MORPHOLOGICAL IMAGE ENHANCEMENT BASED BRAIN TUMOR SEGMENTATION USING MRI IMAGES

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ABSTRACT: Brain tumor is defined as a mass of abnormal cells in the brain that can progress to benign and malignant tumors. Brain tumors develop rapidly and aggressively, causing brain damage and can be life threatening. Determining the extent of the tumor is a major challenge in brain tumor treatment planning and quantitative assessment to ameliorate the quality of life of patients. Magnetic resonance imaging (MRI) tumor segmentation has emerged as a new study area in the medical imaging field. It is very difficult for doctors to detect a brain tumor images at an early stage. MRI images are more susceptible to noise and other environmental disturbances. Therefore, it becomes difficult for doctors to determine the tumor and its causes. In order to solve these issues, Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images is presented in this work. This system will process the selected image using pre-processing steps and at the same time, different algorithms are used to detect the brain tumor. A morphological image segmentation is presented and a variety of image filtering techniques are used to obtain the characteristics of brain MRI image. Segmentation of brain tumors can be accomplished using thresholding and morphological techniques, which are both effective. The tumor will be located and identified using morphological image processing.

KEYWORDS: Brain Tumor, Detection, Segmentation, Image Processing and Morphological Segmentation.

I. INTRODUCTION

The brain is a soft, delicate, non-replaceable and spongy mass of tissue. It is a stable place for patterns to enter and stabilize among each other. Brain tumor is a group of abnormal cells that grows inside of the brain or around the brain. Tumors can directly destroy all healthy brain cells. It can also indirectly damage healthy cells by crowding other parts of the brain and causing inflammation, brain swelling and pressure within the skull. A Brain Tumor is a mass of tissue in which the cells multiply uncontrollably. It arises from different cells - both in the brain and outside [4].

Tumor is an uncontrolled growth of cancer cells in any part of the body. Tumors are of different types and have different characteristics and different treatments. At present, brain tumors are classified as primary brain tumors and metastatic brain tumors. The former begin in the brain and tend to stay in the brain, the latter begin as a cancer elsewhere in the body and spreading to the brain. Brain tumor segmentation is one of the crucial procedures in surgical and treatment planning [3].

When more or less normal, old or damaged cells are destroyed, they are replaced by new cells in a natural process; sometimes, this process goes wrong and the new cells are formed when the body does not need them. The production of additional cells often results in the formation of a mass of tissue, which refers to the growth of tumor and can be formed anywhere in the body especially in the brain [1].

Tumors can be classified into two categories: primary tumors and secondary tumors. Malignant tumors, on the other hand, are cancerous tumors that spread over a prolonged period of time. They are rapidly expanding, but their borders are

unclear. It is possible to develop primary and secondary malignancies. It would be helpful to have an automated system for finding, locating, and classifying things. It is possible to execute a range of medical imaging techniques in order to make an accurate diagnosis of tumors [5].

Cancerous tumors are called Malignant. These are very aggressive and can be life-threatening as they are hard to detect. These tumors grow unevenly in the brain and apply pressure around them. The effect of pressure causes various disorders in the brain that affect the body and symptoms of such diseases in humans; dizziness, headache, fainting attacks, paralysis, etc. Unlike benign tumors, malignant tumors grow erratically, damaging the encircling tissues. Brain tumors also differ according to their origin and location. Primary brain tumors are those that develop directly in the brain, whether or not they are cancerous tumors. The most common malignant tumors include gliomas, medulloblastomas. Among benign primary tumors, rarer than malignant primary tumors, include hemangioblastomas, meningiomas, pituitary adenomas, osteomas, pinealomas, and so on. Secondary brain tumors originate from other organs already affected by cancer whose tumor cells have migrated to the brain and multiply there [2].

Timely diagnosis is an important factor in the treatment of brain tumors, of which medical imaging plays an important role. In recent years, there have been significant improvements in the provision of medical images particularly brain imaging. Image processing used as a tools for accumulating and segmenting useful information from variety of datasets [7]. Medical imaging research has resulted in the development of diagnostic techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. Each has its own set of pros and disadvantages. One of the most important noninvasive and painless medical imaging technologies in this regard is magnetic resonance imaging (MRI) which depicts brain anatomy structures.

Medical imaging is the technique of creating images of the inside of the body in order to aid in the diagnosis of a medical condition. It not only aids in the treatment and identification of sickness but also allows for the discovery of inner structures that lay beneath the surface of the skin and bones, which is quite useful. It identifies abnormalities by comparing them to a database of normal anatomy and physiology [6].

Additionally, computerized image processing techniques can perform auto-segmentation operations on MRI data and separate the different areas of the brain or even classify the different types of tumors; thus if there are lesions shown in the image, physicians can easily figure them out in the brain with the help of image processing techniques. Most of the current conventional diagnosis techniques are based on human experience in interpreting the MRI-scan for judgment; certainly this increases the possibility to false detection and identification of the brain tumor. On the other hand, applying digital image processing ensures the quick and precise detection of the tumor. One of the most effective techniques to extract information from complex medical images that has wide application in medical field is the segmentation process [8].

Segmenting brain tumors is a very difficult task. In the first consideration, there is a large class of tumor types that have a variety of shapes and sizes. The Segmentation of an image entails the division or separation of the image into regions of similar attribute. The ultimate aim in a large number of image processing applications is to extract important features

from the image data, from which a description, interpretation, or understanding of the scene can be provided by the machine. The appearance of a brain tumor at different locations in the brain with different image intensities is another factor that makes difficulties in automated brain tumor detection and segmentation. Many techniques have been proposed for the automatic brain tumor detection and segmentation in recent years such as thresholding based, region growing based, clustering based, neural network based, K-means clustering, fuzzy c-means (FCM) and fuzzy c-means strategy is integrated with HNN [9].

The research examines list of risk factors that are being traced out in brain tumor surveillance systems. Also the method proposed assures to be highly efficient and precise for brain tumor detection, classification and segmentation. For these reasons, accurate semi-automatic or automatic methods are required. To achieve this precise automatic or semi-automatic methods are needed.

Early detection of brain tumors can play an indispensable role in improving the treatment possibilities, and a higher gain of survival possibility can be accomplished. But manual segmentation of tumors or lesions is a time consuming, challenging and burdensome task as a large number of MRI images are generated in medical routine. MRI, also known as Magnetic Resonance Imaging is mostly used for a brain tumor or lesion detection. Brain tumor segmentation from MRI is one of the most crucial tasks in medical image processing as it generally involves a considerable amount of data. Moreover, the tumors can be ill-defined with soft tissue boundaries. So it is a very extensive task to obtain the accurate segmentation of tumors from the human brain. Hence, in this work Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images is presented. The rest of the work is organized as follows: The section II describes the literature survey. The section III presents Morphological Image Enhancement Based Brain Tumour Segmentation using MRI images. The section IV describes the result analysis. Finally, the work is concluded in section V.

II. LITERATURE SURVEY

I.Kalaivani, A.Sheryl Oliver, R.Pugalenthi, P N Jeipratha, A.Ajoe Sweetlin Jeena, G.Saranya et. al., [11] describes Brain Tumor Segmentation Using Machine Learning Classifier. The brain tumor segmentation is done in a slice of Magnetic Resonance (MR) Image where massive abnormal cells are localized and tumor region that are sliced are segmented by machine learning classifiers like KNN, fuzzy C-mean, k-means. Feature are derived using GLCM and those features are trained in such a way it produce accurate segmentation of tumor region is done in less computation time and therefore, in presented system, features derived from the GLCM, so that the segmentation of tumor region using triple technique K-means, KNN and FCM can be done accurately and efficiently. Accuracy and error rate is calculated for brain MRI image using triple technique K-Means, FCM and KNN.

G.Hemanth, M. Janardhan, L. Sujihelen et. al., [12] describes Design and Implementing Brain Tumor Detection using Machine Learning Approach. The research presents an automatic segmentation method that relies upon CNN (Convolution Neural Networks), determining small 3 x 3 kernels. By incorporating this single technique, segmentation and classification is accomplished. CNN (a ML technique) from NN (Neural Networks) wherein it has layer based for results classification. Various levels involved in the presented mechanisms are: 1. Data collection, 2. Pre-

processing, 3. Average filtering, 4. segmentation, 5. feature extraction, 6. CNN via classification and identification. By utilizing the DM (data mining) techniques, significant relations and patterns from the data can be extracted. The techniques of ML (machine learning) and Data mining are being effectively employed for brain tumor detection and prevention at an early stage.

Khizar Abbas, Prince Waqas Khan, Khan Talha Ahmed, Wang-Cheoul Song et. al., [13] describes Automatic Brain Tumor Detection in Medical Imaging using Machine Learning. Firstly, the image preprocessing techniques are used for noise removal and image enhancement. After that different textural features were calculated and reduced by PCA for better classification score. The dataset used is that of MICCAI 2013 containing High-grade tumor and Low-grade tumor for real patient data. This method presented a Dice Score of 0.95 for complete tumor which is by far compared to the methods already available in terms of Dice Score and time complexity.

Toktam Hatami, Mohammad Hamghalam, Omid Reyhani-Galangashi, Sattar Mirzakuchaki et. al., [14] describes A Machine Learning Approach to Brain Tumors Segmentation Using Adaptive Random Forest Algorithm. In this paper a brain tumor segmentation method is proposed which is based on the Random Forest algorithm. This technique is applied to the brain magnetic resonance images and the performance indices including Dice Similarity Coefficient (DSC) as well as algorithm accuracy (ACC) are calculated. The obtained results show that the proposed model can have a good performance when compared with the other segmentation methods. Besides, in this paper the mathematical modeling of the Random Forest algorithm is provided.

Digvijay Reddy, Dheeraj, Kiran, Bhavana.V and Krishnappa H.K et. al., [16] presents Brain Tumor Detection using Image Segmentation Techniques. dicom Magnetic Resonance Image (MRI) is taken as an input and tried to extract tumor cells from the input image. Pre-processing technique is used to remove noise from image. To this image, k-means clustering is applied and from this clustered image, skull was removed using morphological operations to identify tumor cells easily. Finally, image thresholding is applied to this image followed by level set segmentation to extract tumor cells. Performance matrices like true positive (TP), true negative (TN), false positive (FP), false negative (FN), precision and recall to measure the accuracy of our results, is also evaluated.

Himaja Byale, Dr Lingaraju G M and Shekar Sivasubramanian et. al., [17] describes Automatic Segmentation and Classification of Brain Tumor using Machine Learning Techniques. The project aims to have an automated system which plays a important role in assessing whether a lump (mass of tissue) in the brain could be benign (clump thickness) or malignant (marginal adhesion) by classification. The proposed model uses machine learning algorithms in order to improve the accuracy of classification. The system is carried out in four steps that includes pre-processing for noise removal using adaptive median filter, segmentation using Gaussian Mixture Model (GMM) for finding the region of interest, feature extraction using Grey Level Co-occurrence Matrix GLCM for extracting the features of different types of tumors and classification using Neural Networks (NN) to determine and classify the tumor as benign or malignant.

S´ergio Pereira, Adriano Pinto, Victor Alves and Carlos A. Silva et. al., [19] describes Brain Tumor Segmentation using Convolutional Neural Networks in

MRI Images. an automatic segmentation method based on Convolutional Neural Networks (CNN), exploring small 3x3 kernels. The use of small kernels allows designing a deeper architecture, besides having a positive effect against overfitting, given the fewer number of weights in the network. We also investigated the use of intensity normalization as a pre-processing step, which though not common in CNN-based segmentation methods, proved together with data augmentation to be very effective for brain tumor segmentation in MRI images. This technique was validated in the Brain Tumor Segmentation Challenge 2013 database (BRATS 2013), obtaining simultaneously the first position for the complete, core, and enhancing regions in Dice Similarity Coefficient metric (0:88, 0:83, 0:77) for the Challenge data set.

III. MORPHOLOGICAL IMAGE ENHANCEMENT BASED BRAIN TUMOR SEGMENTATION

In this section, Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images is presented. The block diagram of presented approach is shown in Fig.1. A brain tumor is a mass of unnecessary cells growing in the brain or central spine canal. Brain cancer can be counted among the most deadly and intractable diseases. Magnetic Resonance Imaging (MRI) has become a widely-used method of high-quality medical imaging, especially in brain imaging where MRI's soft tissue contrast and non-invasiveness are clear advantages. An important use of MRI data is tracking the size of brain tumor as it responds treatment. Therefore, an automatic and reliable method for segmenting tumor will be a useful tool. MRI provides a digital representation of tissue characteristics that can be obtained in any tissue plane. The images produced by an MRI scanner are best described as slices through the brain. MRIhas the added advantage of being able to produce images which slice through the brain in both horizontal and vertical planes. This makes the MRI-scan images an ideal source for detecting, identifying and classifying the right infected regions of the brain.

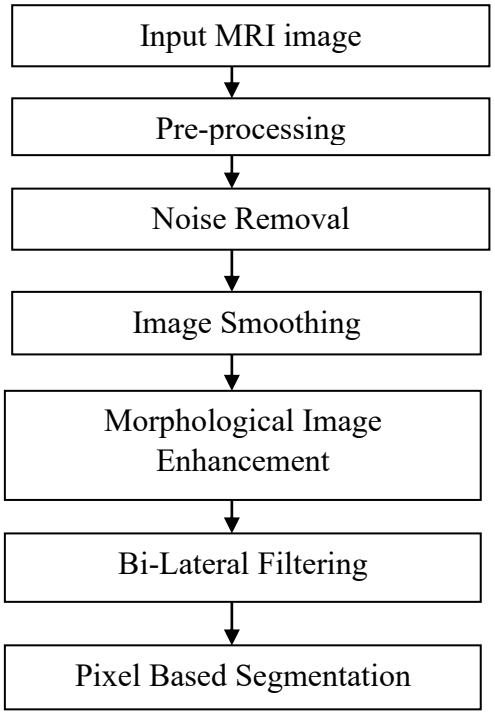

Fig. 1: Block Diagram of Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images

Image Acquisition is the first and foremost step of the process in which the MR images of the brain having tumor and normal brain images are taken. It is always necessary to have improved image quality to achieve better results in the preceding steps.

Image Processing is the practice of conducting such image operations to produce an advance image or to retrieve any advantageous data from it. Image processing is a method of processing in which an image is the input. Image Processing is a technology that is rising quite quickly. Image Processing has the following three steps: Importing the image via image acquisition tools. Analyzing and manipulating the image. Pre-processing of the image plays an important role in delivering the improved features of the image.

Due to existing noise disturbance the MR images get affected. For noise reduction the research work proposes local smoothing methods and nonlocal means. The technique of Image pre-processing involves: data cleaning, data transformation, data integration, data resizing, data reduction etc. The image pre-processing eliminates unnecessary data and smooth up noisy data, detect and eliminate the outlier and rectify the data inconsistencies. Lastly, normalization and aggregation is performed. The technique of Image-processing proves to be highly significant in determining particular heart image, removing noise and for improvising the quality of the image.

Firstly, the MRI image is pre-processed through a few stages and then it is ready for the detection of the brain tumor. De-noising is achieved by eliminating unnecessary deformation and enhancing some essential processing characteristics to improve the image data. This helps in improving the quality of the image for the human. The primary step in image enhancement is to improve the picture's brightness and minimize noise. There are four ways of image enhancement methods on the basis of the size of the neighboring pixels.
Contrast Enhancement- Generally, this grey scale picture has a more intensity, hence its name intensity picture, which is processed to display the data that occurs in the grey scale image's low dynamic range.

De-noising - MRI datasets which are attain from random sources have little external and internal noise Noise is eliminated during midst with the aid of advanced philters called average edge preservation philtres. It substitutes each pixel for the average of all the adjacent pixels. The performance attained after the contrast enhancement and denoise MR image process makes it easier for-viewers to understand.

Image smoothing is a key image enhancement technology that can remove noise within the images. So, it is a mandatory functional module in various image-processing software. Image smoothing is a method of improving the quality of images. Image quality is an important factor for human vision. Image smoothing is an image processing method used to highlight the wide area, low-frequency components, main part of the image or to suppress image noise and high-frequency interference components, which could make the image's brightness smooth and gradual, reduce the abrupt gradient, and improve the image quality.

The Gaussian filter is used for image smoothing. In the Gaussian filter the neighboring pixels are assigned a weight based on the distance from the center pixel. The kernel for the Gaussian filter can be calculated with the help of 2D Gaussian function which is as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

Where x and y are the coordinates of the pixel and sigma can be varied from 1 to any number.

Filtering is a course of action for an image to be changed or improved. To highlight those characteristics or delete other features, an image can be filtered. Smoothing, shaping and edge enhancement provide image processing operations implemented with filtering.

Morphology is basically an image enhancement technique based on mathematical set theory which with the help of structuring element removes noise while retaining useful objects under interest. Basic morphological operations are erosion and dilation.

Morphological technique is one of the image processing operations in which MRI images are processed on the basis of

shapes. To create the same size output image, a structuring element is applied to the input MRI. The pixel value in the original image and the processed image is compared to its neighbors in the morphological operation.

Morphological operations can be used to obtain the attributes of the image, and it is a very simple process. This process can be further used for image segmentation and noise filtering. By applying dilation, erosion, opening, and closing to the image, the quality of the image can be further enhanced. Morphological operation is usually very sensitive to the shapes and size of the input image, but knowing the shape and size of the neighborhood pixels it can be easily constructed. There are 2 methods used in morphological operation such as i) Dilation and ii) ErosionDilation. In dilation process carried out by adding the pixels on object boundaries in MRI Pixels on object boundaries are removed during erosion. In an MRI image the pixels are added and evicted based on the structure parameter such as shape and size. The output pixel value is said to have a maximum of all input pixel neighborhoods.

Erosion: The output pixel value is obtained by using a rule on the input image and its surrounding areas. Based on rule pixel value is calculated. The output pixel value is said to have a minimum of all input pixel neighborhoods.

A bilateral filter is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. Combined domain and range filtering will be denoted as bilateral filtering. The bilateral filter smooths an input image while preserving its edges. Each pixel is replaced by a weighted average of its neighbors. Each neighbor is weighted by a spatial component that penalizes distant pixels and range component that penalizes pixels with a different intensity. The bilateral filter converts any input image (a) to a smoothed version (b). It removes most texture, noise, and fine details, but preserves large sharp edges without blurring. The bilateral filter is a Gaussian that acts strongly on regions of uniform color, and lightly on regions with high color variance. Since we expect edges to have high color variance, the bilateral filter acts as an edge-preserving or edge-aware filter.

Segmentation in digital MR images is mainly done to split the digital MR images to several sections or sets of pixel. The goal of segmentation is to improve and facilitate the formation of an image. The digital image is divided into a series of semantically meaningful, homogeneous and non - overlapping regions based on.

Pixel segmentation is the process of highlighting pixels in an image that represent features you are interested in, then assigning those pixels a class label. Pixel-based technique is often used to extract low level features where the image is classified according to the spectral information where the pixels in the overlapping region will be misclassified due to the confusion among the classes. Pixel segmentation goes beyond simply locating objects. It also provides information about the shape, area, and other object attributes. The tumor portion obtained using thresholding process is considered as the initial portion of the segmentation process. In thresholding (Boundary Approach), pixels are assigned to categories according to the range of values within which a pixel resides. Thresholding is a very uncomplicated and most frequently used segmentation method. The image pixels surrounding the tumor portion that are having similar values nearby the input region, is then grouped. Contours are extracted around the

detected regions. The process is repeated till the boundary of the detected region is within the input region. The final result obtained is the segmented tumor portion. The threshold governs the choice to turn a projected probability or scores into a class label. Based on these results, brain tumor is detected.

IV. RESULT ANALYSIS

In this section, Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images is implemented. The result analysis of presented approach is discussed in this section. Firstly, brain MRI images are collected and are pre-processed in order to improve the accuracy of brain tumor detection. The image pre-processing eliminates unnecessary data and smooth up noisy data, detect and eliminate the outlier and rectify the data inconsistencies. Morphological operations are used to obtain the attributes of the image Bi-linear filter replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels. Pixel segmentation is the process of highlighting pixels in an image that represent features and then those pixels are assigned a class label. The Fig. 2 shows the MRI image of brain.

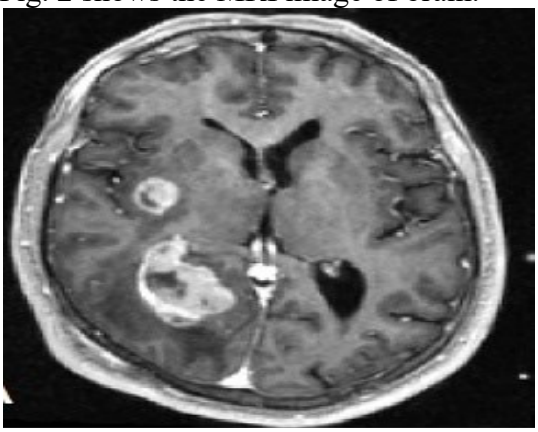

Fig. 2: Brain MRI image

The Fig. 3 shows the result of segmentation.

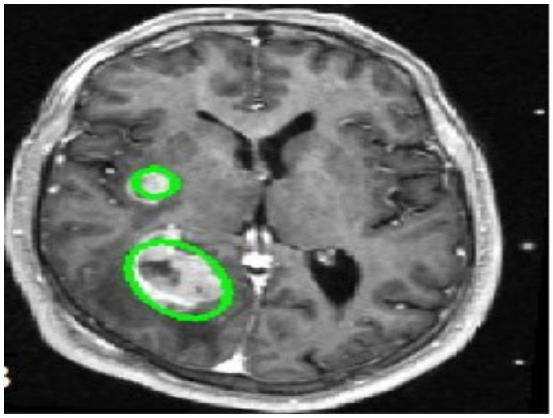

Fig. 3: Segmentation Results

The performance of presented approach is evaluated in terms of segmentation accuracy and segmentation error. The Table 1 represents the performance metrics.

Table 1: Performance Metrics

Approach/ Metrics	Segmentation Accuracy	Segmentation Error
Brain Tumor segmentation using K-Means Algorithm	79.95%	25.46%
Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images	93.42%	5.23%

Compared to Brain Tumor segmentation using K-Means Algorithm, presented Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images has high segmentation accuracy and low segmentation error. The Fig. 4 shows the accuracy comparison. The x-axis shows different brain tumor segmentation approach and y-axis represents the accuracy in terms of accuracy.

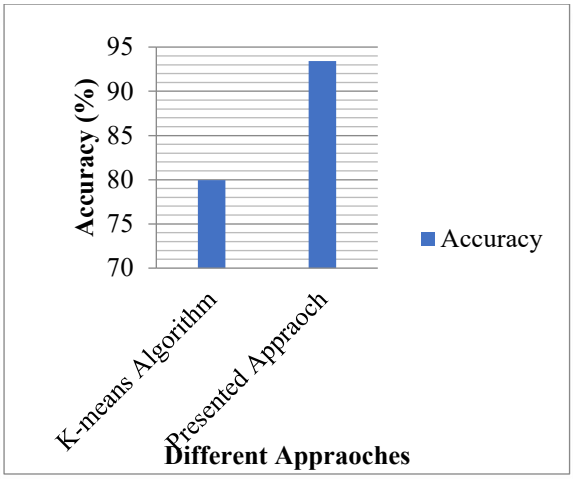

Fig. 4: Segmentation Accuracy Comparison

Presented Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images has high accuracy than earlier approach using k-means algorithm. The Fig. 5 shows the segmentation error comparison.

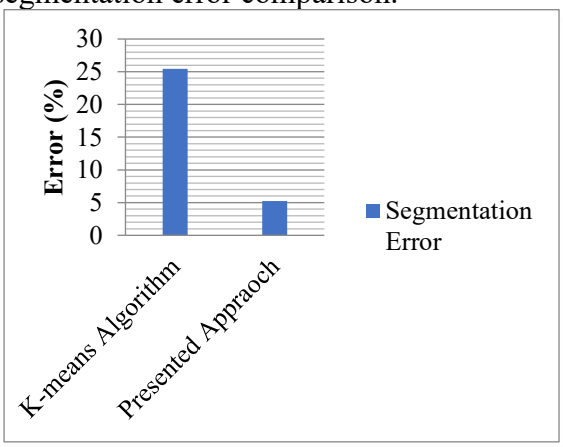

Fig. 5: Segmentation Error Comparison

Compared to k-means algorithm, presented approach has less segmentation error. Hence presented approach has high segmentation accuracy and less segmentation error, as a result brain tumor is detected very accurately. Thereby proper diagnosis will be provided and patient life will be saved.

V. CONCLUSION

In this section, Morphological Image Enhancement Based Brain Tumor Segmentation using MRI images is presented. Image processing techniques are used for noise removal and enhancement because noisy data leads to reduction of segmentation accuracy. The image pre-processing technique has eliminated the unnecessary data and smooth up the noisy data to detect and eliminate the outlier and rectify the data inconsistencies. Morphological operations are used to attain the attributes of the MRI brain images. Bi-linear filter replaced the intensity of each pixel with a weighted average of intensity values from nearby pixels. Pixel segmentation is the process of highlighting pixels in an image that represent features and then those pixels are assigned a class label. From the results, it is observed that presented methodology is robust in detecting and bounding the abnormal cells in MRI images despite the complicate shape of the tumor. Compared to earlier approach this approach has high segmentation accuracy and low segmentation error. This system is used to segment MRI images of the brain to detect and identify a brain tumor.

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