AIN SHAMS UNIVERSITY
Faculty of Computer and Information Sciences
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DEVELOPING AN IMAGE ANALYSIS ALGORITHMS FOR COMPUTER-AIDED DETECTION MEDICAL SYSTEMS

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Publications

1. Heba Mohsen, El-Sayed El-Dahshan, Abdel-Badeeh Salem, “Comparative Study of Intelligent Classification Techniques for Brain Magnetic Resonance Imaging” in the proceeding of the 11th International Scientific Conference on Informatics INFORMATICS 2011, 16-18 November 2011, Rožňava, Slovakia, pp. 175-178.

2. Heba Mohsen, El-Sayed El-Dahshan, Abdel-Badeeh Salem, “A machine learning technique for MRI brain images” in the 8th International Conference on Informatics and systems INFOS, Cairo University, 14-16 May 2012 , Cairo, Egypt.

3. Heba Mohsen, El-Sayed El-Dahshan, Kenneth Revett, Abdel-Badeeh Salem,“A Comparative study on Brain Magnetic Resonance Images Segmentation techniques” in the 8th Annual International Conference on Computer Science and Information Systems, 21-24 May 2012, Athens, Greece.

Abstract

With the advance of computational intelligence and machine learning Techniques, Computer-aided Detection/Diagnosis (CAD) attracts more attention in the field of brain tumor detection and diagnosis. It has become one of the major research subjects in medical imaging and diagnostic radiology. Brain CAD systems can provide radiologists with a 'second opinion' to assist them in the early detection and diagnosis of brain tumors. Consequently, radiologists expect that CAD systems can improve their diagnostic abilities based on synergistic effects between the radiologist and the computer with medical image analysis and machine learning techniques.

The use of computer technology in medical decision support is now widespread and pervasive across a wide range of medical area, such as brain tumors. MRI is often the medical imaging method of choice when soft tissue delineation is necessary and the most important advantage of MR imaging is that it is a non-invasive technique. Thus, MRI is considered the most reliable method for the early detection of brain tumors for yielding a great deal of information that the radiologist has to analyze and evaluate comprehensively in a short time. CAD-Systems help scan MR images for typical appearances and to highlight conspicuous sections (possible diseases). Fully automatic normal and diseased human brain classification can be obtained from MRI; which is a great importance for research and clinical studies.

Many proposed techniques developed for the aim of automatic detecting and diagnosing the brain tumor from Brain MR Images to be the basis for Brain CAD systems which can scan a number of brain MRI in a short time to aid the doctors and radiologists in drawing quicker and easier inferences about the condition of the brain under study. These systems have multiple phases to perform the diagnoses. In general, Computer-aided analysis of medical images obtained from different imaging systems such as MRI involves four basic

steps: a) image filtering or preprocessing, b) image segmentation, c) feature extraction, and d) classification or analysis of extracted features by a classifier or pattern recognition system.

In this study we have developed a hybrid intelligent machine learning technique for detecting brain tumors using information from Brain MRI based on four algorithms including segmentation, feature extraction, feature selection, and classification. The developed technique statrs by image segmentation for defining the ROI in the brain MRI using the Feedback pulse-coupled neural network (FPCNN). The highlighted parts form segmentration step (ROI) is used to provide a better classification results. Then the discrete wavelet transform (DWT) is employed on the segmented regions for feature extraction purpose. and for the excessive number of features provided with the DWT, the principle component analysis (PCA) is applied for feature selection and to reduce the dimensionality of the wavelet coefficients by removing redundant features. The reduced features are sent to backpropagation neural network (BPNN) to classify inputs into normal or abnormal based on feature selection parameters.

Experimental results demonstrate the effectiveness of the developed technique in detecting brain tumors. With A preliminary evaluation on a real MRI brain images dataset of 101 MRI, the developed technique classification accuracy was 99%, which demonstrates its robustness and validity that could be applicable in real life scenarios in order to help non-expert doctors to detect brain tumors. Moreover, to emphasize the developed technique effectiveness, a comparative study was made with the recent published techniques in the domain field.

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List of Abbreviations

CAD	Computer-Aided Detection
ACD	Automated Computer Diagnosis
MRI	Magnetic Resonance Imaging
ROI	Region Of Interest
PCNN	Pulse-Coupled Neural Network
FPCNN	Feedback Pulse-Coupled Neural Network
WT	Wavelet Transform
DWT	Discrete Wavelet Transform
WPT	Wavelet Packet Transform
PCA	Principle Component Analysis
FFBPNN	Feed Forward Backpropagation Neural Network
PACS	Picture Archiving and Communication System
DSA	Digital Subtraction Angiography
CT	Computed Tomography
PET	Positron Emission Tomography
SPECT	Single Photon Emission Computed Tomography
EEG	Electroencephalography
MEG	Magnetoencephalography
NIRS	Near infrared spectroscopy
Roc	Receiver Operating Characteristic
CR	Computed Radiography
FPD	Flat Panel Detector
MDCT	Multi-Detector Computed Tomography
MRA	Magnetic Resonance Angiography
US	Ultrasound
FFDM	Full-Field Digital Mammography
CARS	Computer Assisted Radiology and Surgery
AAPM	American Association of Physicists in Medicine

RSNA	Radiological Society of North America
CBTRUS	Central Brain Tumor Registry of the United States
CNS	Central Nervous System
MRF	Markov random field
SOM	Self-Organizing Maps
SOFM	Self-Organizing Feature Map
LVQ	Learning Vector Quantization
FCM	Fuzzy C-means
PCM	Prossibilistic C-Mean
AFCM	Alternative fuzzy C-means
PNFCM	Possibilistic Neuro Fuzzy C-Means Algorithm
k-NN	k-Nearest Neighbor
ANN	Artificial Neural Network
FFNN	Feed Forward Neural Network
BP	Backpropagation network
SVM	Support Vector Machine
PD	Proton Density
BAM	Bidirectional Associative Memory

Chapter 1

Introduction

In radiology, the task of image interpretation can be broken down into 3 essential parts: detection, description, and differential diagnosis. As medical images came to be acquired or displayed through the use of computers, the possibility of having computers performs any or all of these interpretive steps have been contemplated. This field became known as Computer-Aided Detection/Diagnosis (CAD) [5].

Advances in the area of Artificial Intelligence (AI) and Soft Computing techniques have a tremendous impact on the enhancement of medical images' interpretation and contributed to early diagnosis. Modern medical imaging includes image processing and computer-aided detection/diagnosis (CAD) which is the currently applied computerized analysis of medical images that combine artificial intelligence and digital image processing with radiological image processing. For that, now CAD is a widely used tool in detection and differential diagnosis of abnormalities (e.g. brain tumors) and quantification of disease progress in medical imaging (e.g. brain MRI) [4,6].

Imaging techniques in diagnostics yield a great deal of information, the radiologist has to analyze and evaluate comprehensively in a short time. To detect an abnormality, the radiologist usually performs visual scanning of the images of many healthy subjects. The procedure of image scanning lends itself to CAD, since it is a repetitive, burdensome task involving mostly normal images—a situation prime for oversight errors (e.g. In the case of lesion characterization, complex anatomy, variation in the presentation of benign and malignant states, and the varying abilities of the radiologists may result in interpretation errors)[6].

CAD system aims to assist doctors by drawing attention to regions of interest that may require further review and facilitate the detection and characterization tasks, which reduce cancer missed due to increasing workload, overlooked or data overloaded, enhance the radiologists' capabilities by improving the consistency of the radiologists' image interpretation and reducing the time required for accurate diagnosis [3,6]. Thus with CAD, radiologists use the computer output to provide "second opinion" rather than an output "decision" as the final decision should be made by the radiologists in the process of image interpretation (see Figure 1.1). For that, CAD has become one of the major research subjects in medical imaging and diagnostic radiology.

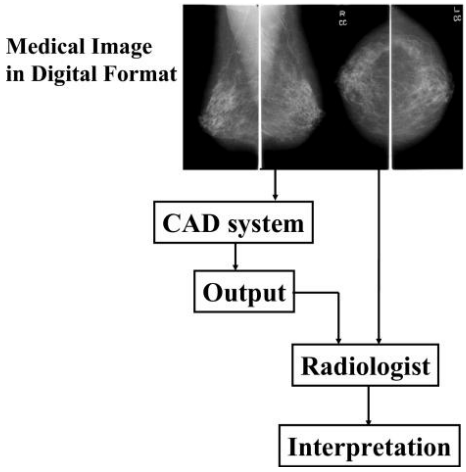

Figure 1.1 *Schematic diagram of a CAD system for medical image interpretation*

The concept of CAD was established by taking into account equally the roles of radiologists and computers; unlike known from 1960s the concept of automated computer diagnosis (ACD) was based on computer algorithms only. With CAD, the performance by computers (CAD systems) does not have to be comparable to or better than that by radiologists, but needs to be complementary to that by radiologists. For that, as the demands on clinicians grow, the need for CAD products in the radiology market, as in other medical markets, is likely to increase significantly [1].