Brain Tumor Detection using K-SVD Denoising & Fuzzy C-means Clustering

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Abstract— In MRI images, the amount of data is too much for manual interpretation and analysis. Because of high quantity data in MRI images, the tumor segmentation and classification is very hard. During past few years, brain tumor segmentation in MRI (magnetic resonance imaging) has become an emergent research area in the field of medical imaging system So far, brain tumors are identified by the expertise of the radiologists but this paper presents a new technology of detecting the tumor by simply feeding the MRI (magnetic resonance imaging) of the brain into the system to obtain knowledge on the occurrence of the brain tumor. Initially the MRI brain image quality enhanced through K-SVD (Singular Value Decomposition) Denoising algorithm. An efficient algorithm is proposed for tumor detection based on the Spatial Fuzzy C-Means Clustering, this paper introduces a novel module in combining the techniques to detect brain tumor and to obtain the result.

Key words: Image Segmentation, Brain MRI (Magnetic Resonance Imaging), K-SVD Denoising, Spatial Fuzzy C-Means Clustering

I. INTRODUCTION

Information is conveyed through images. Image processing is a process where input image is processed to recognize the image under consideration. All the images used in today's world are in digital format. Medical images are images that show the physical attributes. Medical imaging modalities as in MRI, CT scan mostly depend on computer technology to display digital images of the internal organs of the human body which helps the doctors to visualize the inner portions of the body. Magnetic Resonance Imaging has taken over conventional x-ray imaging, by allowing the doctors see the body's third dimension.

A. Magnetic Resonance Imaging

Protons and neutrons of the nucleus of an atom have an angular momentum which is known as a spin. These spins will cancel when the number of subatomic particles in a nucleus is even. Nuclei with odd number will have a resultant spin .This forms the basis of magnetic resonance imaging. A magnetic resonance imaging (MRI) scanner uses powerful magnets to polarize and excite hydrogen nuclei (single proton) in human tissue, which produces a signal that can be detected and it is encoded spatially, resulting in images of the body. The MRI machine emits radio frequency (RF) pulse that specifically binds only to hydrogen. The system sends the pulse to that specific area of the body that needs to be examined. Due to the RF pulse, protons in that area absorb the energy needed to make them spin in a different direction. This is meant by the resonance of MRI. The RF pulse makes the protons spin at the Lamoure frequency, in a specific direction. This frequency is found based on the particular tissue being imaged and the strength of the main magnetic field. MRI uses three electromagnetic fields: static field which is a very strong static magnetic field which polarizes the hydrogen nuclei; gradient field which is a weaker time-varying field used for spatial encoding; and a weak radio frequency field for manipulation of the hydrogen nuclei to produce measurable signals, which are collected through radio frequency antenna.

B. Challenges

The brain is the anterior most part of the central nervous system. Brain tumor is an intracranial solid neoplasm. Tumors are created by an abnormal and uncontrolled cell division in the brain. In this work, we have used axial view of the brain image (2D) from MRI scan because MRI scan is less harmful than CT brain scan. A patient is subjected to different diagnostic methods to determine the cause of the symptoms. Techniques like performing a biopsy, performing imaging, like taking a MRI or CT scan of the brain will be done. In biopsy, pathologists take a specimen of the brain tissue under consideration for checking the presence of tumor. A pathologist looks at the tissue cells under a microscope to check for presence of abnormality. Though biopsy will show the presence of tumor and its pathology, when doctors go for surgery, they must know the tumor extent and the exact location of tumor in the brain, which can be found by taking MRI scan of the patient as MRI doesn't involve the use of harmful radiations when compared to CT scan. Traditional method in hospitals is to segment the medical image under consideration, manually and this depends on how well the physician can perceive the image under consideration to get the required region extracted out, which is made difficult because of minute variations and resemblance between the original and affected biological part in the image. The shortage of radiologists and the large volume of MRI to be analyzed make these readings labor intensive and also cost expensive. It also depends on the expertise of the technician examining the images. Estimates also indicate that between 10 and 30% of tumors are missed by the radiologists during the routine screening.

II. PROPOSED METHODOLOGY

The work carried out involves the processing of MRI images of brain for the detection of brain tumors. The image processing techniques like image segmentation, image enhancement and feature extraction are used on the background of the module. The image processing occurs on the initial stage of image analysis and if the tumor is detected by the module then the result is obtained on the system. The system is designed to be user friendly and is created by linking the various matlab codes in a single module. The following are the steps involved in the module:
Step 1: Consider MRI scan image of brain of patients. Step 2: Test MRI scan with the knowledge base.
Step 3: Two cases that are available are

1) Tumor detected
2) Tumor not detected

Fig. 1: Step 1

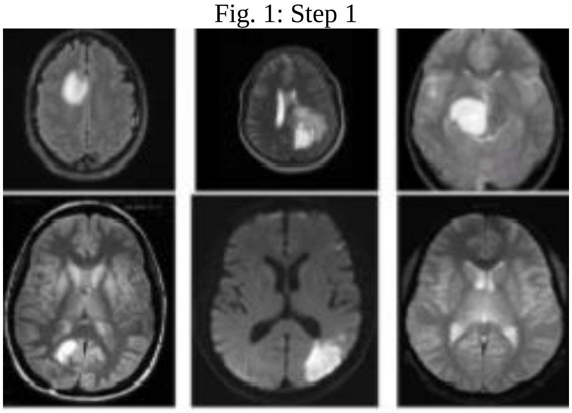

Fig. 2: Dicom Images

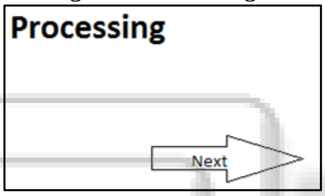

Fig. 3: Step 2

III. IMAGE PROCESSING TECHNIQUES

During the acquisition of medical images, there are possibilities that the medical image one gets might be degraded because of problems that can occur during the acquisition stage. So the original image may not be suitable for analysis. Image segmentation can be defined as the partition or segmentation of a digital image into similar regions with a main aim to simplify the image so that it is easier to analyze visually. Image segmentation is one of the significant processes in majority of medical analysis. Image segmentation can be based on thresholding. The block diagram is shown below:

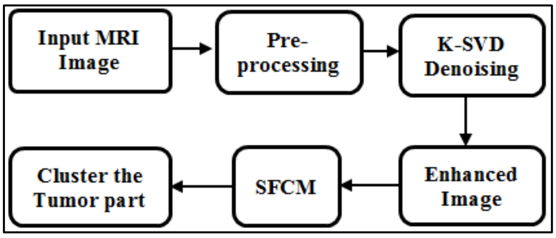

Fig. 4: Block Diagram

A cluster can be defined as a group of pixels where all the pixels in certain group defined by a similar relationship. Clustering is also known as unsupervised classification technique. The name unsupervised classification because the algorithm automatically classifies objects based on user given criteria. Here Spatial Fuzzy C-means clustering algorithm for segmentation of the image is used for tumor detection from the brain MRI images.

The algorithm that we have proposed is as follows:

1) Let $x_1,\ldots,x_M$ are N data points in the input image, let k be the number of clusters which is given by the user.
2) Choose $c_1,\ldots,c_K$ cluster centers.
3) Distance between each pixel and each cluster centre is found.
4) The distance function is given by J= | xi-cj | for i=1,…,N and for j=1,…,k, where | xi-cj | is the absolute difference of the distance between a data point xi and the cluster centre cj and indicates the distance of the N data points from their respective cluster centers.
5) Distribute the points x among the k clusters using the relation $x \in {}_{Cj}$ if $|x-c_j| < |x-c_i|$ for $i=1,2,\ldots,k$, $i \neq j$, where C_j denotes the set of data points whose cluster centre is C_j .
6) Updated cluster centre is given as, $C_j = {}^{1}/m_i \; \Sigma_{\,x \,\in\, Ci} x$, for $i=1,\ldots,k$, where m_i is the number of objects in the dataset C_i ,where C_i is the cluster and i^{th} is the centre of cluster C_i .
7) Repeat from Step 5 to Step 8 till convergence is met.
8) After segmentation and detection of the desired region, there are chances for misclustered regions to occur after the segmentation algorithm, hence morphological filtering is performed for enhancement of the tumor detected portion. Here structuring element used is disk shaped.

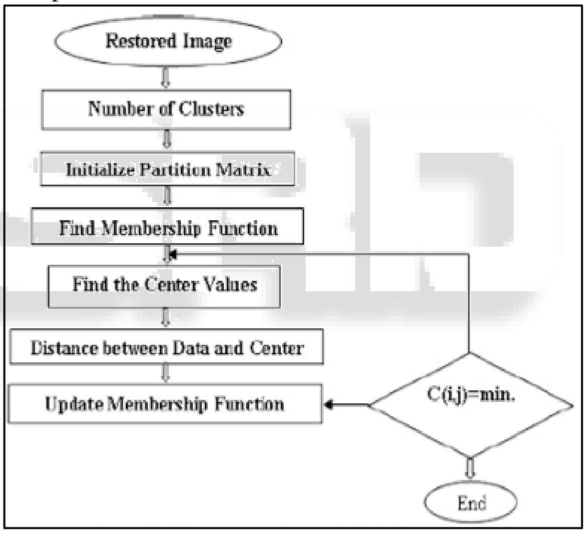

Fig. 5: Flow Chart Spatial Fuzzy Clustering

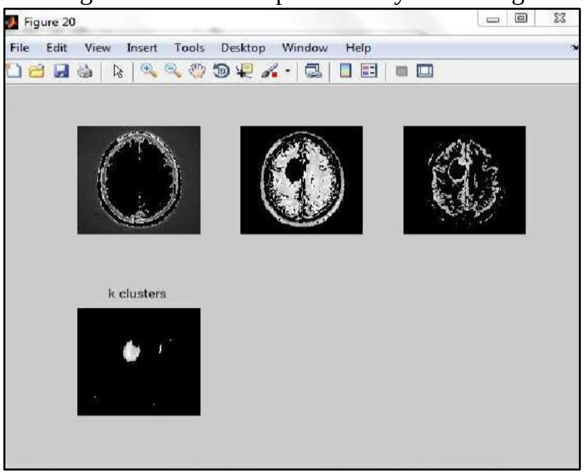

Fig. 6: Extraction of Features

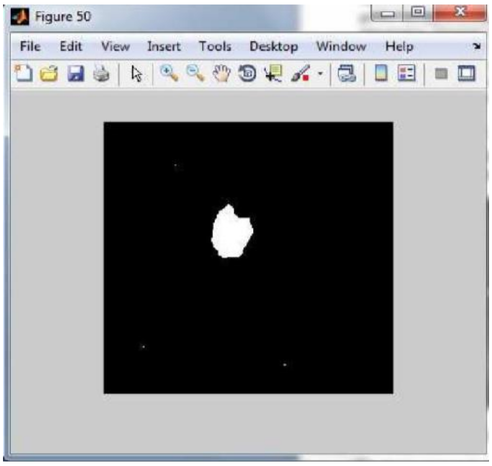

Fig. 7: Tumor Detected

Morphology is the study of shapes and structures from a scientific perspective. Morphological filters are formed from the basic morphology operations. A structuring element is mainly required for any morphological operation. Morphological operations operate on two images, structuring element and the input image. Structuring elements are small images that are used to probe an input image for properties of interest. Origin of a structuring element is defined by the centre pixel of the structuring element. In morphology, the structuring element defined will pass over a section of the input image where this section is defined by the neighborhood window of the structuring element and the structuring element either fits or not fits the input image. Wherever the fit takes place, corresponding image that represents the input image's structure is got and suppression of the geometric features of the input image that doesn't fit the structuring element's neighborhood takes place. Two main morphology operations are erosion and dilation where erosion results in the thinning of the objects in the image considered and dilation results in thickening of the objects in the image. Dilation uses the highest value of all the pixels in the neighborhood of the input image defined by the structuring element and erosion uses the lowest value of all the pixels in the neighborhood of the input image.

IV. Conclusion

The project has presented an automated brain image classification system for tumor detection and has also contoured the tumor region using image segmentation. Initially the MRI Brain image can enhanced through K-SVD Denoising algorithm. Here spatial fuzzy C-means clustering algorithm was utilized effectively for accurate tumor detection and area measurement. Thus, the system has proved that it provides better classification accuracy and high specificity than the existing models.

V. Future Scope

There is a future scope of locating the lobe where the tumor has been identified, thus featuring the diagnosis of the symptoms based on the occurrence.

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