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BRAIN TUMOR DETECTION USING CLUSTERING

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Abstract: This paper focuses on detecting brain tumor in human beings. A brain imaging technique called Magnetic Resonance Imaging (MRI) is used to collect the images of the brain. MRI scan can provide information about the blood circulation throughout the body and blood vessels and also enabling the detection of problems related to the blood circulation in the brain. In this work, first the image is segmented using K-means clustering algorithm. Next performed a feature extraction on the segmented image using Discrete Wavelet Transform (DWT). Finally, the extracted features are classified using Support Vector Machine (SVM). In SVM I first create a classification model and then classify the new data based on the trained dataset. The classifier created by the proposed research work produced an accuracy of 90% and is efficient.

Keywords: Brain Tumor, Magnetic Resonance Imaging, Clustering, Support Vector Machine, Classification

I. INTRODUCTION

Data mining is a technology that blends traditional data analysis methods with sophisticated algorithms for processing large volume of data. It has also opened up exciting opportunities for exploring and analyzing new types of data and for analyzing old types of data in new ways [1]. Data mining is an integral part of knowledge discovery in databases, which is the overall process of converting raw data into useful information. It is the non-trivial extraction of implicit previously unknown and potentially useful information about data [2]. In brief, data mining is the process of extracting patterns from data [3].A brain tumor or intracranial neoplasm occurs when abnormal cells from within the brain. There are two main types of tumors: malignant or cancerous tumors and benign tumors. Cancerous tumors can be divided into primary tumors that start within the brain, and secondary tumors that have spread from somewhere else, known as brain metastasis tumors. All types of brain tumors may produce symptoms that vary depending on the part of the brain involved. Imaging is an essential aspect of medical science to visualize the anatomical structures of the human body. Neuroimaging or brain imaging is the use of various techniques to either directly or indirectly image the structure, function/pharmacology of the nervous system. It is a relatively new discipline within medicine, neuroscience, and psychology. The purpose of this research paper is to introduce an automated brain tumor detection system from MRI images using K-means clustering algorithm and Discrete Wavelet Transforms (DWT). A detailed literature review is made in Section 2. Section 3 describes about Brain Tumour and Neuroimaging. The proposed implementation methodology is explained in Section 4. Section 5 presents the result analysis and findings followed by Section 6 deals with conclusion and future research work.

II. LITERATURE REVIEW

Magnetic resonance imaging (MRI) is an important imaging technique used in the detection of brain tumor. Brain tumor is one of the most dangerous diseases occurring among the children and adults. It is apparent that of chances survival of patient could be expanded if tumor is identified at its initial stage. Manual classification of brain tumor is time devastating and bestows ambiguous results. Automatic image classification is emergent thriving research area in medical field. Brain MRI plays a very important role for radiologists to diagnose and treat brain tumor patients. In this paper I present an overview of the current research being carried out using the neural network techniques and Tissue Segmentation Techniques for the diagnosis of brain tumor. Automating this process is a challenging task because of the high diversity in the appearance of tumor tissues among different patients and in many cases similarity with the normal tissues. MRI is an advanced medical imaging technique providing rich information about the human soft-tissue anatomy. There are different brain tumor detection and segmentation methods to detect and segment a brain tumor from MRI images. These detection and segmentation approaches are revieId with an importance placed on enlightening the advantages and drawbacks of these methods for brain tumor detection and segmentation.

According to Y.Jayaurya, A.V.Prabu, SmaranikaGouda, PallaviNayak color-based segmentation algorithm with K-means is to change a given gray-level MR image into a color space image(RGB) and then separate the position of tumor objects from other items of an MR image by using Kmeans clustering process and histogram-clustering [4]. Experiments proved that the method successfully accomplish segmentation for MR brain images to help find pathologists distinguish exact lesion size and region.

Ming-Ni Wu, Chia-Chen Lin and Chin-Chen Chang describes that a color-based segmentation method that uses the K-means clustering technique to track tumor objects in magnetic resonance (MR) brain images[5].

A.Sivaramakrishnan and Dr. M.Karnan proposed a novel and an efficient detection of the brain tumor region from cerebral image was done using Fuzzy C-means clustering and histogram. The histogram equalization was used to calculate the intensity values of the grey level images. The decomposition of images was done using principle component analysis which was used to reduce dimensionality of the wavelet co - efficient. The results of the proposed Fuzzy C-means (FCM) clustering algorithm successfully and accurately extracted the tumor region from brain MRI brain images [6].

III. BRAIN TUMOR AND NEURO IMAGING

Several new complex medical imaging modalities, such as X-ray, magnetic resonance imaging (MRI), and ultrasound, strongly depend on computer technology to generate or display digital images. With computer techniques, multidimensional digital images of physiological structures can be processed and manipulated to help visualize hidden diagnostic features that are otherwise difficult or impossible to identify using planar imaging methods. Segmentation is an important process in most medical image analysis and classification for radiological evaluation or computer-aided diagnosis. Basically, image segmentation methods can be classified into three categories: edge-based methods, region-based methods and pixel-based methods. K-means clustering is a key technique in pixel-based methods. Because pixel-based methods based on K-means clustering are simple and the computational complexity is relatively low compared with other region-based or edge-based methods, the application is more practicable. Furthermore, K-means clustering is suitable for biomedical image segmentation as the number of clusters is usually known for images of particular regions of the human anatomy. In this paper, I carefully select the appropriate features from brain images as the clustering features to achieve good segmentation results while maintaining the low computation aspect of the segmentation algorithm. Because the color space transformation function in our proposed method is a fundamental operation for most image processing systems, the color space translation does not cause extra overhead in the proposed scheme. Therefore, by using color-based segmentation with K-means clustering to magnetic resonance (MR) brain tumors, the proposed image tracking method maintains efficiency

Neuroimaging is a technique that either directly or indirectly takes the images of the nervous system. It is more helpful for finding neurological disorders in a person. Through imaging I can see the various actions of the brain by a photographed. When a brain image is taken, the neuronal firing acts as a sparks of light to light up the brain areas where the activity is present. Neuroimages depends only on the parameters of the scan and the blood flow change.

Neuroimaging falls into two broad categories:

- Structural imaging, which deals with the structure of the nervous system and the diagnosis of gross (large scale) intracranial disease (such as tumor) and injury.
- Functional imaging, which is used to diagnose metabolic diseases and lesions on a finer scale (such as Alzheimer's disease) and also for neurological and cognitive psychology research and building brain-computer interfaces.

Functional imaging enables, for example, the processing of information by centers in the brain to be visualized directly. Such processing causes the involved area of the brain to increase metabolism and "light up" on the scan.

There are different brain imaging techniques used such as Computed tomography (CT) or Computed Axial Tomography (CAT), Diffuse optical imaging (DOI) or diffuse optical tomography (DOT), Event-related optical signal (EROS), Magnetic resonance imaging (MRI) , Functional magnetic resonance imaging (fMRI) and arterial spin labeling (ASL), Magnetoencephalography (MEG), Positron emission tomography (PET) , Single-photon emission computed tomography (SPECT) and Cranial ultrasound [7].

In this research work I have used Magnetic resonance imaging (MRI) to take the brain images. Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease. MRI scanners use strong magnetic fields, radio waves, and field gradients to generate images of the organs in the body. MRI does not involve x-rays, which distinguishes it from computed tomography (CT or CAT). While the hazards of x-rays are now Ill-controlled in most medical contexts, MRI still may be seen as superior to CT in this regard. MRI often may yield different diagnostic information compared with CT. Compared with CT, MRI scans typically take greater time, are louder, and usually require that the subject go into a narrow, confined tube. MRI is based upon the science of nuclear magnetic resonance (NMR). Certain atomic nuclei are able to absorb and emit radio frequency energy when placed in an external magnetic field. In clinical and research MRI, hydrogen atoms are most-often used to generate a detectable radio-frequency signal that is received by antennas in close proximity to the anatomy being examined. Hydrogen atoms exist naturally in people and other biological organisms in abundance, particularly in water and fat. For this reason, most MRI scans essentially map the location of water and fat in the body. Pulses of radio waves excite the nuclear spin energy transition, and magnetic field gradients localize the signal in space. By varying the parameters of the pulse sequence, different contrasts may be generated betIen tissues based on the relaxation properties of the hydrogen atoms therein [8].

Several new complex medical imaging modalities, such as X-ray, magnetic resonance imaging (MRI), and ultrasound, strongly depend on computer technology to generate or display digital images. With computer techniques, multidimensional digital images of physiological structures can be processed and manipulated to help visualize hidden diagnostic features that are otherwise difficult or impossible to identify using planar imaging methods. Segmentation is an important process in most medical image analysis and classification for radiological evaluation or computer-aided diagnosis. Basically, image segmentation methods can be classified into three categories: edge-based methods, region-based methods and pixel-based methods. K-means clustering is a key technique in pixel-based methods. Because pixel-based methods based on K-means clustering are simple and the computational complexity is relatively low compared with other region-based or edge-based methods, the application is more practicable. Furthermore, K-means clustering is suitable for biomedical image segmentation as the number of clusters is usually known for images of particular regions of the human anatomy. In this paper, I carefully select the appropriate features from brain images as the clustering features to achieve good segmentation results while maintaining the low computation aspect of the segmentation algorithm. Because the color space transformation function in our proposed

method is a fundamental operation for most image processing systems, the color space translation does not cause extra overhead in the proposed scheme. Therefore, by using color-based segmentation with K-means clustering to magnetic resonance (MR) brain tumors, the proposed image tracking method maintains efficiency.

IV.METHODOLOGYAND IMPLEMENTAION

The system is implemented in MATLAB. MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python. MATLAB is a software that has an excellent graphical capability and a poIrful programming language. It is a data analysis and visualization tool designed to support matrices and matrix operations. In MATLAB programs are designed to support a particular task. It has a platform-independent interpreted language optimized for numerical (matrix and array) computation. It allows performing numerical calculations easily and has a Simple High Level Syntax. MATLAB allows its user to accurately solve problems, produce graphics easily and produce code efficiently.

A) Clustering

Clustering can be considered the most important unsupervised learning problem. A cluster is therefore a collection of objects which are "similar" betIen them and are "dissimilar" to the objects belonging to other clusters. The goal of clustering is to determine the intrinsic grouping in a set of unlabeled data. In this research work I have used image segmentation using k-means clustering algorithm. Image segmentation is the classification of an image into different groups. Many researches have been done in the area of image segmentation using clustering. There are different methods and one of the most popular methods is k-means clustering algorithm. K - means clustering algorithm is an unsupervised algorithm and it is used to segment the interest area from the background. K-means clustering aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into Voronoi cells. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture.

B) Feature Extraction

Next a feature extraction is performed on the segmented image and for this research work; I have used Discrete Wavelet Transform (DWT). In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency and location information (location in time). There are different kinds of wavelets in use such as Haar wavelets, Daubechies wavelets, the dual-tree complex wavelet transform. In this research work I have used Haar wavelets. The first DWT was invented by Hungarian mathematician Alfred Haar. For an input represented by a list of 2^n numbers, the Haar wavelet transform may be considered to pair up input values, storing the difference and passing the sum. This process is repeated recursively, pairing up the sums to prove the next scale, which leads to 2^n-1differences and a final sum. In mathematics, the Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal basis. The Haar sequence is now recognized as the first known wavelet basis and extensively used as a teaching example. The Haar wavelet is also the simplest possible wavelet.

C) Classification

The extracted features are classified as normal or abnormal using a classifier known as Support Vector Machine (SVM). Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for both classification and regression challenges. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall. A good separation is achieved by the hyperplane that has the largest distance to the nearest training-data point of any class, since in general the larger the margin the loIr the generalization error of the classifier. In SVM I first train a support vector machine and then cross validate the classifier and use this trained machine to classify the new data to obtain a satisfactory predictive accuracy.

D) Proposed Work

The proposed work is to identify the persons having brain tumor from those who are normal. For doing this research work MRI images of the brain where collected from hospitals as Ill as through internet. The collected images where segmented using K-means clustering algorithm and features where extracted from the segmented image. The features thus extracted are trained using a classifier and the accuracy of the classifier is calculated. The trained machine is used to classify the new data.

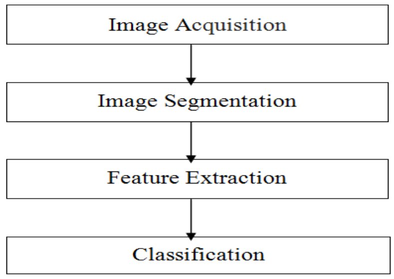

Figure 1: General Model

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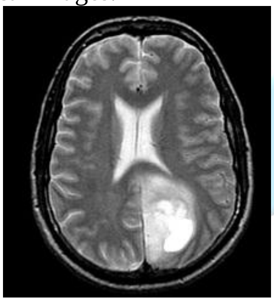
E) Image Acquisition And Segmentation

The images used in this research work are Magnetic Resonance Imaging (MRI). Magnetic resonance imaging (MRI) of the body uses a poIrful magnetic field, radio waves and a computer to produce detailed pictures of the inside of your body. Unlike conventional x-ray examinations and computed tomography (CT) scans, MRI does not utilize ionizing radiation. Instead, radiofrequency pulses re-align hydrogen atoms that naturally exist within the body while you are in the scanner without causing any chemical changes in the tissues. As the hydrogen atoms return to their usual alignment, they emit different amounts of energy that vary according to the type of body tissue from which they come. The MR scanner captures this energy and creates a picture of the tissues scanned based on this information. Image segmentation is the classification of an image into different groups. There are different methods and one of the most popular methods is *k*-means clustering algorithm. *K*-means clustering algorithm is an unsupervised algorithm and it is used to segment the interest area from the background. Clustering is a process of partitioning or grouping a given sector unlabeled pattern into a number of clusters such that similar patterns are assigned to a group, which is considered as a cluster. Segmentation is an essential process to extract information from composite medical images.



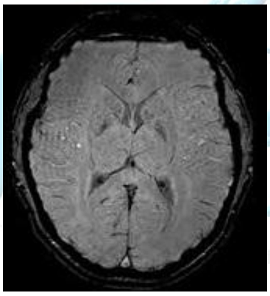


Figure 2: Abnormal MRI image Figure3: Normal MRI image

F) The K-Means Algorithm

K-means clustering is a data mining/ machine learning algorithm used to cluster observations into groups of related observations without any prior knowledge of those relationships. The k-means algorithm is one of the simplest clustering techniques and it is commonly used in medical imaging, biometrics, and related fields. The k-means algorithm is an evolutionary algorithm that gains its name from its method of operation.

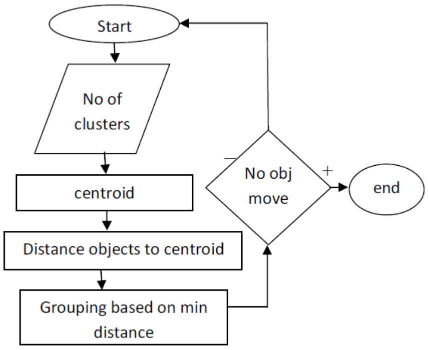


Figure 4: K-means algorithm flowchart

H) Support Vector Machine

The classifier used in this research work to distinguish betIen normal and abnormal image is Support Vector Machine (SVM). A support vector machine (SVM) is used when data has exactly two classes. A Support Vector Machine (SVM) is a discriminative classifier formally defined by a separating hyperplane. In other words, given labeled training data (*supervised learning*), the algorithm outputs an optimal hyperplane which categorizes new examples. The operation of the SVM algorithm is based on finding the hyperplane that gives the largest minimum distance to the training examples. Twice, this distance receives the important name of margin within SVM's theory. Therefore, the optimal separating hyperplane maximizes the margin of the training data.

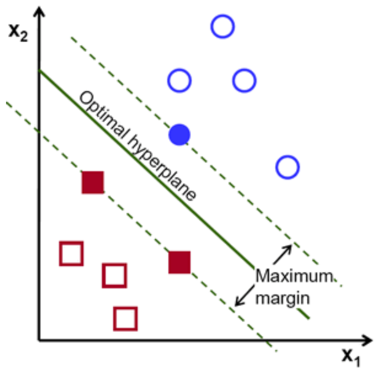


Figure 5: SVM classifier

Support Vectors are simply the co-ordinates of individual observation. Support Vector Machine is a frontier which best segregates the two classes (hyper-plane/ line). The easiest way to interpret the objective function in a SVM is to find the minimum distance of the frontier from closest support vector (this can belong to any class). Once I have these distances for all the frontiers, I simply choose the frontier with the maximum distance (from the closest support vector).

I) Training And Testing

The classification using SVM has two steps. The first one is training the dataset and then testing the dataset. The training and testing consist of sub steps.

1. Training
   a. Image segmentation using k-means clustering algorithm.
   b. Feature Extraction – to extract the features.
   c. Model Estimation- I estimate a model for the training dataset.
2. Testing
   a. Image segmentation using k-means clustering algorithm.
   b. Feature Extraction – to extract the features.
   c. Classification- compare the features with the estimated model.

J) Classification

To classify new data I use the result of training, SVMStruct , with the svmclassify function. The svmclassify classify using SVM.

Group = svmclassify(SVMStruct, Sample) classifies each row of the data in Sample, a matrix of data, using the information in a support vector machine classifier structure SVMStruct, created using the svmtrain function. Like the training data used to create SVMStruct, Sample is a matrix where each row corresponds to an observation or replicate, and each column corresponds to a feature or variable. Therefore, Sample must have the same number of columns as the training data. This is because the number of columns defines the number of features. Group indicates the group to which each row of Sample has been assigned.
Group = svmclassify(SVMStruct, Sample, 'Showplot', true) plots the Sample data in the figure created using the Showplot property with the svmtrain function. This plot appears only when the data is two-dimensional.

- SVMStruct - Support vector machine classifier structure created using the svmtrain function.
- Sample - A matrix where each row corresponds to an observation or replicate, and each column corresponds to a feature or variable. Therefore, Sample must have the same number of columns as the training data. This is because the number of columns defines the dimensionality of the data space.
- Showplot- Describes whether to display a plot of the classification. Displays only for 2-D problems. Follow with a Boolean argument: true to display the plot, false to give no display.
- Group - Column vector with the same number of rows as Sample. Each entry (row) in Group represents the class of the corresponding row of Sample.

V. RESULT ANALYSIS AND FINDINGS

The research work is implemented in MATLAB. MRI images Ire collected from various hospitals as Ill as through internet that are correctly classified by experts and this dataset has been used for training. The total number of MRI images collected is 66, out of which 56 are used for training and 10 for testing. The training dataset consist of 29 abnormal images and 27 normal images. The number of features extracted for each dataset is 2500 and these features Ire analyzed for classification. The research work provides a simple GUI which can be used by the user to train the database, to classify new image and to find the accuracy of the classifier. In this research work our input image is a MRI image of brain and the image of each person is processed in the same way to analyze whether the person is affected with tumor or not. To evaluate the performance of the classifier I have used Confusion matrix. Performance is evaluated based on three measures viz., Accuracy, Specificity and Sensitivity. Accuracy is used to process the quality of the classification. Sensitivity deals with only positive cases, specificity with negative cases whereas accuracy deals with both positive and negative cases.
The confusion matrix for our classifier is as shown below:

Actual	Predicted	
	Yes	No
Yes	4	0
No	1	5

Table 1 - Confusion matrix for SVM

The research work measured all 4 test images for abnormal MRI as tumor image whereas from 6 normal images, 5 Ire correctly classified as normal image and 1 was classified as tumor image. Based on the above tables the three measures of performance can be calculated as: Accuracy= 90%, Sensitivity = 83% and Specificity = 100%. For the 10 test cases given , the accuracy of the test case is 90% which means that the classification has an excellence of 90%, sensitivity of the test case is 83% which means that 83% depends only on the positive cases and specificity is 100% which means that 100% of them depended only on the negative cases.

In this research work, medical imaging technique called MRI is used to take the images of the brain. The MRI images Ire collected from hospitals and different Ibsites like RADIOPAEDIA.ORG, BRAINIX, LONI Image data archive (IDA). The database consists of 66 images out of which 56 images are used for training and 10 images are used for testing. The training dataset consist of 27 abnormal and 29 normal images and 4096 features of image Ire studied.
In this research work, k-means clustering algorithm was used to segment the images. The K-means algorithm is an iterative technique that is used to partition an image into K clusters. In brain MRI analysis, image segmentation is commonly used for measuring and visualizing the brain's anatomical structures, for analyzing brain changes, for delineating pathological regions, and for surgical planning and image-guided interventions. Then features Ire extracted from the segmented image and I have used Discrete wavelet transform (DWT) to extract features from each image. DWT decompose signals into sub bands of smaller bandwidths and sloIr sample rates. DWT is a wavelet transform in which the wavelets are discretely sampled. It captures both location frequency and location information. I have used Haar wavelet decomposition in this research work. In Haar wavelet I perform two iterations of the 2D Haar wavelet decomposition on the image i.e. the original image is high-pass filtered it is then low-pass filtered and downscaled yielding an approximation coefficient sub image (this is performed once again on the approximated image).

Then, all the extracted features Ire classified using Support Vector Machine (SVM). A support vector machine (SVM) is used when data has exactly two classes. A Support Vector Machine (SVM) is a discriminative classifier formally defined by a separating hyperplane. In other words, given labeled training data (*supervised learning*), the algorithm outputs an optimal hyperplane which categorizes new examples. The operation of the SVM algorithm is based on finding the hyperplane that gives the largest minimum distance to the training examples. SVM has two steps; the first one is training the dataset and then testing the dataset. The training and testing consists of sub steps: for Training I first perform image segmentation using K-means clustering algorithm. Then feature extraction is performed to extract the features and I estimate a model for the training dataset. For testing I perform image segmentation using K-means clustering algorithm and then feature extraction is performed to extract the features and compare the features of the image with the estimated model.
The performance measures of the classifier Ire calculated using Confusion matrix. Accuracy is the classification

excellence and is calculated to be 90%. Sensitivity of the classifier, that is the dependence on positive cases is 83% and specificity is 100% means that the dependence on negative cases is 100%.

VI. CONCLUSION

In this research work, medical imaging technique called MRI is used to take the images of the brain. MRI is particularly useful for the scanning and detection of abnormalities in soft tissue structures. There is no involvement of any kind of radiations in the MRI, so it is safe for the people who can be vulnerable to the effects of radiations. such as pregnant women or babies. MRI scan can provide information about the blood circulation throughout the body and blood vessels and also enabling the detection of problems related to the blood circulation. The research work presents an automated brain tumor detection system from MRI images using K-means clustering algorithm and Discrete Wavelet Transforms (DWT).

The MRI images are then segmented using K-means clustering algorithm. The K-means algorithm is an iterative technique that is used to partition an image into K clusters. In brain MRI analysis, image segmentation is commonly used for measuring and visualizing the brain's anatomical structures, for analyzing brain changes, for delineating pathological regions, and for surgical planning and image-guided interventions. The features are extracted from the segmented image and I have used Discrete Wavelet Transform (DWT) to extract features from each image. DWT decompose signals into sub bands of smaller bandwidths and sloIr sample rates. I have used Haar wavelet decomposition in this research work as it can analyze the signals with sudden transitions. Then, all the extracted features Ire classified using Support Vector Machine (SVM) and accuracy is measured using Confusion matrix. The performance measure of the classification model is measured in terms of accuracy, sensitivity and specificity calculated as 90%, 83% and 100% respectively. Thus I can conclude that the brain tumor detection using K-means clustering algorithm exhibits high accuracy, thus making it efficient.

MRI images help the neurosurgeons in identifying the abnormal conditions in the brain with high precision. This technology will help the researchers in identifying many new things. In future, this research work can be extended to identify the different types of tumor such as Glioma, Medulloblastoma, and Meningioma etc. by extracting different features collaboratively with the symptoms shoId by the infected persons.

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BIOGRAPHY

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