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Certain Investigations on 3D spatial and wavelet texture analysis for discrimination and classification of brain tumor

Brain tumors, a serious life threatening disease in today's scenario are the second leading cause of death in children, males and fifth leading cause of death in females, which must be diagnosed at early stage for proper treatment. Brain tumor alters tissue structure unequally which has a chaotic or a rougher structure in an image. The image thus obtained that reveals the internal structure of the organs of the human body noninvasively which captures the changes more effectively by Three Dimensional (3D) imaging than Two Dimensional (2D) imaging. Traditionally, radiologists use two major features (intensity and spatial distribution) for identifying suspicious region of tumor in Magnetic Resonance Images (MRI). But image texture can provide significant information on the health of examined tissues. Radiologists seeking greater accuracy in characterization of brain tumors can effectively use this texture analysis in the diagnostic interpretation of MR imaging that has become a rapid growing field of research.

The main objective of this research is to enhance the outcome of MR images by extracting the most effective and discriminating information and to indicate the minor variations in the images. This thesis proposes a novel 3D tumor discrimination technique that can capture even the micro level changes in the texture present in the tumor tissues. Computer Aided Diagnosis (CAD) a powerful non-invasive tool can go beyond the radiologists visual system capabilities and also provide a second opinion for them which are done by deeply analyzing the MR images. The analysis is performed by getting some mathematical measures that characterize the image and achieve the task of tumor tissue discrimination.

This thesis presents several comprehensive algorithms for integrated feature analysis systems for the purpose of brain tumor, tissue classification. Automated MRI brain tumor segmentation is a difficult task due to the variance of the tissues and complexity of tumors. But the ability to automatically segment a tumor can substantially improve both the diagnosis and the surgical planning for patients. By comparing segmented tumor through various stages of treatment surgeons can analyze the shape and size of a tumor prior to surgery, or monitor the progress of a patient. However, due to the complexity of the medical images, and the irregular shapes and sizes of tumors, this segregation process can be a difficult task. The proposed algorithm is composed of several stages, such as: First, the regions that are highly suspicious are selected and tumors are extracted.

Tumor extraction is an important operation in medical applications for diagnosing diseases. In the domain of brain tumor segmentation in MR images, segmentation is best described using texture features. The brain tissues and tumors are extracted using using textural features for which an improved hybrid clustering based segmentation using textural features is proposed in this work.

Second, the selected regions are further examined by constructing a typical feature sets both in 2D and in 3D space that has a good discrimination. This analysis is based on the features derived by Haralick and his coinvestigators from a Gray Level Co-occurrence Matrix (GLCM) that can be used to analyze image texture. The constructed feature sets composed of statistical feature sets obtained both in spatial domain and multiresolution domain. Six GLCM features that were found to be useful for the differentiation between tumorous and non-tumorous regions and among the tumor regions are computed. Using the above features an analysis is performed based on its statistical property for the tumor tissue discrimination and a simple classification of various tumors.

Next 2D textural features from the image histogram, the GLCM and Grey level Run-Length Matrices (GRLM) were extracted from 50 sets of MR-images. Similarly, an equal number of 3D textural features were also calculated from volume images both in spatial and multiresolution domain in the attempt to maximize classification performances. Discrete Wavelet Transform (DWT) is used in multiresolution analysis since the properties of wavelets make them special as it possesses a good time and frequency localization which make them ideal for the processing of non-stationary signals like the biomedical signals and images.

The constructed features are enormous and cumbersome and all the features may not carry useful information. Only a limited number of features are considered for further data analysis which is performed by selecting the best feature subset that identifies the tumorous regions both in spatial and multiresolution domain. This task is achieved by proposing different dimensionality reduction methods which transforms the data to a new lower dimension space without any degradation in the information and with no correlation among the transformed lower dimensional features. The features used to identify the best subset of features are Mutual information, fisher coefficient and probability of error combined with average correlation coefficient methods. Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Non-linear Discriminant Analysis (NDA) of feature selection methods are used to evaluate qulitaitively the feature separation ability of different texture classes. These reduced features are classified into different tumors using conventional classifiers like simple Back Propagation Network (BPN) and improved Probabilistic Neural Network (PNN) achieving classification accuracies of 84.61% in distinguishing primary benign from primary malignant tumors and 86.55% in discriminating primary from secondary. When volumetric 3D features were employed, these results improved to 92.31% for discriminating between primary benign from primary malignant tumors and 91.81% for distinguishing primary from secondary using PNN classifier in spatial domain. The classification accuracies were also found to be increased in wavelet domain.

Finally, the last proposed fragment in this thesis is the hardware implementation of brain image filtering and a novel tumor characterization algorithm using a Spartan 3E Field Programmable Gate Array (FPGA) board. The necessary model based hardware model is built and programmed into the FPGA board where a parallel and fast computing is performed using a model based design available in Xilinx System Generator and Simulink. This hardware module of image filtering algorithms outperforms other existing hardware algorithms.

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