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FACULTY OF GRADUATE STUDIES

DEPARTMENT OF BIOMEDICAL ENGINEERING

Breast Tumors Classification Using Adaptive Neuro-Fuzzy Inference System (ANFIS)

تصنيف اورام الثدي باستخدام نظام الاستدلال العصبي-الضبابي المنطقي المتكيف

A Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Science in Biomedical Engineering

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Dedication

To...

Our most loved ones....

Parents, families and closest friends,

With their loving and promising support,

Their unbounded motivation that has given us the perseverance we need to accomplish our goals.

Special thanks go to my husband, my guardian angel, my reason of success, for his support in all my life.

And mostly,

To all those women who have struggled with breast cancer

Acknowledgement

In the name of the Almighty Allah, to whom we are grateful for, for all the blessings, guidance and constant perseverance that we have been gifted with throughout this experience.

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Last but not least, the unconditional love and support from dear families and friends and specially my dear husband cannot be forgotten, and without which, accomplishing this task would not have been possible.

مستخلص البحث

سرطان الثدي هو حاليا السبب الأول في وفيات النساء في جميع أنحاء العالم .في السودان نسبه لزيادة النسبه، والكشف في المراحل المتأخرة والبداية المبكرة للمرض يجعل الكشف المبكر وتشخيص سرطان الثدي مهمة طاغية.

حاليا تعتبر الاشعه السينيه لتصوير الثدي هي الاكثر فعاليه والاقل تكلفه والاكثر حساسيه لاكتشاف الاورام الصغيره، ولكن تعتمد حساسية الجهاز على كثافة انسجة الثدي مما يؤثر على دقة التشخيص وبالتالي، هناك ضرورة كبيرة لتطوير طرق الكشف الألي وتصنيف المناطق المشبوهة في تصوير الثدي بالأشعة السينية، كوسيلة لمساعدة أطباء الأشعة لتحسين فعالية برامج الفحص و تجنب الخزعات غير الضرورية.

الهدف من هذه الدراسة هو إنشاء نظام واجهة كمبيوتر لتحديد المكان ، وكشف وتصنيف كتلة الثدي باستخدام نظام الاستدلال العصيبي-الضبابي المنطقي المتكيف.

نظام الاستدلال العصيبي-الضبابي المنطقي المتكيف المستخدم في الدراسة للكشف عن سرطان الثدي يعتمد علي خمسة مدخلات تميز السرطان. هذا النظام يجمع بين خاصية القدره علي التكيف عند الشبكات العصبيه و النهج النوعي للمنطق الضبابي.

ويتم تنفيذ هذه المراحل باستخدام برنامج MATLAB. تم تصميم واجهة المستخدم الرسومية (GUI) لكل مرحلة من مراحل الخوارزمية. أظهرت نتائج المنهجيات المقترحة بان لها قدرة عالية في تحسين صور الثدي، توطين، كشف وتصنيف الورم الثدي .وكان النظام قادرا على تحقيق دقة حساسية 94.4٪، و 100٪ خصوصية، 97.1٪ القيمة التنبؤية الإيجابية، و 100٪ القيمة التنبؤية السلبية، قيمة Az تساوي 0.972 ودقة التصنيف الكلية 98٪.

اثبت النظام فعاليته في تحسين صور الثدي والتمييز بين الأورام الخبيثة والحميدة مع مستوى فعال من الدقة.

Abstract

Breast cancer is currently the foremost cause in women's mortality worldwide. In Sudan, the increasing incidence, detection at late stages and the early onset of the disease makes early detection and diagnosis of breast cancer an overbearing task.

Currently, X-ray mammography is the single most effective, low-cost, and highly sensitive technique for detecting small lesions. However, the sensitivity of mammography is highly challenged by the presence of dense breast parenchyma, which deteriorates both detection and characterization tasks. Thus, there is a significant necessity for developing methods for automatic detection and classification of suspicious areas in mammograms, as a means of aiding radiologists to improve the efficacy of screening programs and avoid unnecessary biopsies.

The objective of this study is to create a computer interfacing system for the localization, detection and classification of breast masses using ANFIS.

The ANFIS classifier was used to detect the breast cancer when five features defining breast cancer indications were used as inputs. The proposed ANFIS model combined the neural network adaptive capabilities and the fuzzy logic qualitative approach.

Results demonstrated the proposed methodologies have high potential in enhancing breast images, localizing, detecting and classifying the breast tumor. The system was able to achieve an accuracy of 94.4% sensitivity, 100% specificity, 97.1% positive predictive value, 100% negative predictive value, an *Az* value of 0.972 and an overall classification accuracy of 98%.

The created systems have therefore, proved to effectively enhance the quality of the breast images and discriminate between malignant and benign tumors with an effective level of precision.

CONTENTS

List of Tables

List of Figures

Glossary

ANFIS : Adaptive Neuro-fuzzy Inference System
MF : Membership Function
AUC : Area Under Curve
BI-RADS : Breast Imaging-Reporting and Data System
BLAS : Basic Linear Algebra Subprograms
BSE : Breast Self Examination
CAD : Computer Aided Diagnosis
CAT : Computerized Axial Tomography
CDF : Cumulative Distribution Function
CLAHE : Contrast Limited Adaptive Histogram Equalization
DWT : Discrete Wavelet Transform
DWT : Dyadic Wavelet Transforms
EISPACK : Eigen System Package
FCLAHE : Fuzzy Contrast-Limited Adaptive Histogram Equalization
FCM : Fuzzy C-Means
GA-LFS : Linear Forward Selection and Genetic Algorithm
GLCM : Gray-Level Co-occurrence Matrices
GUI : Graphical User Interface
K-nn : K-nearest neighbor
LAPACK : Linear Algebra Package
LINPACK : Linear System Package
LRM : Local Range Modification
LDA : Linear Discriminant Analysis
LSMD : Least-Squares Minimum Distancex
MATLAB : Matrix Laboratory
MC : Microcalcification
MCPCNN : Multiple Circular Path Convolution Neural Network
MIAS : Mammographic Image Analysis Society
MLP : Multi-Layer Perceptron
MSE : Mean Square Error
PSNR : Peak Signal to Noise Ratio
RBF : Radial Basis Function
RDWT : Redundant Dyadic Wavelet Transform
RICK : Radiology and Isotope Center of Khartoum
ROC : Receiver Operating Characteristic
ROI : Region Of Interest
SGLD : Spatial Gray Level Dependence Matrices
SVM :Support Vector Machine
PGM : Portable Gray Map