'J&K 1', 'J&K 2' and 'J&K Diag' Algorithms used for Extraction and Diagnosis of Brain Abnormality and Diseases from T1 and T2 MRI Images in IDIS.

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Abstract. Intelligent diagnostic Imaging System (IDIS) is a developing imaging modality that is beginning to show promise of detecting and characterizing abnormalities of the brain. The paper is concerned with the development of image processing tools and intelligent algorithms that will automatically detect the abnormalities of the brain and diagnosis of the abnormalities based on the structural information gathered from the images. Two new algorithms (J&K 1 and J&K 2 algorithms) are developed, one for T1 and other for T2. Around 99% of abnormalities of T1 and T2 images can be correctly extracted using the new algorithms. For Diagnosis, a new efficient algorithm (J&K Diag algorithm) is developed.

Keywords: Graphical User Interface (GUI), Intelligent Diagnostic Imaging system (IDIS), Magnetic Resonant Imaging (MRI), Jose and Khan Algorithm 1 (J&K 1), Jose and Khan Algorithm 2 (J&K 2), Jose and Khan Diagnostic Algorithm (J&K Diag).

1. Introduction

The purpose of abnormality extraction is to understand and identify the abnormality which is very helpful for the physician to gain knowledge of the severity of the disease. Region based segmentation is used for this purpose. In abnormality extraction, the threshold detection is very important and it can be considered as the key feature of the Intelligent Diagnostic Imaging System. Usually image segmentation is an initial and vital step in a series of processes aimed at overall image understanding. Different algorithms are used for T1 and T2 MRI Images. MATLAB tools are used to do the segmentation. Region Growing, Region Splitting and Merging and Marker controlled Watershed segmentation method are studied and most pertinent segmentation method is selected and GUI is developed to see the abnormality and diagnose the abnormalities. After getting the information of abnormalities from the developed algorithm, the results are compared with the doctor's diagnosis report.

The image processing methods that will helps the development of IDIS are Filtering, Restoration, Segmentation, Reconstruction, Registration and Pattern Recognition. Proper filtering methods can be adopted to remove the unwanted signal intensities and motion artifacts. Normally MRI scan sequence lasts for half an hour to two hours. It is very difficult to make the scan without motion artifacts. Because of the patient movement, blur images, overlapped or unclear images may result. One of the options is to repeat the scanning process. If the motion artifact is not severe then image restoration methods can be used. If some abnormalities are found by using image registration or some other means, then from each slice of axial, coronal and sagittal planes, the abnormalities can be segmented and reconstructed to get correct size and shape of abnormalities. The normal slice thickness is 5mm and counts the number of slices in axial, coronal

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and sagittal direction where the abnormalities are present. Then we multiply the number of slices with the slice thickness in axial, coronal and sagittal direction. This will give volumetric information of the abnormalities. By using the segmented abnormalities from each slice and slice thickness we can reconstruct the abnormalities. This will help the surgeon in his surgery.

Medical image abnormality extraction is generally difficult because often Noise-to-signal ratio is 10%. This is ten times the Noise-to-signal ratio of camera images. Medical images are often textured in complex ways and relatively poorly sampled. Many pixels contain more than one tissue type. This is called Partial Volume Effect. Objects of interest have complex shapes and the signs of clinical interest are very subtle.

2. Development of IDIS

MATLAB tools are used for IDIS development. The important steps for the development of IDIS are explained below.

2.1. Image Preprocessing

In this work the image preprocessing consists of image format conversion, image database formation, database management, noise removal, and spatial domain image enhancement.

2.2. Abnormality Extraction (Key factor for IDIS)

For abnormality extraction, Different Image segmentation methods are tried. Region growing segmentation algorithm is well suited for abnormality extraction. The threshold detection methods for region growing already available which uses Otsu's method are not working proper for abnormality extraction and it can be applicable only to some of T2 images. Two new algorithms (J&K 1 and J&K 2 algorithms) are developed in this work, one for T1 and other for T2. Around 99% of abnormalities of T1 and T2 images can be correctly extracted using the new algorithms.

2.3. Diagnosis.

Medical diagnosis refers to the process of attempting to determine and/or identify a possible disease or disorder and the opinion reached by this process. After the abnormality is extracted using algorithm mentioned above, a new method for diagnosis (J&K Diag algorithm) is developed based on the boundaries of the abnormality.

2.4. Graphical User Interface (GUI)

Finally Graphical User Interface (GUI) has been developed and utilized to see the result of the IDIS in an easy way. MATLAB based GUI is studied and developed for proper functioning of IDIS. GUI is used for reading the image slice by slice, extraction of the abnormality, Diagnosing the abnormality and displaying the result. So, GUI is used to enhance the application of IDIS.

3. J&K 1 and J&K 2 Algorithms for abnormality extraction.

Two algorithms are developed by the author for threshold detection of T1 and T2 Images. The algorithm for threshold detection of T1 is J&K 1 algorithm and for T2 is J&K 2 algorithm. MATLAB functions are developed for these algorithms, threshodep_modt1 for J&K 1 and threshodep_modt2 for J&K 2. Threshold is based on the analysis of the histogram and represents:

- The difference between seed point (255) and the location of the valley point decided by the algorithm for T2.
- The difference between seed point (0) and the location of the valley point decided by the algorithm for T1.

Histogram is divided into many overlapped subsections. The maxima of each subsection have to be found. To do that a moving window is used of size 10 and it is moved from high intensity level to the low intensity level for T1 and T2 in an overlapped manner of 5 intensity level. Thus we found the maxima (pixel). In this algorithm size of the subsection is 10 intensity levels.

For T2, the maxima values are analyzed from high intensity side to the low intensity side. For T1 it is vice versa. For T2 the first hill point can be found by the following method. If three consecutive maxima are

identical in high intensity side, then that maxima is considered as hill point. Or if two consecutive maxima values are identical and the left and right maxima from the identical maxima are decreasing in magnitude in high intensity side then the identical maxima whose intensity levels are same can be consider as a hill point.

The space between the two hill points is divided into three regions and the valley point of each section is found. If all the valley points satisfy a predefined criteria then left most valley point is considered for T2 as main valley point and rightmost valley point is considered for T1.

Absolute value of the subtraction of main valley point from the Seed Point gives the threshold. Seed Point can be decided by the author. Seed Point can be a single point or a matrix. In IDIS Seed Point is a single point and it is the maximum intensity point for T2 images and minimum intensity point for T1 images.
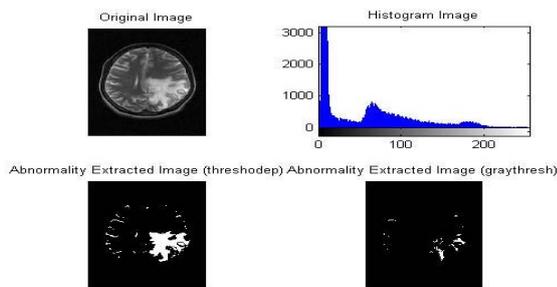

Figure 1: T2 Turbo Spin-echo Axial 13th Slice Image of a 30 year old patient with Venous Infarct. Extraction using threshodep_modt2 function developed by J&K 2 algorithm and existing MATLAB graythresh function. Function threshodep_modt2 gives good result and graythresh failed in this case.
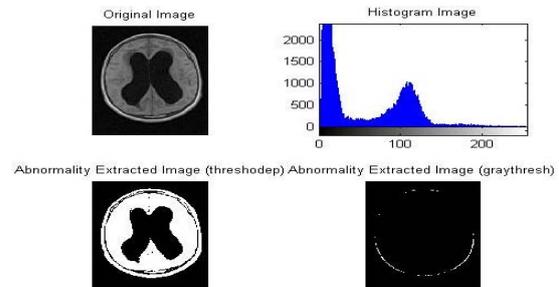

Figure 2: T1 Spin-echo Axial 12th Slice Image of an 18 year old patient with hydrocephalus due to Colloid Cyst. Extraction using threshodep_modt1 function developed by J&K 1 algorithm and existing MATLAB graythresh function. Function graythresh failed in this case.

4. J&K Diag Algorithm for Diagnosis.

After having extracted the abnormality from the image using the new algorithms, the disease has to be diagnosed from the extracted image. The diagnosis then should be compared to the diagnosis done by the medical experts like a doctor or a radiologist. Here we describes the diagnosis of the diseases, methods used and gives a comparative study of diagnosis of the disease by the doctor and by the developed algorithms in the Diagnostic Imaging System (IDIS).

IDIS Diagnosis can be thought of as a combination of Computer-aided diagnosis and Medical imaging Diagnosis. But it differs from present CAD and Medical imaging Diagnosis. The main difference is that it is a complete automatic diagnostic system meant for Brain Abnormalities. The MRI images are given to IDIS and it gives the result that exactly matches with the doctors finding. The IDIS Diagnosis system will do the diagnosis immediately after the MRI scan is taken and time required is much less compared to the doctor's diagnosis.

The IDIS diagnosis section (J&K Diag algorithm) consist the following process. After the abnormality extraction, the abnormality extracted images must be processed as follows for diagnosis.

Filtering (abnormality extracted image): The abnormality extracted image must be filtered using proper filter to remove unwanted portion, dots etc.

Intensity to Binary image conversion: Convert the image to black and white in order to prepare for boundary tracing using bwboundaries (MATLAB).

Noise removal: Using morphology functions, remove pixels which do not belong to the objects of interest. Remove all objects containing fewer than some predefined number of pixels. Fill any holes, so that regionprops can be used to estimate with the percentage of the area enclosed by each of the boundaries.

Boundary calculation: Concentrate only on the exterior boundaries. Option 'noholes' will accelerate the processing by preventing bwboundaries from searching for inner contours. Use regionprops to obtain estimates of the area for all of the objects. Notice that the label matrix returned by bwboundaries can be reused by regionprops.

Area calculation & Perimeter calculation: Estimate each object's area and perimeter. Use these results to form a simple metric indicating the roundness of an object

Metric calculation: Metric = 4*pi*area/perimeter^2. This metric is equal to one only for a circle and it is less than one for any other shape. The discrimination process can be controlled by setting an appropriate threshold.

Decision Making (Diagnosis): Depending on the Metric Value we can do the diagnosis. Normally the important abnormalities have particular boundary shape. If the abnormality is well circumscribed then we can understand that it is a Benign Tumor. If the abnormality is well circumscribed but the edges are little blotted (spread like ink) then the abnormality is a Malignant Tumors and if the abnormality is more blotted then it is a Lesion. If the abnormality whose boundaries are confined but irregular shape then we can conclude that it is a Hydrocephalus. Metric calculation of all abnormality slices of a particular patient must be done prior to the decision making. The range of Metric of majority of the slices must be considered for decision making.
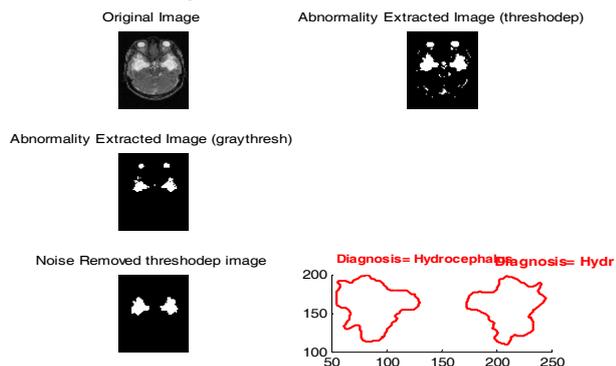
Figure 3: Figure shows the IDIS result of T2 TSE Transverse 6th Slice of a Patient with obstructive hydrocephalus. Resulted figure window shows original image, thresodep and graythresh abnormality extracted image, noise removed image and Diagnosis result.
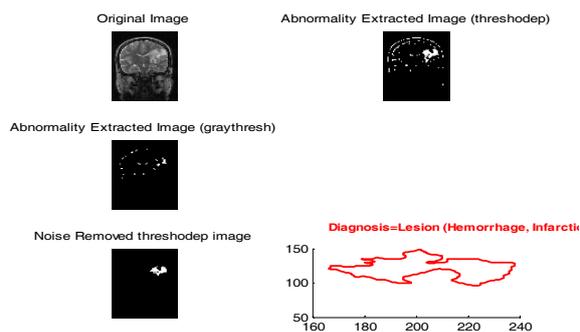
Figure 4: Figure shows the IDIS result of T2 TSE Coronal 12th Slice of a Patient with granulomatous lesion. Resulted figure window shows original image, thresodep and graythresh abnormality extracted image, noise removed image and Diagnosis result.

5. Conclusion &Future Scope

Around 99% of abnormalities of T1 and T2 images can be correctly extracted using the new algorithms. After working with many samples, it is found that using Region Growing Segmentation algorithm with automatic seed point and author defined threshold functions (collectively called as J&K 1 and J&K 2 algorithms), the abnormalities are precisely extracted. Author defined functions thresodep_modt1 and thresodep_modt2 succeeded in about 99% of cases. graythresh MATLAB M function succeeded only for 30 to 40 percentage of cases of T2 images only. graythresh failed in T1 images. If the image contains hypo and hyper intensity abnormalities then both algorithms thresodep_modt1 and thresodep_modt2 should be used to extract the abnormalities. MRI Sample images of over 100 patients were taken and studied. About 2000 slices of abnormal images were subjected to the developed algorithm. The result thus obtained and diagnosed by the developed IDIS are in tandem with the clinical diagnosis of the doctor.

Present Algorithm can be used for the diagnosis of major abnormalities with clear intensity change. There are lots of abnormalities where the intensity change is not evident. Therefore technologies can be developed so that the system can be a complete diagnostic system. More features that can even detect the complicated diseases like Alzheimer's disease can be added to the system. All slice abnormalities of a particular patient can be assembled to get volumetric information of the abnormalities which will help the surgeon while performing surgery.

6. Acknowledgements

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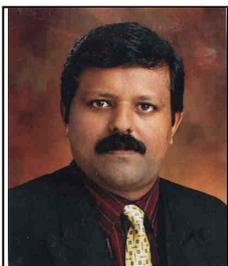
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