

# Cluster Analysis for MRI Brain Tumor Segmentation

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## Abstract

The abnormal tissues which are originated from the brain cells are known as brain tumor. It may be cancerous tumor or non-cancerous tumor; these can cause pressure inside the skull to increase the tumors. This damages the brain and become life-threatening. The main cause of brain tumor is still unknown. The early diagnosis is required otherwise it increases the mortality rate. The segmentation of tumor part is essential to identify the affected area in the brain. In this study, an effective method for Brain Tumor Segmentation (BTS) is presented. The BTS system uses Discrete Wavelet Transform (DWT), K-Means Clustering (KMC) algorithm and morphological operations for segmentation. Firstly, the input brain images are given to DWT for decomposition and it produces lower and higher frequency sub-band coefficients. Then the Inverse DWT (IDWT) is applied to reconstruct the image. The reconstructed image is given to KMC technique for segmentation. Then the unwanted regions are removed by morphological operations to detect the brain tumor in the given input image.

**Keywords:** Brain Tumor Segmentation, Discrete Wavelet Transform, Inverse DWT, K-Means Clustering

## Introduction

BTS to calculate tumor percentage is described in [1]. Initially the input brain images are pre-processed by using median filter. Then the preprocessed image is given to segmentation algorithm like thresholding, watershed and cropping. Finally, the tumor area and brain area is calculated for the area percentage calculation. Dynamic Angle Projection Pattern (DAPP) features based BTS and classification using watershed algorithm is presented in [2]. Initially, the brain images are given to segmentation technique using watershed algorithm. Then the features are extracted by DAPP. Convolutional Neural Network (CNN) is used for classification.

Region growing approach based BTS to integrate symmetric property is presented in [3]. The brain images are given to geometric transformation and systematic analysis. Then the contrast stretching operation is performed and region growing operation is applied. Then the unwanted regions are removed by morphological operation to detect the tumor. BTS and detection for computer analysis is discussed in [4]. At first, brain image is given to preprocessing to remove noise. Then the preprocessed image is segmented by thresholding technique. Then the morphological operation is used to

remove the unwanted regions. Windowing technique is applied to detect the brain tumor.

BTS method using U-net architecture is described in [5]. At first, the input brain image is given to loss function and optimized to perform the preprocessing and U-net model structure is used for segmentation. Then the feature recombination layer and convolutional layer are used for prediction. BTS for cuckoo search optimization algorithm is presented in [6]. Firstly, the input brain images are preprocessed by image acquisition, enhancement and preprocessing techniques. The map values are obtained by markov random field. The optimum thresholding algorithm is obtained by cuckoo search algorithm for segmentation.

BTS and classification for brain images using CNN is described in [7]. At first, the brain images are given to CNN for the prediction and segmentation of the affected area. Then the tumor area is separated. BTS based on features of separated local square is presented in [8]. Input brain images are given to image acquisition technique. The super pixels are segmented. Then features like statistical and texture features are extracted. Finally, the prediction is made by Support Vector Machine (SVM).

BTS using watershed and edge detection algorithm is discussed in [9]. The input image is converted into three different color formats. Then each region performs the contrast enhancement. Watershed transform is applied for each region. Then the three segmented region are combined to form the segmented image. Combined approach for BTS is described in [10]. The input brain images acquisition and pre-processed to remove noise. The gray level co-occurrence matrix and local binary pattern features are extracted. Back propagation network is used for prediction.

Different wavelet analysis for brain image classification is described in [11]. The wavelet transform like Daubechies, symlet and biorthogonal wavelets are used for feature extraction. Then SVM classifier is used for classification. BTS using non-negative matrix factorization is presented in [12]. Firstly, the initial brain images are denoised by anisotropic diffusion filtering. Then the non-negative matrix factorization method and FCM is used for the feature segmentation.

BTS analysis using segmentation technique is presented in [13]. The brain image is acquiesced pre-processing technique using some filter. Then the segmentation is made by watershed method. Then the post processing also has done. Finally, the brain tumor area is detected. BTS for multimodal brain scans using expectation maximization algorithm is presented in [14]. The input brain images are pre-processed at first. Then the pre-processed brain image is segmented by using expectation maximization algorithm. Then KMC technique is used to identify the tumor region.

A novel method for BTS is presented in this study using DWT, KMC and morphological operations. The rest of the paper is as follows: In Section 2 the methods and materials used for BTS system is described. Section 3 describes the experimental results and discussions of BTS system. The BTS system using DWT, KMC and morphological operations is concluded in last section.

## Methods and Materials

Figure 1 shows the overall workflow of BTS system using DWT, KMC and morphological operations. Initially, the brain images are decomposed by DWT and IDWT is applied to reconstruct the brain image. Then KMC is used for segmentation. The unwanted

background regions are removed by morphological operations to detect the tumor region.

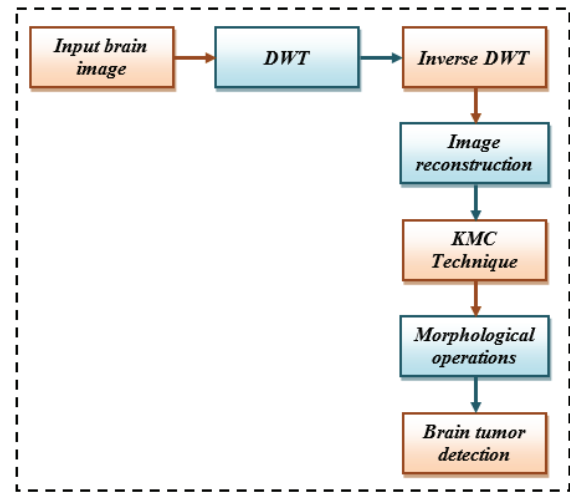


Figure 1 BTS system – workflow

### DWT Decomposition

The discretely sampled wavelets are known as DWT in both numerical and functional analysis. It has temporal resolution in a Fourier transform to capture both location and frequency information. DWT has large number of applications in computer science, mathematics, engineering and science. It produces familiar wavelet transform and produces the lower and higher frequency. DWT implements the rules under the translation scales and discrete set of wavelets. The discrete set of input images is decomposed into suitable size. The DWT is defined by,

$$\delta(k) = \sum_{m=-\infty}^{\infty} (-1)^m P_{R-1-m} \psi(2k-m) \quad (1)$$

where  $R$  is defined as even integer, to decompose the set of wavelets. DWT is also used in other fields like object recognition [15] and speech emotion recognition [16]. In this study, the DWT is used to decompose the input images, then inverse DWT transform is applied to reconstruct the image.

### KMC Segmentation

KMC is a vector quantization method in processing an image for the cluster analysis in the data mining. The  $n$  observations in  $k$  clusters are belongs to nearest mean prototype. KMC has the cluster variances with irregular Euclidean distances. The geometric median minimizes the Euclidean distances in the optimized squared errors.

The Euclidean distances are minimized only by the geometric median. The convergence of efficient heuristic algorithm is local optimum. This algorithm is similar to expectation maximization algorithm for Gaussian mixture modeling. It uses clusters to model the data, and then KMC used to find the clusters in spatial extent. The expectation maximization mechanism allows clusters to have different shapes. The KMC is given by,

$$K(S) = \sum_{u=1}^m \sum_{v=1}^{m_u} (\|y_u - s_v\|)^2 \quad (2)$$

where,  $\|y_u - s_v\|$  is Euclidean distance between  $y_m$  and  $s_v$ ,  $m_u$  is the number of data points in  $u^{th}$  cluster,  $u$  is the number of clusters. KMC is also used in other fields like gene expression data [17] and tree identification [18] marine and rain removal images segmentation [19-20]. In this study, the reconstructed image is given to KMC for the BTS.

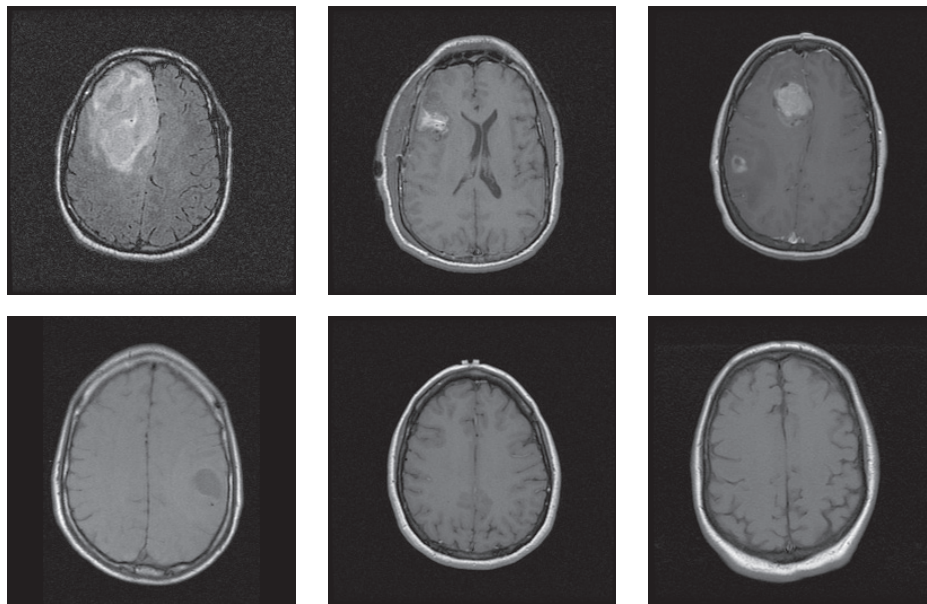
### Morphological Operations

The structural element in the morphological

operation combines a 3 x 3 matrix. The neighborhood pixel values process the images into pixel by pixel. The morphological operation techniques are available for the gray level images or binary images. It performs operations like erode, reconstruct, dilate and other morphological operations. It process the images based on shapes. The value of the other pixel in the neighborhood is adjusted by morphological operations. The morphological operation is also used in other fields like licence plate localization [21] and shadow detection [22]. In this study, morphological operations are used to remove the unwanted region of brain.

### Results and Discussion

The performance of the BTS system is evaluated by REpository of Molecular BRAin Neoplasia DaTa (REMBRANDT) database [23]. The image size is 256x256 pixel resolutions. Figure 2 shows the some of the images in REMBRANDT database.



**Figure 2** Sample images in REMBRANDT database

Initially, the brain image is given to DWT for decomposition, after that the inverse transform is applied for image reconstruction. Figure 3 and 4 shows the DWT decomposition and inverse DWT decomposition.

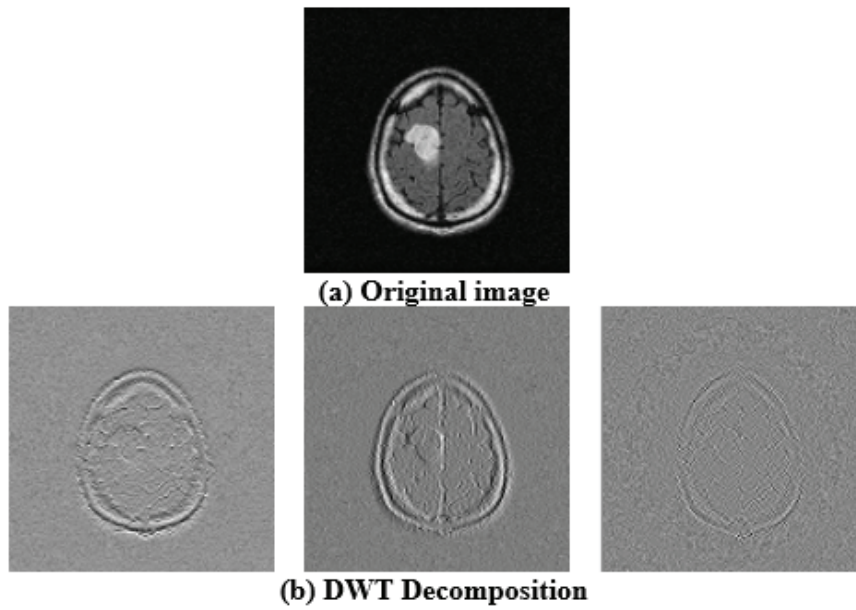


Figure 3 DWT decomposition and its coefficients

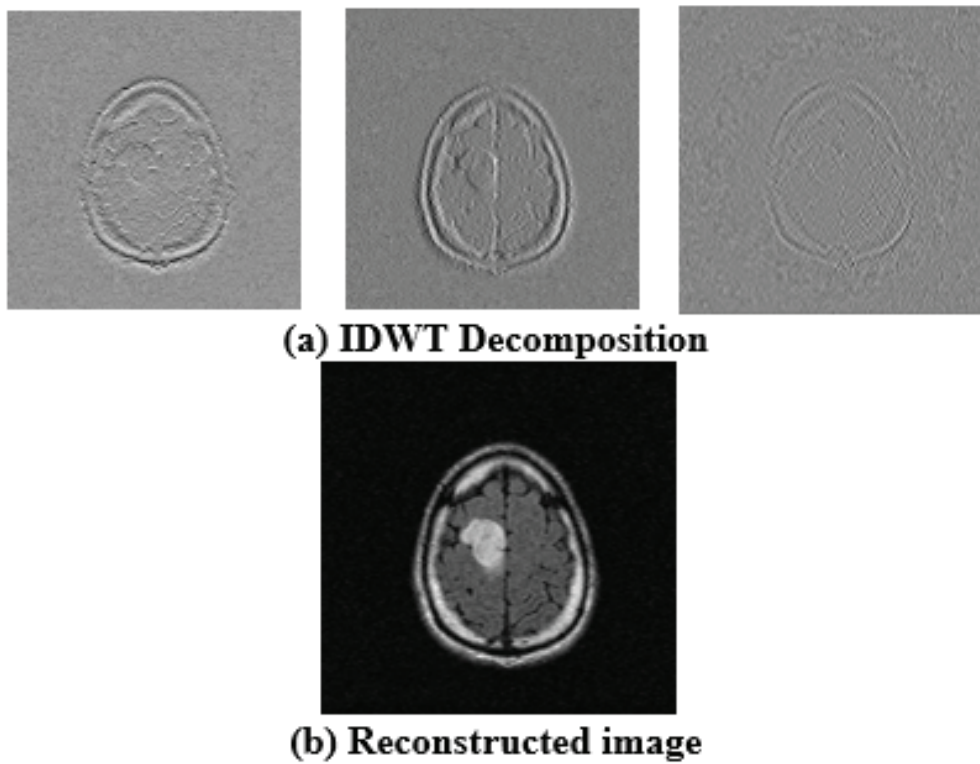


Figure 4 Inverse DWT Decomposition and reconstructed image

□

The reconstructed image is given as input for KMC technique for segmenting the tumor. Then the unwanted background areas are removed by using morphological operations. At first the reconstructed image is converted

into grayscale image. KMC technique is applied for BTS. Then the morphological operations are used to remove the background region of tumor. Finally, the tumor is detected. Figure 5 shows the tumor detection using KMC and morphological operations.

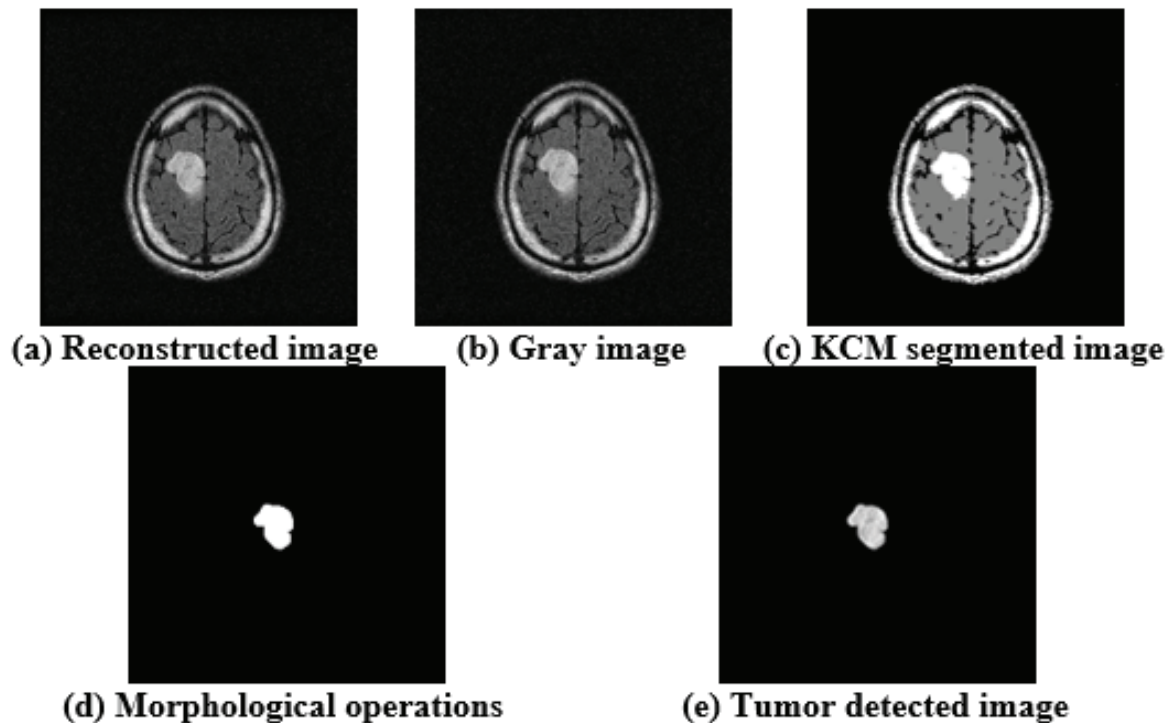


Figure 5 Tumor detection using KMC and morphological operations

### Conclusion

The cluster analysis for BTS system using DWT, KMC and morphological operations is discussed in this study. The performance evaluation of BTS system is made by using REMBRANDT database. The input image is given to DWT for decomposition and it produce sub-band coefficients and inverse DWT is also applied and it also produces the sub-band coefficients for brain image reconstruction. Then reconstructed brain image is converted into gray scale image then the KMC technique is used to detect the tumor region by using clusters for segmentation of tumor. Then the background region of brain image is removed by using morphological operations. Finally tumor region is detected.

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**Conflict of Interest:** Nil

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