MRI Brain Image Segmentation and Detection Using K-NN Classification

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Abstract—Detection of brain tumor at an early stage is important to avoid death. Brain tumor arises due to the abnormal growth of the cells. Magnetic Resonance Imaging (MRI) is a computer-based image processing technique used for detecting tumor size, location and shape. In order to classify it is important to segment MRI brain images. In this paper, MRI brain tumor is segmented using k-means clustering algorithm and various features of the segmented tumor was analyzed using Gray level Co-Occurrence matrix (GLCM). These features were used as input for the k-Nearest Neighbour (k-NN) classifier and used for the classification of tumor as Benign or Malignant. The accuracy of the proposed algorithm is 85% respectively.

Keywords—Magnetic Resonance Imaging (MRI), Image segmentation, K-means clustering, the k-Nearest Neighbours (k-NN)

1. INTRODUCTION

A brain tumor is a disease which is dangerous and more affected among children while compared to elders. A brain tumor is a growth of mass abnormal cells in the brain and all tumors are not cancerous. Hence, tumors are classified as two types such as benign and malignant. In benign tumors cells will not spread and such tumor is known as non-cancerous and another type of tumor is malignant, where abnormal cells will spread and destroy the normal cells known as cancerous cell. So patients with either benign or malignant tumors, need immediate recovery treatment after the diagnosis of tumor. Medical experts are trying to achieve a high degree of correctness to investigate human brain tissues through different digital imaging methods. The brain is the most important commanding part of the human body and is responsible for controlling blood pressure (BP), temperature, fluid balance, heartbeat, memory and emotions [1]. Mostly medical experts prefer the latest digital image scanning technique like Magnetic resonance imaging (MRI) for diagnosis of a tumor. MRI image is also helps to detect brain related diseases such as Parkinson’s, Hydrocephalus, Alzheimer’s, brain stroke [2]. MRI technique has the ability to capture the internal part of brain. Magnetic resonance imaging provides more desired contrast information about brain tissues such as shape, size, location, thus becoming the standard method and widely available technique for the brain tumor diagnosis [3].

Recently, development in the advance technology of brain MRI image data have created more opportunities for neurosurgeons and medical scientists to diagnosis brain tumor. Neurosurgeons usually requires accurate delineation of the tumor with size and stage before to the diagnosis and surgery, which required the important image processing of brain tumor segmentation. Usually radiologist preferred manually segmenting of brain which is time-consuming [3]. However, Neurosurgeons don’t follow a standard thump rule which can help them in detection of brain tumor and normally different opinion arise between doctors. The detection of tumor size at early stage must be detected accurately for the diagnosis purpose and which will increase the survival rate of tumor. To overcome this issue in the recent decades, many researchers have been constantly working on the development of automated brain tumor segmentation methods.
In worldwide researchers have proposed several automated segmentation algorithms for MRI brain images [4],[5]. MRI brain image segmentation still remains as a challenge among medical field, due to its complexity. But still up to date there is no standard algorithm that can detect brain tumor with high accuracy. So research is needed in the medical field to detect brain tumor. In this paper k-means clustering is adopted for image segmentation. The analysis of MRI images consist of four steps (i) images filtering (ii) segmentation (iii) feature extraction and (iv) classification. The remaining of this paper is organized as follows. In Section II included literature review of different preprocessing, segmentation and classification of MRI brain tumor images. Section III presented proposed methodology. In IV present our evaluation and results and conclude the paper and future work in Section V.

### 2. LITERATURE SURVEY

Processing and analyzing of MRI brain tumor images, are the most challenging in the medical field. Basically, image processing of MRI images involves four steps.

#### A. Pre-processing

The brain MRI digital images contain unwanted noises such as Gaussian, salt & pepper and so, it is very important to remove noise from MRI brain image to achieve high accuracy. Hence, filtering technique/ preprocessing are adopted. The role of image preprocessing is performed in MRI images are to remove noise and to enhance the important features in brain. For further processing as per requirement. Deepa and Sumithra [6] reported medical image affected by noise such as salt and pepper, Gaussian, Speckle and Brownian noise. Nalin and Nachamai et al [7] stated that noise removal technique is important in MRI image which may reduce error like the root mean square error. Filtering method is adopted to remove this noise and different types of filters are (i) Median filter [8], Mean filter, Weiner filter, Sobel filter, Robert filter, Prewitt filter, Gaussian [9] and Laplacian filter. Filters like mean filter, median filter and Weiner filter algorithms are commonly used in noise removal. The mean filter has a drawback of poor preservation of edges [10]. The median filter sharpens and preserves the edges of images and is the best choice for salt and pepper noise. The median filter has been used for the noise removal [8]. Recently, [11] adopted Median filter to remove noise from MRI images. Similarly, another researcher also adopted median filter for preprocessing MRI images [12].

Tahir et al [13] reviewed various filtering techniques available for enhancement such as KSL filter, median filter, wiener filter, adaptive filter and mean filter. They concluded that among all the filtering techniques, the median filter performs better result to remove noise from MRI brain image. The median filter technique have advantage in maintains its edges as well as in removing noise. Therefore, median filter is adopted in this to preprocess MRI images, for further processing of image segmentation.

#### B. Image Segmentation

Segmentation of MRI brain image is one of the most important phase in the digital image processing. Segmentation is a procedure of partitioning of similar features in MRI brain image based on color, texture tone, brightness and contrast. Tjahyaningtijas et al[14] reviewed different algorithms existing for segmentation of MRI brain images such as thresholding, region growing method & clustering methods. Another author recently reviewed [15] different types of algorithms used for segmentation of MRI brain images such as watershed, Patch-based, Bayesian with HMM, SVM, K-Means, Neural network based, and support vector machine. Each algorithm has its own advantage and disadvantages. However, the accuracy of the algorithm depends upon the features that are used.

Segmentation of brain tumor in MRI image is involve in identifying accurate locations, size and shapes. Cluster analyses has the power to recognizes a similar object groups. K-means clustering
algorithm is an unsupervised clustering algorithm that has been widely used in MRI brain image. K-means clustering is an important process in pixel-based methods. Hence, in this paper K-mean clustering algorithms is applied for segmentation of MRI brain tumor image.

C. Feature extraction

The features from MRI brain images is extracted using various methods like Histogram of Oriented Gradient (HOG), Local Binary Pattern, Gray Level Co-occurrence Matrix (GLCM) and Speeded-Up Robust Features (SURF). Most of the authors have used GLCM algorithms for feature extraction. Astina Minz [16] proposed a GLCM technique which is used for extracting the features and results show that 89.90% accuracy in classifying the tumor. Haralick et. al. [17] in their research applied fourteen textural features and were extracted from the GLCM, and based on image textural characteristics such as homogeneity, linearity, and contrast. Nitish Zulpe [18] applied GLCM algorithm and extracted four different types of classes from MRI brain images based on textural features of each class, and applied input in Neural Network and achieved with an accuracy of 97.5% c. The GLCM is used for extracted features of the MRI brain image and those features were fed as the input to the classifier for the classification of the tumor.

D. Classification

For the classification, supervised algorithms such as k-Nearest Neighbour (k-NN) and Artificial Neural Network (ANN) and unsupervised algorithms such as Fuzzy-C means, Self Organization Map (SOM) are used. Supervised algorithms have better classification accuracy as compared to unsupervised algorithms[8]. Hence, in this paper k-NN algorithm is used for classifying MRI brain tumor.

3. PROPOSED METHODOLOGY

In the proposed system K-means clustering is adopted in segmentation of MRI brain images and Grey Level Co-occurrence Matrix (GLCM) is employed to convert feature extraction. k-nearest neighbour algorithm is applied to classify the conventional and abnormal tissue and overall methodology is shown in figure1. The proposed method consists of the following four steps:

Fig.1: Flow diagram of Proposed method
E. Pre processing

Image enhancement-Median filter

Image enhancement is a procedure of adjusting digital images or to enhance the quality of features in the MRI image for further analysis. Among enhancement technique, median filter is one of most popularly used to remove noise in the field of MRI image processing, because it preserves edges of tumor as well as removes noise. Median filter helps to remove noise at an earlier stage to achieve good accuracy at the classification stage. The three by three mask is applied to remove noise from MRI brain image.

F. Segmentation-k-mean clustering

Digital images are being divided into multiple segments (commonly sets of pixels, also known as super-pixels) are popularly known as Image Segmentation. It is used to identify objects or to extract other relevant information.

(i) K-means algorithm

K-means algorithm is simplest clustering method is used in segmentation of MRI images and algorithm is shown in figure 2. Purpose of k – means algorithm is to group the object based on features into N number of cluster. Cluster is calculated by minimizing the sum of the squares of distances between data and the corresponding centroid of the cluster. In this algorithm, initially define the number of clusters that are k and then fix the random cluster centers from the n objects. The Euclidean function is used.

![Fig.2: Flow chart of k-means algorithm](image-url)
to calculate distance between the each pixel and each clusters center point. Then single pixel is compared to all cluster centers using the below formula [19]

\[
M = \frac{\sum_{i=1}^{K} \frac{x_i^T}{N}}{x_i}, \quad k=1\ldots K
\]  

(1)

\[
D(i) = \arg \min_{\|X_i - M_k\|^2}, \quad i=1\ldots N
\]  

(2)

The pixel is moved to the particular cluster which has the shortest distance among all and then the centroid is re-estimated. Again each pixel is compared to all centroids and the process continuous until the center converges.

**G. Gray Level Co-Occurrence Matrix**

Feature extraction is a technique to represent the object of interest from segmented image. Usually the features are having a unique characteristic and to extract this features statistical method is used known as the Gray Level Co-occurrence Matrix (GLCM). In this paper the Gray Level Co-occurrence Matrix is utilized and image co-occurrence matrix is generated from the segmented image. The features extracted gives the property of the texture features are used to distinguish between normal and abnormal brain tumors.

**H. K-NN classification**

The k-nearest neighbour algorithm is a supervised classifier in machine learning algorithm used for pattern recognition and non-parametric method. Like other algorithms in machine learning, k-NN algorithm also consists of a two stages namely (i) training stage (ii) testing stage. In the training stage, stored data points in n space and points used to define attributes with a corresponding class. Whereas in the testing phase, calculated the distance between new extracted features and features from training data. The Euclidean distance is used to calculate distance between the training and testing stored data and the formula is given below [20].

\[
d(a,b) = \sqrt{\sum_{i=1}^{n}(a_i - b_i)^2}
\]  

(3)

In this algorithm defines the k-closest training and set images feature as zero and remaining tumor part is set as one, so that it can be classified. In the k-NN algorithm, class membership decides the output by classifying the images whether the tumor (benign and malignant) is present or not, the k-nearest neighbour algorithm is as follow:

- Select the k values and it is mostly based on past available data.
- Define a Euclidean distance measurement to calculate distance.
- In training stage, consist of training dataset, coherent class and no of training set.
- In the testing stage calculate the distance between new feature and training set.
- If the result is not suitable or appropriate then change value of k and continue the process still obtain the suitable result.
4. RESULT AND DISCUSSION

The performance of brain tumor segmentation is evaluated based on k-means clustering. The MRI image dataset that has used in image segmentation technique. This MRI images considered for this paper is 40 tumors affected. In k-means algorithm initially 2 cluster was assigned and observed that tumor pixels are not segmented properly and later 3 cluster was applied. The output images shown clearly that tumor part well segmented from the normal cells. The figure 3&4 shows for malignant brain MRI and benign brain MRI.

Fig.3: Shows Malignant brain MRI (a)Original image (b)Tumor image

Fig.4: Shows benign brain MRI (a)Original image (b)Tumor image

1. Performance of Algorithm

The segmented MRI image is classified by applying K-NN algorithm and identified tumor pixels and non tumor pixels. The performance of the k-NN algorithm is calculated based on Sensitivity, Specificity and overall accuracy. The formulae applied to the calculated performance is given below:

\[
\text{Sensitivity} = \frac{TP}{TP+FN} \times 100\% \quad (4)
\]

\[
\text{Specificity} = \frac{TN}{TN+FP} \times 100\% \quad (5)
\]

\[
\text{Accuracy} = \frac{TN+TP}{TP+TN+FP+FN} \times 100\% \quad (6)
\]

TP = Tumor pixels
TN = Non tumor pixels
FP = Tumor pixels error (type I error)
FN = Non tumor pixels error (type II error)

The pixels in classified algorithm have segregated the tumor pixels and non tumor pixels. Tumor pixels are known as True positive and non tumor pixels as True negative. During this process of segmentation, few numbers of tumor pixels and non tumor pixels were mixed with each other and those pixels are considered as false positive and false negative. The parameter such as accuracy is calculated for both the techniques are 85% accuracy achieved.

5. CONCLUSION

K-mean clustering for MRI brain image segmentation have successfully implemented and achieved with accuracy of 85%. However, it is known that the accuracy of the machine learning algorithm depends upon the features that used. The proposed algorithm can be used to detect other MRI imaging diagnosis application like Liver cancer, Lung cancer, Breast cancer and Bladder cancer.

In future scope of this paper is to train and test this algorithm on large number of datasets and to compare result with other algorithms. Further Neural networks can also be applied for the diagnosis of the brain tumor in the future.

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