditions where the CT image was assumed as better in quality and visualization. The process was manually done, inconvenient and hassle.

The proposed technique automatically provide the NSR value without required any external information. The novelty of the research is the proposed method will utilize the information gathered from the image itself and automatically generate the desirable value of NSR. The proposed method was tested with sixty random CT images and all the images provide significant enhanced image in term of quality of visualization.

Generally, the method proposed yields a promising result on restoring CT image. However, the result is still depending on the complexity of the CT image with various organ structure, whether it consists of either complex or plain structure anatomy. The formed result of the image restoration will be less significantly visible if less anatomy structures emerged out of the CT image. Finally, based on values presented by both quality assessments, it can be concluded that the proposed restoration technique manage to yield CT image with better quality of visualization compared to the original CT image yielded by the CT scan machine. Furthermore still be able to maintain most of the elements inside the CT image.

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

**ANGGARAN AUTOMATIK NISBAH SPEKTRUM KUASA HINGAR
KEPADA SPEKTRUM KUASA ISYARAT DALAM TURAS WIENER UNTUK
IMEJ - IMEJ TOMOGRAFI BERKOMPUTER**

Oleh

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Salah satu daripada teknik-teknik pengimejan perubatan yang paling popular digunakan dalam memeriksa struktur dalaman badan manusia pada masa ini adalah Tomografi Berkomputer (CT). Konsep asas pengimejan CT ialah untuk menghasilkan imej-imej keratan lintang organ-organ dan juga tisu-tisu tubuh badan. Tambahan pula imej CT sangat berguna untuk menentukan takat kerosakan tulang dan amat penting dalam menilai takat penyakit pada kawasan sekitar tisu lembut. Dalam banyak aplikasi terutamanya pengimejan perubatan, proses degradasi lazimnya berlaku disebabkan oleh hingar dan fenomena degradasi. Fenomena degradasi yang juga dikenali sebagai fungsi titik rebak (PSF), boleh disebabkan oleh beberapa faktor seperti daripada kekaburan gerakan, kekaburan turbulensi atmosfera, kekaburan tidak fokus dan hingar elektronik.

Pada praktikalnya, pemulihan imej ialah satu proses yang cuba untuk membina semula atau memulihkan degradasi imej dengan menggunakan informasi yang menyebabkan fenomena degradasi. Untuk memulihkan semula kembali imej, informasi mengenai fenomena degradasi dan turas songsang mestilah diperolehi atau dianggar. Oleh itu teknik-teknik pemulihan diorientasikan secara matematik untuk menganggarkan jenis degradasi PSF dan mengaplikasikan bersama-sama proses turas songsang untuk memulihkan semula imej asal.

Dalam penyelidikan ini, satu teknik pemulihan yang sesuai untuk imej-imej CT telah dibentangkan. Keseluruhan penyelidikan ini adalah berkenaan tentang turas Wiener dan parameternya seperti spektrum kuasa isyarat dan spektrum kuasa hingar, PSF dan nisbah isyarat-hingar (NSR). Objektif utama penyelidikan ini adalah untuk menyediakan satu kaedah penganggaran spektrum kuasa yang sesuai untuk isyarat hingar dan isyarat imej CT terdegradasi melalui domain frekuensi. Kedua-dua spektrum kuasa akan digunakan sebagai NSR dalam persamaan turas Wiener. Satu

lagi parameter turas Wiener yang dipertimbangkan ialah PSF, beberapa jenis-jenis PSF dibandingkan, oleh itu satu perbandingan analisis dapat dibuat mengenai kecekapan PSF khususnya dalam memulihkan imej-imej CT ini. Semua prosedur-prosedur itu menggunakan maklumat asal daripada imej CT. Kualiti imej-imej CT akan diukur menggunakan dua jenis taksiran penilaian matematik iaitu teknik Metrik Kabur dan Penilaian Buta Kualiti Imej melalui Tak Isotropi (BIQAA), oleh itu satu nilai standard imej berkualiti baik boleh ditakrifkan dari segi kekaburan dan kontras.

Pada dasarnya, teknik yang dicadangkan akan menyediakan satu penganggaran automatik untuk nilai NSR berbanding teknik – teknik kebiasaan dan sebelum ini. Teknik kebiasaan dan sebelum ini mendapat nilai NSR biasanya dengan menganggap nilai tersebut sebagai malar dan kemudiannya di teruskan dengan menggunakan kaedah cuba gagal. Proses yang berulang – ulang itu akan terhenti apabila ia mencapai keadaan di mana imej CT telah dianggap sebagai lebih baik dari segi kualiti dan penggambaran. Teknik tersebut dijalankan secara manual, tidak sesuai dan sukar.

Teknik yang dicadangkan, secara automatik akan memberikan nilai NSR tanpa memerlukan sebarang maklumat luar. Sesuatu yang baru tentang kajian ini ialah kaedah yang dicadangkan mampu untuk menghasilkan nilai NSR yang di ingini secara automatik dengan menggunakan maklumat daripada imej itu sendiri. Kaedah ini telah diuji kepada 60 imej CT yang dipilih secara rawak dan secara keseluruhannya kesemua imej tersebut telah menunjukkan peningkatan ketara dari segi kualiti penggambaran.

Pada umumnya, teknik yang dicadangkan telah menghasilkan satu keputusan yang baik dalam memulihkan imej CT. Bagaimanapun ia bergantung kepada kerumitan imej CT dengan berbagai – bagai struktur organ, sama ada ia mengandungi organ-organ kompleks atau organ-organ ringkas. Perubahan hasil pemulihan imej akan kelihatan kurang ketara jika kekurangan organ-organ kompleks terletak di dalam imej CT. Akhir sekali, berdasarkan kepada nilai-nilai yang ditunjukkan oleh kedua-dua penilaian kualiti, ia boleh dirumuskan bahawa teknik pemulihan yang dicadangkan berjaya menghasilkan imej CT dengan kualiti yang lebih baik dan jelas berbanding dengan imej CT asal yang dihasilkan oleh mesin imbas CT. Tambahan ia masih dapat mengekalkan kebanyakan elemen - elemen asal di dalam imej.

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I certify that a Thesis Examination Committee has met on **18 November 2013** to conduct the final examination of Mohamad Naeem Bin Hussien on his thesis entitled “**Automatic estimation of noise to signal powerspectrum ratio (NSR) in Wiener filtering technique for Computed Tomography images**” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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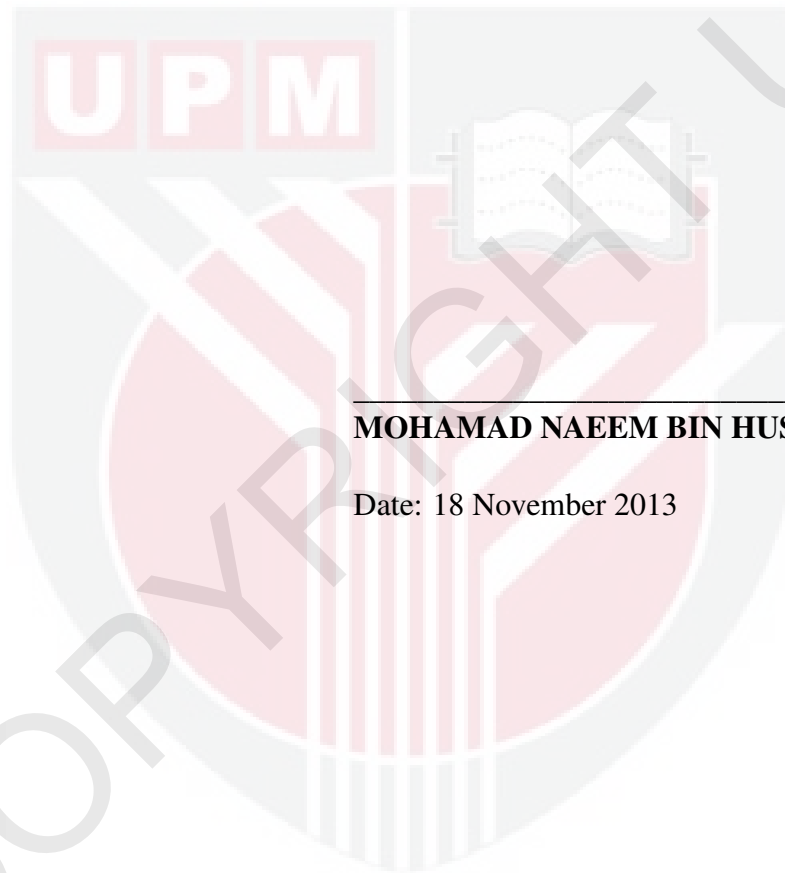
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DECLARATION

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



MOHAMAD NAEEM BIN HUSSIEN

Date: 18 November 2013

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