



**A NOVEL APPROACH USING OPTICAL FRINGE
ANALYSIS FOR BREAST CARCINOMA
DETECTION**

by

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LIST OF ABBREVIATIONS

TNM	Tumor Node Metastasis
BSE	Breast Self Examination
CBE	Clinical Breast Examination
FNA	Fine Needle Aspiration
FFDM	Full Field Digital Mammography
CEDM	Contrast Enhanced Digital Mammography
CESM	Contrast Enhanced Spectral Mammography
MRI	Magnetic Resonance Imaging
DCE-MRI	Dynamic Contrast Enhanced Magnetic Resonance Imaging
DWI	Diffusion Weighted Imaging
PET	Positron Emission Tomography
PET-CT	Positron Emission Tomography–Computed Tomography
DEI	Diffraction Enhanced Imaging
EIS	Electrical Impedance Scanning
FEA	Finite element analysis
SPECT	Single Photon Emission Computed Tomography
2D	Two Dimensional
3D	Three Dimensional

LIST OF SYMBOLS

σ_{ij}	Stress Tensor Components
f	Forces/Unit Volume
ε_{ij}	Strain Tensor Components
E	Young modulus
ν	Poisson's ratio
δ_{ij}	Kronecker delta
$A(I,j)$	Uniform Background Intensity
$B(I,j)$	Amplitude Of The Sinusoidal Waveform
$\phi(I,j)$	angle at point (I,j)
$\Delta\phi$	phase displacement
θ_i	illumination angle
θ_v	angle of view
p	spatial period
Δh	height variation

Pendekatan Novel Menggunakan Analisis Optik Unjuran Bagi Pengesanan Kanser Payudara

ABSTRAK

Kanser payudara adalah salah satu kanser yang utama di mana ia menyumbang sebanyak 25.1% daripada semua jenis kanser yang didiagnosis di kalangan wanita. Kaedah yang telah diiktiraf bagi pengesanan dan diagnosis kanser payudara adalah termasuk pemeriksaan sendiri payudara, pemeriksaan fizikal, kaedah invasif seperti penyuntikkan jarum halus dan biopsi, kaedah bukan invasif, iaitu pengimejan payudara seperti mamografi, ultrabunyi dan pengimejan resonans magnet. Walaubagaimanapun, pemeriksaan sendiri payudara, pemeriksaan fizikal, mamografi, ultrabunyi dan pengimejan resonans magnet merupakan kaedah yang tidak sepenuhnya bukan invasif kerana ia memerlukan sentuhan fizikal pada payudara. Berdasarkan kajian yang dilaporkan sebelum ini, penggunaan kaedah optik terbukti sebagai kaedah tanpa sentuhan penuh dan tanpa invasif. Oleh itu, terdapat ruang untuk penambahbaikan yang luas dalam penggunaan kaedah optik untuk mengesan kanser payudara di peringkat awal berdasarkan analisis permukaan payudara. Teknik unjuran pinggir muncul sebagai alat tanpa sentuhan dalam metrologi optik dengan aplikasinya yang terdiri daripada pengukuran komponen MEMS tiga dimensi, pengukuran kerataan tepat, analisis getaran dan aplikasi didalam bidang bioperubatan untuk penilaian bentuk badan manusia secara tiga dimensi. Walaupun teknik ini menunjukkan aplikasi yang luas dalam bidang bioperubatan, penggunaan teknik unjuran pinggir bagi pengesanan dan penilaian kanser payudara adalah sangat minimum. Oleh itu, dalam kajian ini, penggunaan rig unjuran pinggir berdasarkan teknik anjakan fasa sebagai kaedah tanpa invasif bagi analisis permukaan metrologi payudara untuk pengesanan kanser payudara pada peringkat awal telah dilakukan. Rig unjuran pinggir telah digunakan untuk menganalisis perubahan permukaan payudara dengan kehadiran ketulan didalam payudara. Sebelum melaksanakan analisis eksperimen, kaedah simulasi telah digunakan untuk mengesahkan kehadiran tekanan di permukaan payudara dengan kehadiran ketulan dalam payudara, Rig unjuran pinggir yang digunakan terdiri daripada beberapa komponen, iaitu projektor paparan hablur cecair (LCD), kamera peranti cas terdinding (CCD) dan komputer peribadi. Dalam kajian ini, empat jenis prostesis payudara yang berlainan bentuk, iaitu bentuk bulat, bentuk air mata, bentuk segi tiga dan bentuk heliks telah digunakan sebagai sampel ujian. Corak pinggir anjakan fasa telah diunjurkan ke permukaan payudara dan pesongan corak pinggir direkodkan melalui kamera CCD untuk generasi peta fasa. Analisis unjuran pinggir dilakukan dalam dua bahagian utama, iaitu analisis 2D dan analisis 3D. Menyelaras lokasi dan pengesanan piksel telah digunakan bagi analisis 2D untuk mengesan perubahan di permukaan payudara daripada peta fasa. Bagi analisis 3D, peta ketinggian 3D dijana dari peta fasa melalui beberapa langkah pemprosesan imej dan perubahan permukaan payudara telah dianalisis. Analisis simulasi telah mengesahkan bahawa kehadiran ketulan dalam payudara menyebabkan tekanan pada permukaan payudara. Rig unjuran pinggir telah dapat mengesan dengan tepat perubahan permukaan disebabkan oleh perubahan saiz ketulan dari saiz minimum 0.1 cm sehingga 1 cm. Di samping itu, pemetaan 3D payudara dan pengesanan perubahan ketinggian permukaan payudara untuk saiz ketulan dari 0.1 cm sehingga 1 cm telah dicapai melalui rig unjuran ini.

A Novel Approach Using Optical Fringe Analysis For Breast Carcinoma Detection

ABSTRACT

Breast carcinoma is one of the primary cancers diagnosed among woman with 25.1 % accounted of all cancers in women. Recognized methods for breast carcinoma detection and diagnosis include breast self examination (BSE), physical examination, invasive methods such as fine needle aspiration (FNA) and biopsy and non-invasive breast imaging methods such as mammography, ultrasound and magnetic resonance imaging (MRI). However, BSE, CBE, mammography, ultrasound and MRI are not entirely non-invasive as the methods somehow requires physical touches to the breast. Based on the reported previous works, the feasibility of using an optical method is evident as a full non contact and non invasive method, and there is room for vast improvement in using optical methods for early breast carcinoma detection based on surface analysis. Fringe projection techniques are emerging as non-contact tool in optical metrology with applications ranging from 3D Micro-electromechanical systems (MEMS) component measurement, accurate flatness measurement, vibration analysis and biomedical applications for assessment of complex three-dimensional human form. Despite the vast applications in the biomedical field, application of fringe projection in breast carcinoma detection and assessment is notably minimal. Thus, in this work, the usage of a fringe projection rig based on phase shift technique for non-invasive surface metrology analysis of the breast as an adjunct tool for early breast carcinoma detection was done. The fringe projection rig was utilized to analyze the surface changes of the breast due to the presence of breast lump within the breast. Prior to performing the experimental analysis, simulation method was first adopted to validate the presence of breast surface stress due to the presence of lump within the breast, before proceeding to the fringe projection method to analyze the surface changes of the breast due to the presences of lump. The fringe projection rig developed comprised of liquid crystal display (LCD) projector, charge-coupled device (CCD) camera and personal computer. In this work, four types of breast prosthesis, namely round shape, teardrop shape, triangular shape and helical shape were used as the test sample. The phase shift fringe patterns were projected onto the breast surface and the fringe pattern deflections were recorded through CCD camera for phase map generation. The fringe projection analysis was done in two major parts, which comprised of 2D analysis and 3D analysis. Coordinate location and pixel tracing method were utilized in the 2D analysis to perform the breast surface deflection analysis from the phase map. As for the 3D analysis, 3D height map was generated from the phase map through few image processing steps and the breast surface changes were analyzed. The simulation analysis has confirmed that the presence of lump within the breast causes stress on the breast surface and varies according the condition investigated. The fringe projection rig was found to be able to detect accurately the surface changes due to lump size variation from a minimal range of 0.1 cm up to 1 cm. In addition, the fringe projection rig has shown its capability in providing 3D mapping of the breast and detecting the surface height changes of the breast for lump size of 0.1 cm up 1 cm.