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Rough Sets in Feature Reduction and Image Classification of Magnetic Resonance Images

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Abstract-The brain is a complex organ as it contains 50-100 billion neurons forming a gigantic neural network. Detection of anatomical brain structures with their exact location is important for treatments like radiation therapy and surgery. Computer aided detection of abnormality in medical images is primarily motivated by the necessity of achieving maximum possible accuracy. Phases for brain tumor detection using MR image are Pre-processing, Segmentation, Feature Extraction, Classification. The MRI (Magnetic resonance Imaging) brain tumor segmentation is a complicated task due to the variance and intricacy of tumors. Image processing has become an area of boundless possibilities to explore as the advances in research field in this domain are gaining momentum. The principle aim of the project is to perform the MRI Brain image classification of cancer, based on Rough Set Theory and Feed Forward Neural Network classifier.

Keywords- *Brain- complex organ, Magnetic resonance Imaging ,Segmentation, Rough Set Theory, FFNN.*

1. INTRODUCTION:

Brain is the center of human Central nervous system. The brain is a complex organ as it contains 50-100 billion neurons forming a gigantic neural network. Radiologists perform the diagnosis of brain tumour manually on MRI images but it being time consuming and error prone as large no of image slices and the large variations between them. Besides, the customization and optimization features of a computer system stand among the major driving forces in adopting and subsequently strengthening the computer aided systems. DICOM (Digital Imaging and Communications in Medicine) plays a key role as it is the standard for handling, storing, reading, viewing and writing, printing information for medical Imaging. Manual segmentation is an alternate method for segmenting an image. This method is not only tedious and time consuming, but also produces inaccurate results.Brain Tumours are composed of the cells that exhibit abnormal and unrestrained cell division. Brain tumour can be benign or malignant, benign being non-cancerous and malignant are cancerous. Medical imaging constitutes various modalities to create images of the human body such as X -RAY, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Ultrasound. X-RAY, invented by Winhelm in 1895 is the oldest source of electromagnetic radiation used for imaging having wavelength in the range of 0.01 to 10 nanometers.MRI images to detect brain tumour classifies the tumour depending on whether the brain is an abnormal tissue containing normal volume brain tissues like white matter, gray matter and CSF (cerebro-spinal fluid) but also have some slices contain pathology like edema and necrosis hence making them abnormal brain tissues. Curing cancer has been a major goal of medical researchers for decades, but development of new treatments takes time and money. Science may yet find the root causes of all cancers and develop safer methods for shutting them down brain tumors are benign and can be before they have a chance to grow or spread. Based on the CSF Symmetry on the vertical axis through the brain center a normal volume brain tissue and an abnormal volume brain tissue could be classified. Approximately 40 percent of all primary successfully treated with surgery and, in some cases, radiation. Brain cancer is a complex disease, classified into 120 different types.Segmentation is process of partitioning the image into different parts having similar features. The pre-processing stages needs to done on the image initially, followed by clustering algorithms and towards the fag end thresholding be done for the extraction of the tumour which is the region of interest (ROI) from the entire image. The features for thresholding being intensity based, area based Thresholding is the vital part of segmentation as the tumour must be isolated from the brain image. Brain tumors are the leading cause of cancer death in children under the age of 20. They are the second leading cause of cancer death among 20-29 year old males. Metastatic brain tumors result from cancer that spreads from other parts of the body into the brain. The below is a flowchart (sequence) of exactly how a tumour is detected in ours system.

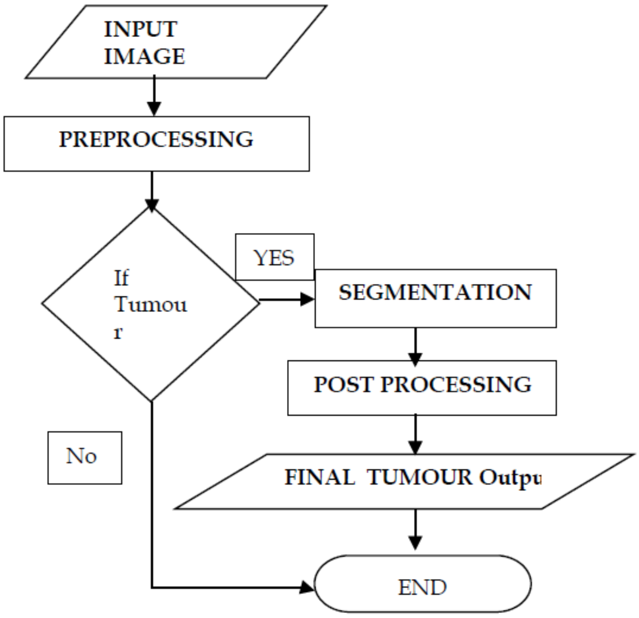

Fig. Flowchart for Brain Tumour Detection

A lot of research efforts have been directed in the field of 'Medical Image Analysis' with the aim to assist in diagnosis and clinical studies. Medical image classification is a key task in many medical applications such as surgical planning, abnormality detection, and so on. Brain image classification is very important for detecting tumors. Magnetic resonance imaging (MRI) is an important imaging technique for detecting abnormal changes in different parts of the brain in early stage. MRI images have good contrast in comparison to computerized tomography (CT).

2. DATA SET:

For the implementation of this application we need to have the images of different patients in our database in order to identify their condition. The MRI image is stored along with our main file from various sources. Various class of MRI image is considered.

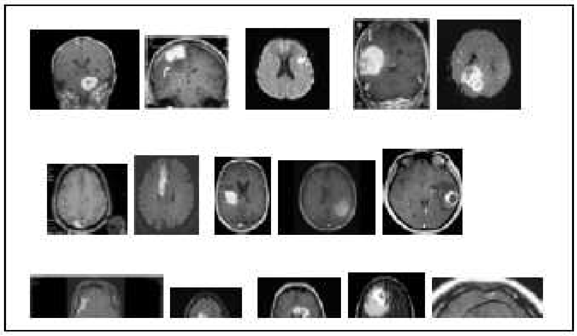

Fig.: Different Patients Images

3. PRE-PROCESSING:

Pre-processing methods use a small neighborhood of a pixel in an input image to get a new brightness value in the output image. The presence of noise is common in all unprocessed medical images. So it becomes obvious that the noise components present in the MRI images are removed and suppressed to the maximum possible extend to obtain accurate results after processing. In modern literature there are several techniques available for noise removal in images. One such technique is the use of pre-processing filters. Here we use a Gaussian filter for noise removal. If this algorithm gives location of tumour then only apply segmentation methods.

Step 1: Given image divided in four equal parts.

Step 2: As human brain is symmetric about vertical axis, upper two parts compared on basis of number of pixels present in each intensity level i.e. histogram matching.

Step 3: Step 2 repeated for lower two parts.

Step 4: if mismatch found in upper two parts’ histogram comparison, symmetry disturbed in upper part hence ‘tumour present in upper part’

Else if mismatch found in lower two parts’ histogram comparison, ‘tumour present in lower part’

Else ‘tumour not present’ in given image.

By preprocessing these unwanted artifacts are removed from the images and prepare the images for further processing like feature extraction, classification, etc. filtering is the basic tool in image preprocessing used to remove these unwanted artifacts. This preprocessing technique is required as in the detection of edges of tumor the tumor appears very dark on the image which is very confusing.

4. SEGMENTATION TECHNIQUE:

Cluster analysis or clustering is the task of assigning a set of objects into groups (called clusters), so that the objects in the same cluster are more similar to each other than to those in other clusters. Clustering can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to efficiently find them. A cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters. The algorithm comprises of the following successive steps:

1. Feature vectors computation to create the feature matrix P using the sliding window.

2. Initialization of the learning process coefficients and the network weights matrix W.

3. Iterative application of the competitive process and the Kohonen learning rule for all feature vectors during the learning stage.

4. NN simulation to assign class numbers to individual feature vectors.

5. Evaluation of the regions classification results.

5. FEATURE EXTRACTION:

The proposed system uses the Discrete Wavelet Transform (DWT) coefficients as feature vector. The wavelet is a powerful mathematical tool for feature extraction, and has been used to extract the wavelet coefficient from MR images. Wavelets are localized basis functions, which are scaled and shifted versions of some fixed mother wavelets. The main advantage of wavelets is that they provide localized frequency information about a function of a signal, which is particularly beneficial for classification. The main feature of DWT is multi scale representation of function. By using the wavelets, given function can be analyzed at various levels of resolution.

The original image is process along the x and y direction by h(n) and g(n) filters which, is the row representation of the original image. As a result of this transform there are 4 sub band (LL, LH, HH, HL) images at each scale. Sub band image LL is used only for DWT calculation at the next scale. To compute the wavelet features in the _rst stage, the wavelet coefficients are calculated for the LL sub band using Harr wavelet function.

6. INFORMATION SYSTEMS AND ROUGH SETS:

Due to space limitations, we provide only a brief explanation of the basic framework of rough set theory, along with some of the key definitions. Rough sets theory provides a novel approach to knowledge description and to approximation of sets. Rough theory was introduced by Pawlak during the early 1980s and is based on an approximation space-based approach to classifying sets of objects. In rough sets theory, feature values of sample objects are collected in what are known as information tables. Rows of such a table correspond to objects and columns correspond to object features. Rough sets provide reasonable structures for the overlap boundary, given domain knowledge. The case study for images of the heart on cardiovascular magnetic resonance (MR) images also extends to handling multiple types of knowledge including: myocardial motion, location, and signal intensity. Research involving color images appears in Histons (i.e., encrustations of a histogram) are used as the primary measure and a visualization of multidimensional color information. The basic idea of a histon is to build a histogram on top of the histograms of the primary color components: red, green, and blue. The authors show that the base histogram correlates with the lower approximation, whereas the encrustation correlates with the upper approximation. The problem of a machine vision application where an object is imaged by a camera system is considered. The object space can be modeled as a finite subset of the Euclidean space when the objects image is captured via an imaging system. Rough sets can bound such sets and provide a mechanism for modeling the spatial uncertainty in the image of the object.

Entropy-based information theoretic approaches have received considerable interest in image analysis approaches such as image registration. Previous work on entropic thresholding is based on Shannon's entropy. The idea is to calculate Shannon's entropy based on a co-occurrence matrix and use it as a criterion for selecting an appropriate threshold value. The approach using relative entropy for image thresholding has been shown very competitive compared to Pal's methods, where the relative entropy is chosen to be a thresholding criterion of measuring mismatch between an image and a thresholded image. Currently, there are various published approaches using relative entropy and applying it to medical images, multispectral imagery, temporal image sequences, multistage thresholding, and segmentation.

7. ROUGH SETS IN MEDICAL IMAGE SEGMENTATION:

The basic idea behind segmentation-based rough sets is that while some cases may be clearly labeled as being in a set X (called the positive region in rough sets theory), and some cases may be clearly labeled as not being in set X (called the negative region), limited information prevents us from labeling all possible cases clearly. The remaining cases cannot be distinguished and lie in what is known as the boundary region. Among many difficulties in segmenting MRI data, the partial volume effect arises in volumetric images when more than one tissue type occurs in a voxel. In such cases, the voxel intensity depends not only on the imaging sequence and tissue properties, but also on the proportions of each tissue type presenting the voxel.Widz et al. discussed the partial volume effect problem in the segmentation of MRI data that entails assigning tissue class labels to voxels. They employ rough sets to automatically identify the partial volume effect, which occurs most often with low-resolution imaging.

An interesting strategy for color image segmentation using rough set theory has been presented by Mohabey and Ray. A new concept of encrustation of the histogram, called histon, has been proposed for the visualization of multidimensional color information in an integrated fashion and its applicability in boundary region analysis has been shown. The histon correlates with the upper approximation of a set such that all elements belonging to this set are clarified as possibly belonging to the same segment or segments showing similar color value.The proposed encrustation provides a direct means of segregating a pool of inhomogeneous regions into its components. Experimental results for various images have been presented in their work. They also introduced a hybrid rough set theoretic approximations and fuzzy c-means algorithm for color image segmentation. They segmented natural images with regions having gradual variations in color value. The technique extracts color information regarding the number of segments and the segments' center values from the image itself through rough set theoretic approximations, and presents it as input to a fuzzy c-means block for the soft evaluation of the segments.The performance of the algorithm has been evaluated on various natural and simulated images. Many clustering algorithms have been developed and applied in medical imaging problems, although most of them cannot process objects in hybrid numerical/nominal feature space or with missing values. In many of them, the number of clusters has to be manually specified while the clustering results are sensitive to the input order of the objects to be clustered. This clearly limits their applicability and reduces the quality of clustering.An improved clustering algorithm based on rough sets and entropy theory was presented by Chena and Wang that aims to avoid the need to prespecify the number of clusters while also allowing clustering in both numerical and nominal feature space with the similarity introduced to replace the distance index. At the same time, rough set theory endows the algorithm with the function to deal with vagueness and uncertainty in data analysis. Shannon's entropy was used to refine the clustering results by assigning relative weights to the set of features according to the mutual entropy values. A novel measure of clustering quality was also presented to evaluate the clusters. The experimental results confirm that performances of efficiency and clustering quality of this algorithm are improved.

Widz et al. introduced an automated multispectral MRI segmentation technique based on approximate reducts derived from the theory of rough sets. They utilized T1, T2, and PD MRI images from a simulated brain database as a gold standard to train and test their segmentation algorithm. The results suggest that approximate reducts, used alone or in combination with other classification methods, may provide a novel and efficient approach to the segmentation of volumetric MRI datasets. Segmentation accuracy reaches 96% for the highest resolution images and 89% for the noisiest image volume. They tested the resultant classifier on real clinical data, which yielded an accuracy of approximately 84%.

CONCLUSION:

Rough sets are ideally appropriate for feature-based image segmentations, image clustering and approximations of medical images. Bear in mind that the focus in the rough set approach to medical imaging is on approximation methods applied to single images or in grouping parts of an image in terms of equivalence classes.

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