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ENHANCING ULTRASOUND IMAGES FOR BETTER INTERPRETATION OF BREAST CANCER

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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FARZAN KHATIB

September 2012

Chair: Prof. Rozi Mahmud, PhD

Faculty: Medicine and Health Sciences

This work was carried out with the aim to help radiologists in ultrasonography in diagnosing breast diseases. In particular, the study was done to improve their efficiency in interpreting results. As the work concerns with identifying breast disease, the focus is on B-Mode ultrasound that is suitable for breast. Thus, to improve the interpretation of results, a multi-purpose multi-tissue breast phantom is used to capture all the combinations of possible functions in the B-Mode.

In the first step, ultrasound images were captured using a Quality multi tissue equivalent Breast Phantom that contains all the needed specifications. All the possibilities for grey scale images were used on some ultrasound machines. In order to check the quality of image, a variety of transducers were used with different frequency responses and the same frequency setting. This work focused on two lesion

types, namely, Cyst and Solid, besides other specifications of Phantom.

A review of previous research on breast disease has shown that most of them have been done on modalities other than ultrasound, specifically on mammography and digital mammography. Although some work has been done on ultrasound, these are rather limited to very special cases in kidney and abdomen.

In order to enhance ultrasound breast image, image factors such as Signal to Noise Ratio (SNR) and Receiver Operating Characteristic (ROC) analysis like sensitivity, specificity, and accuracy were used. Meanwhile, classification of the masses was done based on the features that were extracted from two types of images, namely, phantom images and real human breast images. Then, the proposed designed was applied to all the images and the output data (benign or chance of malignancy) were gathered. After classifying the masses, a set of samples was selected to make the required tests for the current work, such as the ROC analysis.

As breast disease is one of the deadliest reasons for death among women in most societies, the aim of the present work was on aiding the radiologists in checking and detecting some of these abnormalities. Findings showed an improved sensitivity of 99% and an enhanced accuracy of 98% for Ultrasound Phantom images. Evaluation of results for breast Ultrasound images also gave 98.5%

for sensitivity and 98.2% for accuracy. So a powerful and reliable Computer Assisted Detection framework was introduced. In addition to these results, a full machine performance evaluation was done based on the findings of the proposed routines. Finally, regarding to this thesis findings, Ultrasound can be a good screening modality as the first row image modality in breast imaging.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENINGKATAN IMEJ ULTRA BUNYI UNTUK MENINGKATKAN KESAN INTERPRETASI KANSER PAYUDARA

Oleh

FARZAN KHATIB

September 2012

Pengerusi : Prof. Rozi Mahmud, PhD

Fakulti : Perubatan Dan Sains Kesihatan

Kajian ini dijalankan bertujuan untuk membantu ahli radiologi melaksanakan ujian ultrasonografi dalam mengenal pasti penyakit payudara. Secara khususnya, kajian ini dijalankan bagi meningkatkan kecekapan instrumen dalam mentafsirkan keputusan ujian. Oleh kerana kajian ini berhubung kait dengan kaedah bagi mengenalpasti penyakit payudara, fokus utama adalah kepada ultrabunyi Mod B yang sesuai untuk payudara. Justeru, bagi meningkatkan tafsiran keputusan ujian, tisu pelbagai payudara *phantom* pelbagai guna digunakan untuk mencerap semua kebarangkalian kombinasi fungsi dalam Mod B.

Sebagai langkah permulaan, imej ultrabunyi dirakam menggunakan tisu pelbagai payudara *Phantom* berkualiti yang mengandungi semua

spesifikasi diperlukan. Segala kebarangkalian kepada imej berskala kelabu digunakan ke atas beberapa mesin ultrabunyi. Bagi memeriksa kualiti imej, pelbagai transduser digunakan dengan tindak balas frekuensi yang berbeza dan penetapan frekuensi yang sama. Kajian ini memberi tumpuan kepada dua jenis lesi iaitu Sista dan Pepejal di samping spesifikasi *Phantom* yang lain.

Kajian terhadap penyelidikan mengenai penyakit payudara sebelum ini menunjukkan bahawa sebahagian besar daripada kajian tersebut telah dilakukan ke atas kaedah selain daripada ultrabunyi, khususnya ke atas mamografi dan mamografi digital. Walaupun beberapa kajian telah dilakukan ke atas ultrabunyi, ia agak terhad kepada kes-kes terpilih di dalam buah pinggang, perut dan payudara.

Dalam usaha untuk meningkatkan imej ultrabunyi payudara, faktor imej analisis Isyarat kepada Nisbah Bunyi (SNR) dan Penerima Operasi Ciri-ciri (ROC) seperti sensitiviti, pengkhususan dan ketepatan digunakan. Sementara itu, klasifikasi jisim dibuat berdasarkan ciri-ciri yang telah diekstrak daripada dua jenis imej iaitu imej *Phantom* dan imej payudara. Kemudiannya, satu reka bentuk cadangan digunakan kepada semua imej dan data output (benigna atau kehadiran malignansi) yang dikumpulkan. Setelah klasifikasi jisim dibuat, satu set sampel dipilih untuk dibuat ujian yang diperlukan dalam kajian semasa seperti analisis ROC.

Oleh kerana penyakit payudara adalah salah satu penyebab utama kematian di kalangan wanita dalam kebanyakan masyarakat, kajian ini dijalankan dengan tujuan utama untuk membantu pakar radiologi dalam memeriksa dan mengesan sebarang keadaan abnormal yang wujud. Dapatan kajian menunjukan peningkatan sensitiviti sebanyak 99% dan juga peningkatan ketepatan sebanyak 98% bagi imej-imej ultrasound phantom. Penilaian terhadap keputusan imej-imej ultrasound juga memberi peningkatan sebanyak 98% bagi sensitiviti dan 98.2% bagi ketepatan. Oleh itu, satu rangka pengesanan menggunakan komputer telah diperkenalkan. Selain daripada dapatan kajian tersebut, satu penilaian mesin sepenuhnya juga telah dilakukan berdasarkan hasil kajian dari rutin yang dicadangkan. Berdasarkan dapatan kajian ini, ultrasound boleh menjadi satu pengimejan modaliti dan juga sebagai pengimejan modaliti utama di dalam pengimejan payudara.

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I certify that a Thesis Examination Committee has met on 11 September 2012 to conduct the final examination of Farzan Khatib on his thesis entitled " **ENHANCING ULTRASOUND IMAGES FOR BETTER INTERPRETATION OF BREAST CANCER** " in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universit Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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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 institution.

FARZAN KHATIB

Date:

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LIST OF ABBREVIATIONS

3D	Three Dimensional
AED	Automatic Exposure Control
AUC	Area Under Curve
BCDDP	Breast Cancer Detection and Demonstration
BMP	Bit Map
BP	Band Pass
BSE	Breast Self Examination
BSGI	Breast Specific Gamma Imaging
BUS	Breast Ultrasound
CAD	Computer Aided Detection
CADG	Computer Aided Diagnosis
CE	Computer Enhancement
CT	Computed Tomography
DCIS	Ductal Carcinoma In Situ
DICOM	Digital Imaging and Communications in Medicine
DPI	Dot Per Inch
DTHI	Differential Tissue Harmony
EFV	Extended Field of View
FCD	Fibrocystic Disease
FIR	Finite duration Impulse Response
FP	False Positive
FTI	Fatty Tissue Imaging

GEN	General
GIF	Graphic Interchange Format
HC	High Contrast
HF	High Frequency
HFP	High Frequency Probe
HP	High Pass
HRT	Hormone Replacement Therapy
HVC	Human Vision Characteristic
IDC	Infiltrating Ductal Carcinoma
IIR	Infinite duration Impulse Response
ILC	Infiltrating Lobular Carcinoma
IR	Infra Red
JPEG	Joint Photographic Experts Group
LC	Low Contrast
LCIS	Lobular Carcinoma In Situ
LF	Low Frequency
LFP	Low Frequency Probe
LP	Low Pass
LUT	Look Up Table
MATLAB	Matrix Laboratory
MC	Medium Contrast
MD	Medical Doctor
MRI	Magnetic Resonance Imaging
MSE	Mean Square Error

NEMA	National Electrical Manufacturers Association
PEN	Penetration
PNG	Portable Network Graphics
PSNR	Peak Signal to Noise Ratio
PSTHI	Pulse Subtraction Tissue Harmony Imaging
PWD	Pulse Wave Doppler
RAW	Raw Image Format
RES	Resolution
ROC	Receiver Operating Characteristic
ROI	Region Of Interest
SF	Subcutaneous Fat
SID	Source to Image Distance
SNR	Signal to Noise Ratio
SRI	Speckle Reduction Imaging
TIF	Tagged Image File Format
US	Ultrasound
VE	Virtual Environment

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