A Brief Review on Brain Tumor Segmentation and Detection Algorithms with Issues and Challenges

Article *in* International Journal of Advanced Trends in Computer Science and Engineering · August 2021

DOI: 10.30534/ijatcse/2021/361042021

1 author:

Saurabh Sharma
Model Institute of Engineering and Technology
8 PUBLICATIONS **1** CITATION

SEE PROFILE

ISSN 2278-3091
Volume 10, No.4, July - August 2021
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse361042021.pdf
https://doi.org/10.30534/ijatcse/2021/361042021

A Brief Review on Brain Tumor Segmentation and Detection Algorithms with Issues and Challenges

Shallu Dogra[1], Saurabh Sharma[2]
[1]Sri Sai University Palampur, India, shalluharshul@gmail.com
[2]Sri Sai University Palampur, India, saurabh23frmsnr@gmail.com

ABSTRACT

Computer vision techniques and development of computer-aided tools are evolving as the areas of research for automatic segmentation of brain tumors. Some of these techniques showed good results but there is no winning technique as these approaches have often not used practically in hospitals. In these days, research on medical healthcare system [1] is an emerging area and main focused on the designing of an efficient segmentation approach with concept of Artificial Intelligence (AI) techniques for appropriate region and fast segmentation purpose. There are a lots of clustering as well as traditional segmentation approaches are available for medical images, but most of them are depended on the data types. In this paper, we presented a brief review on clustering-based medical image segmentation with their challenging factors faced by researchers [2]. Due to high success rate of AI, Deep Learning (DL) algorithms, there has been a considerable amount of brain tumor segmentation works are aimed by researcher and try to solve the exiting challenges. In this survey, various type of brain tumor segmentation and detection system are analyzed to find out the exact tumor location and faced issued by the researchers. In Addition, some challenging factors are also analyzed with various algorithms of segmentation such DL, K-means clustering, Optimization and traditional approaches.

Key words: Image Processing, Segmentation, Brain Tumor, Deep Learning, and Artificial-Intelligence/ Machine-Learning techniques

1.INTRODUCTION

Image segmentation is one of the most challenging aspects in medical science and is widely used in many applications like brain tumor detection, skin cancer detection, leukemia detection, lung disease detection etc. Brain tumor segmentation procedure subdivides an image into its constituent parts or objects. The separation of available tumor in brain Magnetic Resonance Imaging (MRI) is one of the important applications of image segmentation [3]. Manual detection of tumors in MRI need trained radiologists which is a time-consuming process and is also susceptible to errors. Due to large number of patients and scans, manual segmentation of such a large data is too cumbersome. So, there is a need to automate this process and segmentation techniques play an important role in achieving this goal [2]. In this section of article, the introduction behind the brain tumor segmentation and detection model using optimized deep learning from MRI images are outlined.

Brain Tumor: The human brain is an amazing organ of about three pounds [3 kg] of 1.4 Kg that controls all bodily functions, examines information from the outside world, and completes the essence of the mind and soul [4-5]. Intelligence, art, curiosity, and memory are among the various things that the brain directs. Protected inside the skull, the brain contains the cerebrum, cerebellum, and brainstem. The brainstem acts as a transmission center that joins the cerebrum and cerebellum in the spinal cord. Every day the brain receives and transmits information to and from the body [5-6] and various parts of the brain are shown below Fig. 1.

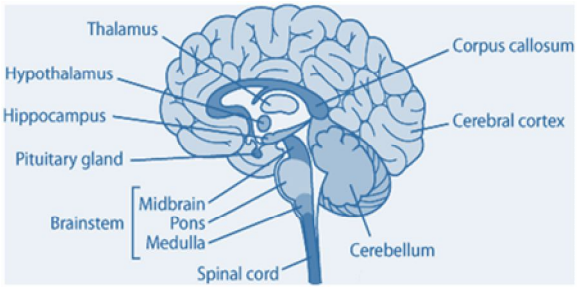

Fig. 1: Parts of Human Brain [23]

A brain tumor is the weight or expansion of abnormal cells in the brain or near the brain. Brain tissue abnormal growth in the brain can be cancerous (malignant) or noncancerous (benign). The effects on the brain of malignant and benign brain tumors [6-7] are very similar and can cause the same types of problems depending upon the type of tumor and where it is located in the brain. Different types of brain tumors exist [8]. Few non-cancerous (dangerous) brain tissue, and some brain tissue are cancerous (dangerous). Brain tissue can start in your brain (the main brain tissue), or cancer can start in other parts of your body and spread to your brain (secondary, or mastatic tissue).The region of brain tumor is given in the Fig 2.

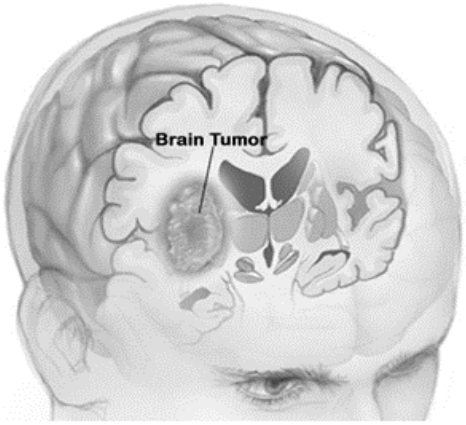

Fig. 2: Brain Tumor [24]

Brain tumor boundary detection is one of the challenging tasks in the medical image processing and it is also known as the Region of Tumor (ROT) segmentation and detection [9]. In first stage of brain tumor boundary detection, abnormal slice of the MRI human head scan is pre-processed by multiple threshold based segmentation, piecewise linear transformation to enhance the tumor portion [10]. Then the output of the transformation is processed by popular K-means clustering technique and this technique is imitates the behavior of data clustering into multiple clusters. In the brain tumor boundary detection process involves De-noising, Enhancement, Binarization, Image Morphological Operations and Segmentation technique.

Basically, Deep Learning (DL) [11] is a subset of Artificial Intelligence (AI) that is used frequently in these days. So, main motive of this survey is o analyses the efficiency of the existing works to find out the issues and challenging factors. Some the significant contributions of this survey are potted as follows:

- The contemporary literature with respect to brain tumor segmentation problem are covered.
- A comprehensive review with a perceptive study of different aspects are discussed including their key contributions.
- We provide a brief summary of brain tumor segmentation applications for numerous medical images.
- Several segmentation issues and challenges with their potential future directions are also covered.

The rest survey article is organized as follows: Section 2 provides a detail literature survey for recent brain tumor segmentation techniques and in Section 3, segmentation issues and challenges are discussed and finally present our conclusions in Section 4 with future directions.

2. LITERATURE SURVEY

We presents an overview of the most significant state-of-the-art brain tumor segmentation and detection from MRI using various type of algorithms. ***S Nema et al.*** had conducted a research for brain tumor segmentation and named as residual cyclic unpaired encoder-decoder network (Rescue-Net). In this research, authors designed a network architecture named as Rescue-Net using the concept of a residual and mirroring principles. This technique utilized the unpaired adversarial training for brain tumor region segmentation followed by core and enhance regions in a brain MRI scan. There are lots of approaches already proposed for an automatic brain tumor analysis but they faced problem of preparing large scale labelled data for training of deep networks. The data labelling is a time consuming process and to eliminate this, authors used unpaired training approach to train the system using Rescue-Net. To validate the system, they evaluated some specific performance parameters such as Dice and Sensitivity and the experimental results are tested on BraTS 2015 and BraTS 2017 dataset and the result outperforms the existing methods for brain tumor segmentation. They not used the concept of any external segmentation optimization approach that

would be better option to make an efficient model for tumor segmentation from MRI images [8]. ***Hao Dong et al.*** presents an automatic brain tumor detection and segmentation using u-net based fully convolutional networks. They have proposed a completely automatic method of cerebral cortex, which is built using U-Net networks based on deep connections. The proposed approach has been tested in the BRATS 2015 data sets and cross-validation has indicated that the proposed approach could achieve a promising split. The proposed function is only applicable to a specific image during the separation process and requires improvement in pre-processing steps for further use of offline images [9]. ***M. J. Khan et al.*** discussed non-invasive hybrid brain interface methods to improve phase accuracy. In hybridization the two techniques are combined to transform the brain images and get better results. The main purpose of hybridization is to increase the number of control commands, to obtain better phase accuracy and to reduce signal acquisition time [10]. ***Astina Minz*** brain tumor was detected using Magnetic resonance imaging (MRI). In this procedure the tumor is analyzed by transmitting a powerful magnetic field into the patient's brain. Diagnosis of brain tumor using MRI method is complicated but provides better accuracy. The author has used an Adaboost machine learning algorithm to improve the accuracy of MRI image. The three processes have three steps designed such as pre-processing, feature removal and separation. Processing used to remove audio from recorded data. The Gray Level Co- Matrix Maturity (GLCM) has been used as a feature removal process and the Adaboost separation process [11] has been used. ***UC Hemasundara Rao and Dr PV Naganjaneyulu*** introduced an automated system to detect and differentiate the tumor site in the brain. The proposed program consists of three steps named as the initial stages, modeling the energy work and improving the energy work. In making the plan a more reliable author used to present the details in the T1 and FLAIR MRI image [12]. ***UR Anita Jasmine and Dr. P Arockia Jansi Rani*** used T1 axial MRI images and algorithms designed for the MATLAB 2010a environment. The parameters are rated by true positive (TP), false positive (FP), negative negative (TN), false negative (FN). In this research work, only T1 images were considered [13]. ***M Gupta et al.*** introduced a new method used to detect tumor in the brain on the basis of distance on the basis of Kurtosis and skewness in combination with morphological features. Features were extracted using the T2-weighted MR brain system to differentiate the upper brain tumor from the lower brain tumor. The vector support mechanism has been used as the separation and validation of the K-fold cross. It is concluded that the accuracy rate obtained using SVM segmentation is 100% [14]. ***UG. Singh and M. A. Ansari*** have studied the many techniques used to remove the image signal obtained from an MRI image. Various filters named as Median filter, Adaptive filter, intermediate filter, Un-sharp masking filter and Gaussian filter have been used to remove any additional noise present in the MRI image. PSNR and MSE parameters are measured. Brain image classification was performed using the K-mean integration algorithm. The division of Naive Bayes and Support vector machine (SVM) has been used which is why the accuracy of the system has increased. By using the SVM value obtained accuracy is 91.49% and for Naïve Bayes the accuracy rate is 87.23%. Therefore, it was concluded that SVM works better than the Naive Bayes classifier [15]. ***Shereen A Taie and Wafaa Ghonaim*** have proposed a method used to detect brain tumors in MR images. The proposed procedure measured brain tumor growth in a patient's brain using four designated measures such as segmentation, feature removal, feature reduction and segregation. The optimization algorithm used is Chicken Swarm Optimization (CSO) and swarm optimization (PSO) optimizers to increase classification accuracy [16]. ***Lubna Farhi and Adeel Yusuf*** examined different machine imaging techniques used to detect brain tumors on MRI images. Gray co-occurrence matrix probabilistic (GLCM) elements have been used to distinguish damaged and damaged cell. Reduce Release Features Used for PCA Principle component analysis. System accuracy has increased from 10% to 27% [17]. ***Kailash D Kharat et al.*** proposed methods for the extraction of a feature called Principal Component Analysis (PCA), a process of the degree of dependence of the gray matter area of the extracting features of MRI brain scans. SVM used for partitioning. The genetic algorithm has been used to differentiate [18]. ***Boucif beddad and Kaddour hachemi*** have developed a novel process of detecting brain tumors in MRI images to design a collaborative process of a biological framework. Initially, the author presented an FCM concept that incorporates location data to obtain an improved level of cluster facilities, over time, the results being considered an effective starting point for Level set. Using this method, several initiatives are set to set the default parameters. The result obtained after satisfactory use, which allows the user to demonstrate that the use of an integrated method of categorized algorithms allows for improved results with more access accuracy [19]. ***Luxit Kapoor***

and Sanjeev Thakur reviewed various methods that are part of Medical Image Processing and are commonly used to obtain brain tissue from MRI Images. Initially, the various methods used these days in the use of medical imaging are extensively reviewed. On the basis of research, this paper has been written with different strategies in use. A general description of all the strategies is also provided. Also, for all the various steps involved in the tissue acquisition process, classification is effective and important [20]. Based on the above survey, we presents some important points in the Table I.

Table 1: Survey of existing work based on advantages and disadvantages.

Authors	Proposed Techniques	Advantages	Disadvantages
S Nema et al. [8]	A model of brain tumor segmentation and named as residual cyclic unpaired encoder-decoder network (Rescue-Net)	To minimize the data labelling is a time, used unpaired training approach to train the system using Rescue-Net.	Authors don't used the concept of any external segmentation optimization approach that would be better option to make an efficient model for tumor segmentation from MRI images.
Hao Dong et al. [9]	U-Net based image segmentation and fully convolutional neural networks (FCNN)	U-net based segmentation is better option for segmentation and by using this efficiency of system is increase as compare to other technique.	The proposed work is only applicable for linear image during the classification process and need to improvement in the pre-processing steps for further usages of non-linear images.
M. J. Khan et al. [10]	Hybrid brain-computer interface (BCI)'s	Due to use of BCI, segmentation results improved	By using the only BCI technique, the detection and segmentation result is not acceptable for medical science research point of view.
Astina Minz [11]	Gray Level Co- occurrence Matrix (GLCM) and Adaboost for classification	Adaboost is the better classier as compare to the other classifier because, it is a multiclass classifier	The system complexity is increased by using the GLCM technique because GLCM returns more number of features.
R. Anita Jasmine [13]	Skull removal, Phase I-Histogram thresholding and Phase II-Region Growing phase	The use of skull removal concept is the better approach as compare to the other work because, the segmentation of tumors become simple	There is any types of feature extraction technique are not used so the tumor retrieval process become difficult.
G. Singh and M. A. Ansari [15]	K-means clustering based segmentation and normalized histogram with Naïve Bayes and Support Vector Machine classifier	The combination of Naïve Bayes and Support Vector Machine as a classifier is the used for tumor detection which achieve better accuracy	The use of K-means clustering as segmentation is a random process which affects the segmentation results.
Shereen A Taie and Wafaa Ghonaim [16]	Chicken Swarm Optimization (CSO) and Particle Swarm Optimization (PSO) with SVM classifier	The classification accuracy is greatly enhanced by the use of the new feature optimization with PSO and SVM classifier	The used of RBF as a kernel function is affect the tumor volume and better option is to select polynomial kernel function

Table 2: Comparison of accuracy in existing work

Authors	Accuracy (%)
S Nema et al. [8]	94.63
Hao Dong et al. [9]	90.00
M. J. Khan et al. [10]	89.30
Astina Minz [11]	87.40
R Anita Jasmine [13]	76.30
G. Singh and M. A. Ansari [15]	71.90
Shereen A Taie and Wafaa Ghonaim [16]	86.11

technique based on the results and comprehensive technique is better option to find out the better technique for automated segmentation and detection of tumor region from the MR brain images. The comparative analysis of results based on the accuracy is given in Table II.

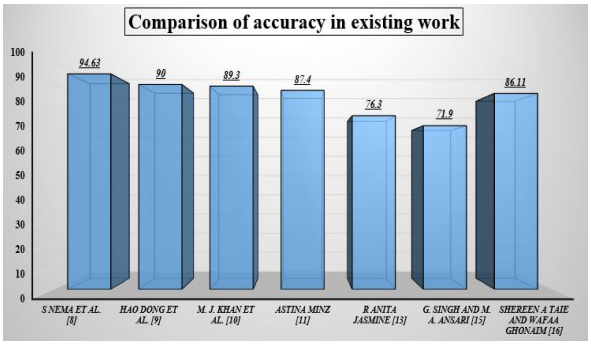

Fig. 3: Comparison of Accuracy

Basically from the literature survey focuses on different solutions to provide better segmentation and detection of brain tumor using different approaches. After analysis of existing research work in the area of medical science, the following points are highlighted.

1. Existing work has not emphasized on the extraction of best and appropriate feature sets from MRI data of brain tumor for cancer detection and thereby leaving a room for further improvement.
2. Clustering algorithms employed for the segmentation of brain tumor ROI are sensitive to the selection of initial cluster center and thereby getting easily trapped into the local optimum solutions. Improvements in these stages will enable early and more efficient diagnosis of brain tumor, thereby providing an aid to the modern clinical environments.
3. Pre-processing is one of the most important steps for a brain tumor segmentation and detection using MRI data should be more appropriate. In existing work, MRI data enhancement was proposed by lots of authors but removal of noise data is not proper for such cases like if contrast of image is low then information loss is high with enhancement procedures.
4. The entire computation arena is focusing on developing the enhanced classification structure but the root of the brain tumor segmentation and detection is a well arranged targeted feature label which can be achieved by optimization techniques. The optimized feature set will always produce good classification accuracy during the brain tumor segmentation and detection model. So due to lack of feature optimization approach in the existing work, the selection of feature set is not good and it is depend on the optimization techniques. Hence a cross validation of the optimization is found to be missing which can produce a better feature sets according to the type of brain tumor data.
5. Swarm-based optimization is used for the optimization of the segmented brain tumor region with improved fitness function but it is a density based optimization algorithm which always needs large volume of data to be processed. So, validation of swarm-based techniques is an important step which is missing in existing work. Need to validation the other swarm based algorithms like Cuckoo, Firefly, Whale etc. also be tried which works with low density as well.

3.CHALLENGES & ISSUES

Most of the available brain tumor segmentation methods are based pixel grouping, texture, and color information of pixels. From the state-of-art analysis, it has been found that most of the segmentation approaches need a perfection to achieve efficiency of the diagnosis system. Most of the authors did not focused to make an efficient system with selection of DL approach for segmentation. Challenges and issues based comparison of various segmentation techniques are given in the Table III.

Table 3: Comparison of Segmentation Methods

Segmentation Methods	Explanation	Advantages	Shortcomings
Deep Learning based [8, 9, 10]	Depend upon the selected hidden layer and neurons size	☞It is simple approach and don't need any previous pixel information ☞Computational complexity is very low	☞Spatial details of an image is not considered for segmentation ☞Faced adjacent pixel overlapping problems ☞Cannot provide batter accuracy of multi portion image and can't promise the segmented groups of image are adjacent
Adaboost machine learning based [11]	The working mechanism is based on pattern continuity	☞If image quality is good, then provide better segmented output	☞In case of noise, resistant capacity is less and doesn't provide exact segmented results
Region based [12, 13]	Homogenous region are identified and then partition is applied to perform segmentation	☞Better option to identify a region in image	☞Consume more time and memory to perform a segmentation
Support Vector Machine based [14, 15]	Topological interpretation is used for segmentation	☞Stability of image segmentation is more during the boundaries detected	☞Gradients calculation is complex and need more time
Clustering based [19]	Based on the centroid, classify or make cluster of an image into numerous region or segments according to the pixels	☞It is an iterative process and segment an image with very few seconds. ☞Also applicable of an irregular image and return better results	☞Performance is worst in case of low quality image ☞Due to unsupervised mechanism, cluster position is not fixed and vary each time ☞Faced pixel mixing problems in case of similar pixel range ☞The size of initiated clusters are expected to be of similar size, and it is not conceivable automatically

Some important challenges and issues of existing clustering as well as traditional segmentation techniques are given in the Table III with advantages and major shortcomings. From the table, we observe that the utilization of DL is a beneficiary steps for medical diagnosis system which help to achieve a better segmentation results in future. The overall conclusion of this survey article is written in the next section.

4.CONCLUSION AND FUTURE WORK

In this survey paper, a brief review on brain tumor segmentation and detection algorithms with issues and challenges is discussed in existing approaches. An inclusive overview for DL-based segmentation methods is described that provides a better detailed view of the different segmentation methods and their potential challenges for future improvement point of view. Main reason behind the survey is to help the medical diagnosis system related to the brain tumor, because early detection of tumor is an essential to identify their stage. In future, DL techniques will be used as a classifier to train segmentation model based on hybridization with soft computing optimization algorithm for maximum accuracy and fast execution purpose.

REFERENCES

[1]. Bhatt, C., Kumar, I., Vijayakumar, V., Singh, K. U., & Kumar, A. (2020). The state of the art of deep learning models in medical science and their challenges. Multimedia Systems, 1-15.

[2]. Tiwari, A., Srivastava, S., & Pant, M. (2020). Brain tumor segmentation and classification from magnetic resonance images: Review of selected methods from 2014 to 2019. Pattern Recognition Letters, 131, 244-260.

[3]. Bengio, Y., Courville, A. C., & Vincent, P. (2012). Unsupervised feature learning and deep learning: A review and new perspectives. CoRR, abs/1206.5538, 1, 2012.

[4]. Cetin, O., Seymen, V., & Sakoglu, U. (2020). Multiple sclerosis lesion detection in multimodal MRI using simple clustering-based segmentation and classification. Informatics in Medicine Unlocked, 20, 100409.

[5]. Raja, P. S. (2020). Brain tumor classification using a hybrid deep autoencoder with Bayesian fuzzy clustering-based segmentation approach. Biocybernetics and Biomedical Engineering, 40(1), 440-453.

[6]. Bonabeau, E., Marco, D. D. R. D. F., Dorigo, M., Théraulaz, G., & Theraulaz, G. (1999). Swarm intelligence: from natural to artificial systems (No. 1). Oxford university press.

[7]. Banks, A., Vincent, J., & Anyakoha, C. (2007). A review of particle swarm optimization. Part I: background and development. Natural Computing, 6(4), 467-484.

[8]. Nema, Shubhangi, Akshay Dudhane, Subrahmanyam Murala, and Srivatsava Naidu. "RescueNet: An unpaired GAN for brain tumor segmentation." Biomedical Signal Processing and Control 55 (2020): 101641.

[9]. Dong, Hao, et al. "Automatic brain tumor detection and segmentation using U-Net based fully convolutional networks." annual conference on medical image understanding and analysis. Springer, Cham, 2017.

[10]. Khan, M. Jawad, Melissa Jiyoun Hong, and Keum-Shik Hong. "Decoding of four movement directions using hybrid NIRS-EEG brain-computer interface." Frontiers in human neuroscience 8 (2014): 244.

[11]. Minz, Astina, and Chandrakant Mahobiya. "MR Image classification using adaboost for brain tumor type." Advance Computing Conference (IACC), 2017 IEEE 7th International. IEEE, 2017.

[12]. M. J. Khan, A. Zafar and K. S. Hong, "Comparison of brain areas for executed and imagined movements after motor training: An fNIRS study," 2017 10th International Conference on Human System Interactions (HSI), Ulsan, South Korea, 2017, pp. 125-130.

[13]. S. A. Taie and W. Ghonaim, "Title CSO-based algorithm with support vector machine for brain tumor's disease diagnosis," 2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), Kona, HI, 2017, pp. 183-187.

[14]. M. J. Khan, A. Zafar and K. S. Hong, "Comparison of brain areas for executed and imagined movements after motor training: An fNIRS study," 2017 10th International Conference on Human System Interactions (HSI), Ulsan, South Korea, 2017, pp. 125-130.

[15]. Jasmine, R. Anita, and P. Arockia Jansi Rani. "A two phase segmentation algorithm for MRI brain tumor extraction." Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2016 International Conference on. IEEE, 2016.

[16]. R. Majid Mehmood, R. Du and H. J. Lee, "Optimal Feature Selection and Deep Learning Ensembles Method for Emotion Recognition from Human Brain EEG Sensors," in IEEE Access, vol. 5, no. , pp. 14797-14806, 2017.

[17]. Singh, Garima, and M. A. Ansari. "Efficient detection of brain tumor from MRIs using K-means segmentation and normalized histogram." Information Processing (IICIP), 2016 1st India International Conference on. IEEE, 2016.

[18]. Taie, Shereen A., and Wafaa Ghonaim. "CSO-based algorithm with support vector machine for brain tumor's disease diagnosis." Pervasive Computing and Communications Workshops (PerCom Workshops), 2017 IEEE International Conference on. IEEE, 2017.

[19]. C. H. Rao, P. V. Naganjaneyulu and K. S. Prasad, "Brain Tumor Detection and Segmentation Using Conditional Random Field," 2017 IEEE 7th International Advance Computing Conference (IACC), Hyderabad, 2017, pp. 807-810.

[20]. M. Gupta, B. V. V. S. N. P. Rao and V. Rajagopalan, "Brain Tumor Detection in Conventional MR Images Based on Statistical Texture and Morphological Features," 2016 International Conference on Information Technology (ICIT), Bhubaneswar, 2016, pp. 129-133.

[21]. L. Farhi and A. Yusuf, "Comparison of brain tumor MRI classification methods using probabilistic features," 2017 13th IASTED International Conference on Biomedical Engineering (BioMed), Innsbruck, Austria, 2017, pp. 55-62.

[22]. K. D. Kharat, V. J. Pawar and S. R. Pardeshi, "Feature extraction and selection from MRI images for the brain tumor classification," 2016 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, 2016, pp. 1-5.

[23]. https://lh3.googleusercontent.com/-MYwzq5CV_qblRYbOb3I-5LHbV3v2lcyw7MNe7UJBYj2-j3gc0Lb8xl2IbFJd99GK-6r=s170

[24]. https://lh3.googleusercontent.com/ERv5O437CswO7UWVzoVhml1TLkcUcuFK0LKTULv_rKAqKYNrzkMLyhKtQexJbeR1SdTROw=s95