MAMMOGRAM IMAGES CLASSIFICATION BASED ON FUZZY SOFT SET

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ABSTRACT

Early detection of the breast cancer can decrease mortality rates. Screening mammography is considered the most reliable method in early detection of breast cancer. Due to the high volume of mammograms to be read by a physician, the accuracy rate tends to decrease. Thus, automatic digital mammograms reading becomes highly enviable, it is premised that the computer aided diagnosis systems are required to assist physicians/radiologists to achieve high efficiency and effectiveness. Meanwhile, recent advances in the field of image processing have revealed that level of noise highly affect the mammogram images quality and classification performance of the classifiers. Therefore, this study investigates the functionality of wavelet de-noising filters for improving images quality. The dataset taken from Mammographic Image Analysis Society (MIAS). The best PSNR and MSE values 46.36423dB (hard thresholding) and 1.827967 achieved with Daub3 filter. Whilst, several medical imaging modalities and applications based on data mining techniques have been proposed and developed. However, fuzzy soft set theory has been merely experimented for medical images even though the choice of convenient parameterization makes fuzzy soft set practicable for decision making applications. Therefore, the viability of fuzzy soft set for classification of mammograms images has been scrutinized. Experimental results show better classification performance in the presence/absence of de-noise filter in mammogram images where the highest classification rate occurs with Daub3 (Level 1) with accuracy 75.64% (hard threshold), precision 46.11%, recall 84.67%, F-Macro 75.64%, F-Micro 60% and performance of FussCyier without de-noise filter classification accuracy 66.49%, precision 80.83%, recall 50% and F-Micro 68.18%. Thus, the results show that proposed approach FussCyier gives high level of accuracy and reduce the complexity of the classification phase, thus provides an alternative technique to categorize mammogram images.

ABSTRAK

Pengesanan awal terhadap kanser payudara boleh mengurangkan kadar kematian. Ujian mamografi merupakan kaedah pengesanan awal kanser payudara yang terbaik. Oleh kerana terlalu banyak mamogram yang perlu dibaca oleh pakar perubatan, maka kadar ketepatan pengesanan berkurang. Bacaan mamogram digital secara automatik memberi saingan yang sangat tinggi, Oleh yang demikian, sistem diagnosis bantuan komputer diperlukan untuk membantu pakar perubatan/radiologi untuk mencapai tahap keberkesanan dan kecekapan yang tinggi. Kemajuan terkini dalam bidang pemprosesan imej telah mendedahkan bahawa tahap hingar data sangat memberi kesan kepada kualiti imej mamogram dan prestasi pengelasan. Oleh itu, kajian ini mengkaji fungsi penapisan gelombang derau untuk mempertingkatkan kualiti imej. Dataset telah diperoleh daripada Mammographic Image Analysis Society (MIAS). Nilai PSNR terbaik dicapai pada 46.36423dB(ambang keras) dengan penapisan gelombang Daub3. Manakala, beberapa kaedah pengimejan-perubatan dan aplikasi berdasarkan teknik-teknik perlombongan data telah dicadangkan dan dibangunkan. Walau bagaimanapun, teori set kabur lembut hanya diuji untuk imej perubatan walaupun pilihan pemparameteran yang sesuai menjadikan set kabur lembut dilaksanakan untuk aplikasi membuat keputusan. Keberkesanan set kabur lembut untuk pengelasan imej mamogram telah diteliti. Hasil eksperimen menunjukkan bahawa ketepatan pengelasan lebih baik dengan kehadiran/ketiadaan hingar dalam imej mamogram di mana kadar pengelasan yang paling tinggi berlaku pada Daub3 (tahap 1) dengan ketepatan 75.64% (ambang keras), kepersisan 46.11%, perolehan kembali 84.67%, F-Makro 75.64%, F-Mikro 60% dan kadar klasifikasi tanpa hingar dengan ketepatan 66.49%, kepersisan 80.83%, perolehan kembali 50% dan F-Mikro 68.18%. Oleh itu, hasil keputusan menunjukkan bahawa pendekatan yang dicadangkan FussCyier memberi tahap ketepatan yang tinggi dan mengurangkan kekompleksan untuk pengelasan dengan menyediakan teknik alternatif untuk mengkategorikan imej mamogram.

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LIST OF SYMBOLS AND ABBREVIATIONS

U	-	Universal set of objects
E	-	Set of parameters
r_i	-	Row sum
t_j	-	Column sum
f	-	Frequency
F_n	-	Frequency in the *nth* frame
SSC	-	Soft Set Classifier
FSSC	-	Fuzzy Soft Set Classifier
k-NN	-	*k*-Nearest Neighbor
ANN	-	Artificial Neural Networks
SVM	-	Support Vector Machine
BBN	-	Bayesian Belief network
BPNN	-	Back propagation Neural Network
GMM	-	Gaussian Mixture Model
GTSDM	-	Gray Tone Spatial Dependence Matrix
GkNN	-	Genetic k-Nearest Neighbor
MLP	-	Multi Layer Perceptron
GLHM	-	Gray Level Histogram Moments
SGLD	-	Spatial Gray Level Dependence Matrix
LDA	-	Linear Discriminant Analysis
CAD	-	Computer-Aided Diagnosis
CADe	-	Computer-Aided Detection
NCR	-	National Cancer Registry
MIAS	-	Mammographic Image Analysis Society
ROI	-	Region of Interest
AWGN	-	Additive White Gaussian Noise

DWT	-	Discrete Wavelet Transform
IDWT	-	Inverse Discrete Wavelet Transform
CT	-	Computed Tomography
MRI	-	Magnetic Resonance Imaging
GLDM		Gray Level Difference Run Method
GLRLM	-	Gray Level Run Length Method
GLCM		Gray Level Coocurrence Method
DOG	-	Difference-Of-Gaussian
RBFNN	-	Radial Basis Function Neural Networks
MAD	-	Median Absolute Value
PSNR	-	Peak Signal-to-Noise Ratio
MSE	-	Mean Square Error
ARM	-	Association Rule Mining
Daub	-	Daubechies
ECG	-	Electrocardiogram
EMG	-	Electromyography
EOG	-	Electrooculography
DDSM	-	Digital Database for Screening Mammography

LIST OF PUBLICATIONS

Journals:

(i) Rosziati Ibrahim, Saima Anwar Lashari, Norhalina Senan and Tutut Herawan (2016). Embedding Wavelet De-Noising in Mammogram Images Classification Based on Fuzzy Soft Set. PLOS ONE, DOI:10.1371 *(In Review).*

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Medical image processing technology has been one of the most important techniques in treating diseases by creating precise images of human bodies. It encompasses image segmentation, feature extraction, classification, image matching, motion tracking, detect changes of image sequences, measurement of anatomical and physiological parameters from images (Otoom *et al.*, 2015; Saha *et al.*, 2015). On the other hand, it assists physicians and scientists to reveal and diagnose many types of diseases and illnesses, such as pneumonia and cancer. These medical images are mostly resolute in the field of radiology, in which X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), ultrasound, Positron Emission Tomography (PET), digital mammogram images are involved for diagnosis and prognosis of diseases (Ramani *et al.*, 2013).

One of the second largest leading causes of deaths among women is breast cancer (Saha *et al.*, 2015). Presently, there are no methods to avert breast cancer, that is why early detection indicate an extremely important factor in cancer treatment and allow reaching a high survival rate (Otoom *et al.*, 2015; Zaidi & ElNaqa, 2010). At the same time, breast cancer etiologies are not clear and neither do they have reasons for the increased number of breast cancer cases all around the world. However, previous studies demonstrated that the possibility to cure breast cancer can increase by 40 percent or up to 40 percent if it is identified in its early stage (Howell *et al.*, 2014; Srinivas & Bangalore, 2012).

Thus, automatic digital mammograms reading turn out to be extremely enviable, that is why the Computer Aided Diagnosis (CAD) systems are required to assist the physicians/radiologists to attain elevated effectiveness in detecting subtle lesions and reducing the probability of the risk of failure in detecting abnormalities (Fenton *et al.*, 2013). In other words, CAD in screening mammographic images is considered as an immediate available opinion for radiologists in identifying high suspicious regions of malignancy (Howell *et al.*, 2014).

However, CAD still facing challenging problems such as low image quality (film noise, low contrast resolutions) and lack of sensitive algorithms for detection of cancerous images (Otoom *et al.*, 2015; James & Dasarathy, 2014). In view of the fact that, the need for improving the image quality which arose from the signal noise (Naveed *et al.*, 2012). A solution to this problem is the de-noising of the images. Therefore, de-noising is primarily used to take away noise that is present in mammogram images and preserve the significant information (Rangarajan *et al.*, 2002). Consequently, wavelet based noise removal has gained much consideration of the researchers for several years (Xiao & Zhang, 2011; Bruni & Vitulano, 2007). Wavelet de-noising filters have been successfully employed in image compression, noise reduction, image enhancement, texture analysis/segmentation and multi-scale registration (Xiao & Zhang, 2011; Xu *et al.*, 1994; Yang *et al.*, 2010) and not yet fully utilized for mammogram images classification.

Hence, this study investigates the functionality of wavelet de-noising filters for noise removal in order to enhance the images quality and viability of fuzzy soft set for classification of mammogram images to increase the classification accuracy while lower the classifier complexity. To accomplish these major tasks, proposed classifier FussCyier comprises of six phases that are data acquisition, data pre-processing, feature extraction, data partitioning, classification using FussCyier and performance evaluation.

1.2 Problem Statement

Despite the fact that, when addressing the mammogram image classification, the emphasis has been placed in the direction of developing image processing algorithms that attempt to improve the imaging quality and regions of interest within images

(Naveed *et al.*, 2012). Even though, the enhancements to images quality have a positive impact towards images classification (James & Dasarathy, 2014). However, the noise present in the images is subtle and varied in appearance which adversely affects classification accuracy of mammogram images (Naveed *et al.*, 2012; Malar *et al.*, 2012). Besides, it is worth noting that there have been relatively few research on the noise removal for mammogram images (Saha *et al.*, 2015, Malar *et al.*, 2013; Naveed *et al.*, 2012); nevertheless, much emphasis has been placed on standard images and other medical images (MRI, ultrasound, CT scan) for noise removal (Taujuddin & Ibrahim, 2015; Sidh *et al.*, 2012; Arivazhagan *et al.*, 2007).

Meanwhile, medical diagnosis and prognosis problems are prime examples of decision making in the face of uncertainty (Begum & Devi, 2011). Uncertainties affect the image analysis and the most challenging problem in image analysis and pattern recognition research is classification (Souza *et al.*, 2008; Mitra & Pal, 2005). Thus, fuzzy set theory plays a vital role in formalizing uncertainties for medical diagnosis and prognosis (Zadeh, 1965; Adlassnig, 1986; Steimann, 2001). To handle uncertainty in the decision making, the use of fuzzy set theory has given rise to a lot of new methods of pattern recognition such as Mushrif *et al.*, (2006) offered a novel method Soft Set Classifier (SSC) for classification of natural textures using the notions of soft set theory.

However, soft set theory is appropriate for binary numbers although still difficult to handle real numbers (Herawan *et al.*, 2010; Ma *et al.*, 2011). For that reason, fuzzy soft set can handle fuzzy attributes (parameters in the form of real numbers) (Roy & Maji, 2007; Handaga & Deris, 2011). Later, Handaga *et al.*, (2012) demonstrated a new application of soft set for numerical data classification by offering a more general concept based on similarity measure between two fuzzy soft sets that is Fuzzy Soft Set Classifier (FSSC), which can handle parameters in the form of real numbers, yet, FSSC has high algorithm complexity.

Limitations of the earlier studies and lack of work on the mammogram images classification using similarity measure on fuzzy soft set motivated the present research. Thus, the present study is intended to increase the mammogram images quality by incorporating wavelet threshold de-noising functions (pre-processing phase) whilst introducing distance measure function for mammogram images classification and named the proposed classifier as FussCyier. All these three classifiers SSC, FSSC and FussCyier comprised of three phases: pre-processing, training and testing respectively. In order to appraise the performance of FussCyier, existing fuzzy soft set classifiers SSC and FSSC were used to benchmark the proposed FussCyier. After that, performances of these three classifiers were evaluated by five performance measures which are classification accuracy, precision, recall, F-Macro and F-Micro.

1.3 Research Objectives

Based on the research background and the related issues, three objectives of this research have been formulated as follows:

i. To propose a wavelet threshold de-noising filter in the pre-processing phase.
ii. To propose and develop a classifier FussCyier for mammogram images classification based on fuzzy soft set.
iii. To evaluate the performance of FussCyier based on classification accuracy, precision, recall, F-Macro and F-Micro and to compare with existing fuzzy soft set based classification algorithms which are Soft Set Classifier (SSC) and Fuzzy Soft Set Classifier (FSSC).

1.4 Research Scope

This study focuses only on testing the effectiveness of an alternative approach FussCyier for mammogram images classification to be categorised into two classes namely benign and malignant. Mammogram images were taken from the Mammographic Image Analysis Society (MIAS) dataset (Suckling *et al.*, 1994). The performance of FussCyier is validated based on five performance measures namely: classification accuracy, precision, recall, F-Macro and F-Micro with the existing fuzzy soft set based classification algorithms SSC and FSSC.

1.5 Thesis Outline

This chapter portrays the briefing of the research. The description encompasses the background of the study, motivation, research objectives, research scope and the thesis outline. In general, this chapter has not only given the preliminary depiction of the research, thus it is an executive summary of the entire research. At the end of this chapter, the organization of the following chapters is discussed in brief to give an overall picture of this thesis. The thesis consists of seven chapters, which are briefly described as follows:

Chapter 1: *Introduction* explains an overview of the research encompasses the background of the study, motivation, research objectives, scope of the study and thesis outline respectively.

Chapter 2: *Literature Review* begins with a glance through soft set theory and fuzzy soft set. The important definitions of soft set theory and fuzzy soft set which structure the focus point of this research are explained in details with some examples. The discussion then continues on computer-aided mammography, mammogram images and breast cancer detection. Later, several complementary approaches and prior research for studying mammogram images and their relevance to the classification tasks is presented.

Chapter 3: *Research Methodology* illustrates the methodology of the research starting from choosing the data used in the experiment until the evaluation of the experimental results. The methodology presented for FussCyier consisting of six phases namely data acquisition, data pre-processing, feature extraction, data partitioning, classification using FussCyier and performance evaluation. Each phase contains its different steps and delivers useful results to be used in the next phase.

Chapter 4: *Design and implementation of FussCyier* describes the development of a proposed classification algorithm for mammogram images. *FussCyier* uses distance measure fuzzy soft set to classify mammogram images. The chapter presents the main three phases involved in the development of FussCyier namely: pre-processing, training and testing phase respectively. Afterwards, FussCyier is explained with few examples.

Chapter 5: *Pre-Processing results and discussion.* A thorough analysis related to identified factors namely: effect of threshold determination on image quality, effect of data partition, effect of presence/absence of de-noise filter and effect of de-noising before and after Region of Interest (ROI) were examined. The proposed de-noising filters allows for a significant improvement in FussCyier efficiency by finding the appropriate parameter settings that must be examined. The obtained results address the first objective of this study.

Chapter 6: *Classification results and discussion* presents the performance of the FussCyier and explained the effectiveness of the FussCyier when compared with SSC and FSSC in terms of classification accuracy, precision, recall, F-Macro and F-Micro. Chapter 6 answered the second and third objectives of the study.

Finally, Chapter 7: *Conclusion and Future works* presents a summary of the dissertation research. Significant contributions are highlighted and additional avenues for research works are given.

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VITAE

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