A Survey: Brain tumor detection techniques of Computer aided diagnosis through MRI image

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ABSTRACT

The brain related disease can be identify with imaging techniques vie, MRI technique. Now day's disease like tumor growth in brain is very common. Brain tumors classified as primary and secondary depending on their abnormalities. The Documented analysis of medical image on MRI is time consuming and gives inaccurate result. The difficulty in brain image analysis is mainly due to the requirement of detection techniques where radiologist suffering the problem of the manual intervention. This type of difficulty can be recovered by the Computer-aided diagnosis (CAD) scheme have capability of improve the diagnosis and less time required for accurate result. The main objective of this review paper is to define the various state-of-the-art detection techniques for the brain MRI images.

Keyword: *Magnetic resonance imaging, Medical imaging, Brain Tumor, CAD, Segmentation, Feature extraction, Classification.*

1. Introduction

Now days the biomedical imaging is very important for many applications for radiologist to diagnose the patient treatment related problems. At present imaging technology is must for patient diagnosis. The various medical images like MRI ,Ultrasound, CT, X-ray etc play an important role in the field of process of disease, diagnosing and treating [36, 45,35]. The recent revolution in medical imaging results from techniques such as CT and (MRI) can provide detailed information about disease. and can identify many pathologic conditions giving an accurate diagnosis. Furthermore, the new techniques are helping to advance fundamental biomedical research. Medical imaging is one of the most common techniques used to improving the diagnoses, understanding and treatment of a large variety of diseases. [41]

The brain imaging analysis is main objective in the field of medical image analysis. Magnetic resonance (MR) imaging have many benefits over the medical imaging modalities such as a useful non invasive technique for assisting in clinical diagnoses, the high level of contrast resolution, multispectral characteristics[46, 9] and ability to provide rich information about human soft tissue[46, 15]. MRI provides useful information in the field of surgery, radiotherapy treatment planning, stereotactic neurosurgery [46, 5]

Computer Aided Diagnosis system has been developed for Automatic Detection of Brain Tumor through MRI. Improving the ability to identify early-stage tumors is an important goal for physicians, because early detection of class of disease is a key factor in producing successful treatments.

There are different type of detection techniques which is use to develop the CAD. To create a CAD system, the integration of various image processing techniques such as segmentation, feature extraction and classification are essential.[41, 42, 13, 11]

2. Methodology of MRI Scheme

A medical imaging technology gives visualization of internal anatomical structures and diagnoses a

disease. The Magnetic Resonance Imaging is found to be much superior to other techniques.

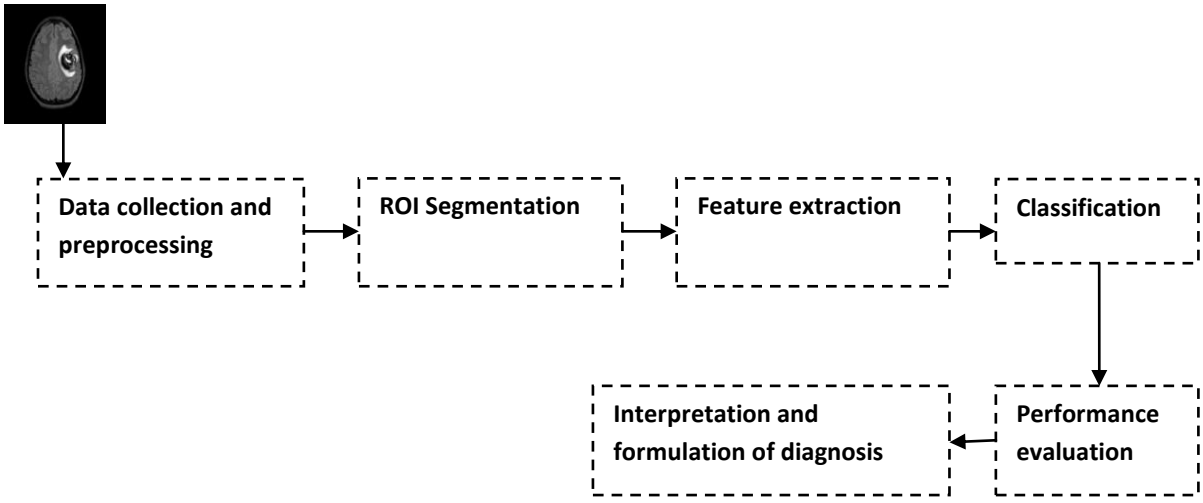

Fig. 1 Methodology of CAD scheme

Figure.1 shows the steps of the CAD scheme. In this paper we reviewed the various state of the art segmentation and classification methods for CAD system. In this paper we discussed about the advantages and the disadvantage of the algorithms from the literature.

Many research publications describe the different detection approaches for medical image analysis which are reported in the literature.

2.1 Pre-processing and Enhancement for MR image

Image pre-processing and enhancement is the starting stage which is important for the further stages. This gives the higher accuracy of CAD system.

Pre-processing and enhancement used to improve the detect the regions in MRI. This stage is used for reducing image noise, highlighting edges, or displaying digital images. The removal of unwanted parts from the brain MR image, finding edge position for removing labels and smoothing the image will be processed by using innovatively new pre-processing methods.

The enhancement stage used some techniques for MR images and gives the noise free, film artifact images. [2, 22]

2.2 Segmentation Techniques For MR Image

Radiologist first to analysis the condition and nature of the brain image abnormality, and then plan for treatment. In case of MR image abnormalities, the abnormal growth may be in increasing or decreasing form which indicates the positive effect and sometimes indicates the negative effect. In any condition the volumetric analysis is very important for analysis the brain tumor growth in MR image. Segmentation methods has ability to detect or identify the abnormal portion from the image which is useful for analyzing the size, volume, location, texture and shape of the extracted image. Several researchers are currently working on this medical image segmentation area. The most famous detection methods are: (i) fuzzy based methods (ii)

Thresholding based methods (iii) region-growing based methods and (iv) Clustering based methods used for tumor segmentation.[46]

Table 1 shows the summary of segmentation techniques and Table 3 compares the different segmentation methods. Clearly, advantages and disadvantages of the most famous detection techniques used for medical imaging analysis are summarized briefly

2.3 Feature Extraction for MR Image

The feature extraction techniques represent the real biomedical/non medical image database in an alternate way by measuring the most popular properties or to extract the features of the image. The different type of feature like shape, texture and boundary used for biomedical images

2.4 Classification for MR Image

The biomedical image classification is very important stage for automated CAD system. In this step define the different normal or abnormal cases for disease with the help of the calculated feature set. Classification is the best approaches for identification of images like any kind of medical imaging. All classification algorithms are based on the prediction of image, where one or more features and that each of these features belongs to one of several classes. Table 2 shows the summary of classification and feature extraction techniques and Table 3 compares the different classification methods. Clearly, advantages and disadvantages of the most famous classification techniques used for medical image classification are summarized briefly

Table1: An overview of Segmentation techniques for medical images through MRI

Author	Segmentation techniques	Purpose
Zhang, Ruan, Lebonvallet, Liao, and Zhu (2011). [32]	Support Vector Machine (SVM) and region growing algorithm	SVM used for learning and selection of feature for MRI and to automatically refine the segmented region contour by region growing technique.
Ratan, Sharma, and Sharma (2009). [17]	Watershed	segmentation of MRI brain tumors in both dimensions.
Siyal and Yu (2005). [7]	Modified FCM algorithm	Segmentation of inhomogeneous MRI images
Rajendran and Dhanasekaran (2011). [24]	Fuzzy-c mean cluster and deformable model	Segmentation of MRI brain image
Yang and siliang(2011). [30]	Fuzzy classification and deformable model	Tumor Segmentation on MRI Brain image
HOSEYNI, Haghipour, and Sorkhabi (2014). [42]	FCM+Watershed marker control algorithm	Segmentation on MRI
Saikumar, Yugander, Murthy andSmitha (2012). [34]	FCM ,water transform and level set algorithm	Image segmentation

Donoso, Veloz, and Allende (2010). [21]	Modified Expectation Maximization	MRI Segmentation
Kazerooni, A.F., Ahmadian, A., Serej, N.D., Saligheh Rad,H., Saberi, H., Yousefi, H., Farnia, P (2011). [27]	Multi-scale Gradient Vector Flow	Segmentation of Brain Tumors in MRI Images
Carlos S. Mendoza, Acha, B., Serrano, C., Gómez-Cía, T(2010). [19]	self-assessed adaptive region growing segmentation algorithm	segmentation with application to surgical planning
M. C. Jobin Christ, S. Sivagowri, P. Ganesh Babu (2014). [45]	Meta Heuristic Algorithms- Ant Colony Optimization (ACO), Artificial Bee Colony Optimization (ABCO), Bacteria Foraging Optimization Algorithm (BFOA), Genetic Algorithm (GA) and Particle Swarm Optimization (PSO)	Segmentation of Brain Tumors MRI Image
Yang, Y., Zhaoa,Yi., Wub,B., Wang H,(2014). [47]	piecewise constant multiphase Vese–Chan model, convex segmentation method and the split Bregman method	Segmentation of real time images
Zexuan, Sun, Xia, Chen, Xia, & Feng, (2012). [37]	Generalized rough fuzzy C-means algorithm	Brain MR image segmentation
Merisaari, Parkkola,Alhoniemi, Teräs, Lehtonen, Haataja (2009). [14]	Gaussian mixture model-based algorithm	Segmentation method for T1-weighted images
Yu chen (2009). [18]	Lattice Boltzmann method	For segmentation of medical image
Balla-Arabé,Gao, and Wang, (2013). [39]	Lattice Boltzmann method+FCM+LSE	For segmentation of medical image
Tsai, Manjunath, and Jagadeesan (1995). [2]	low pass filtered	The bone and soft tissue outlines are eliminated for Automated Segmentation of brain MR Images
Karnan and logeshwari, (2010). [22]	median filter	Improved implementation of Brain tumor detection using segmentation based on soft computing
Dunn, (1973). [1]	Fuzzy c-means (FCM) clustering algorithm.	Segmentation for brain MRI.

Arakeri and Reddy, (2013). [38]	Modified version of MFCM	Segmentation of brain tumor through MRI
Singh,Dubey, Jaffery,and Zaheeruddin. (2009). [16]	Marker controlled watershed segmentation method	Use region property
Rastgarpour and Shanbehzadeh, (2011). [24]	AI	To segment the images
Li, Huang, Ding, Gatenby,and Metaxas, (2011). [26]	Variation level set approach	Segmentation of MRI brain images that is intensity inhomgenety/ heterogeneous images.
Haung, (1998). [4]	K-prototypes algorithm	Segmentation of images.
Li,Chui,Chang and Ong (2011). [25]	Fuzzy + level set algorithm	To segment the brain MR images

Table 2: An overview of feature extraction and classification for medical images through MRI

Auther	**Feature extraction**	**classification**
Herlidou-Meme, Constans, Carsin, Olivie, Eliat, Nadal-Desbarats (2003). [6]	Texture analysis	Hierarchical classification
El-Dahshan, Hosny and Salem (2010). [20]	(DWT) + PCA	FP-ANN, k-NN
Prior and fred (2013). [40]	Random Forest	The random forests classifier accurately predicted radiologist generated segmentations and tumor extent.
Zhang, wang and wu (2010). [23]	DWT + PCA	Adaptive chaotic particle swarm optimization forward neural network (ACPSO–FNN)
Sachdeva, Kumar, Gupta, Khandelwal and Ahuja (2011). [39]	Texture and shaper extraction methods	GA+SVM
Chaplot, Patnaik and Jagannathan (2006). [8]	Wavelets transform	SOM SVM SVM with radial basis function based kernel
Zhang, Dong, Wu & Wang, (2011). [31]	WT + PCA	Back propagation neural network (BPNN)

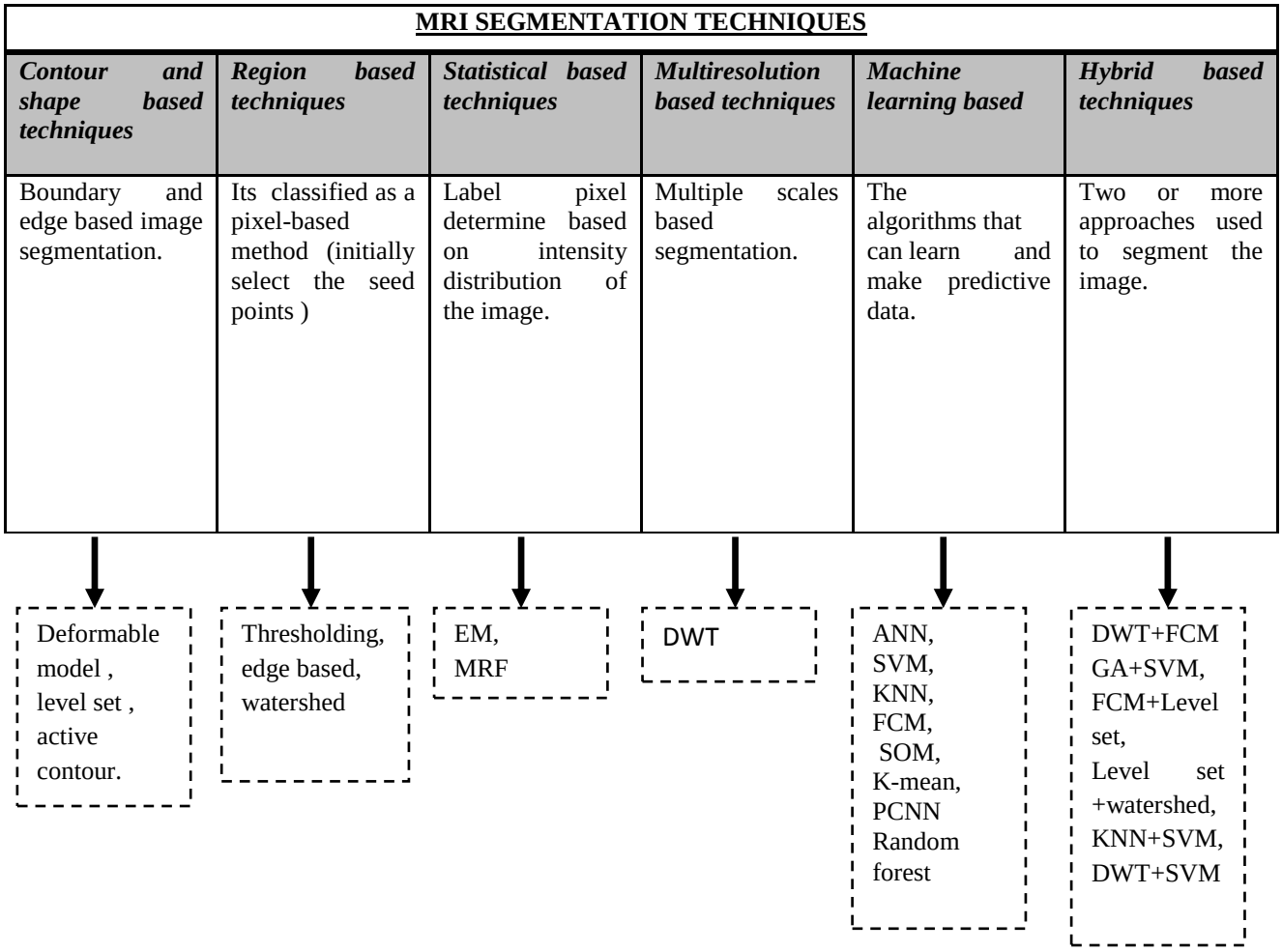

Fig. 2 Overview of segmentation techniques for MRI images

Table 3: advantages and disadvantages of segmentation methods for MRI Images

Methods	Advantage	Disadvantage
Threshold and outlier detection	○ Useful for linear image	○ Not suitable for brain MRI image .
Watershed	○ Components are connected form ○ Ability to implement a priori information.	○ Often needs preprocessing to work well Fragmentation or "over-segmentation" can be a problem
Edge based	○ ○ Less complex ○ Good contrast enhancement	○ low contrast ○ Sensitive to noise ○ Robust edge linking is not trivial
Region	○ Ability to separate the different regions	○ Can deal with noisy image

Growing	○ Ability to cover all pixels ○ better work on noisy image	○ Problem with power and time consuming.
Level set	○ Best for segmentation. ○ Less computational time. ○ Work on heterogeneous images also ○ Best for weak object boundaries.	○ Need to identified initial curves
SVM	○ Ability to handle Large datasets. ○ perform good in a wide range of non- ○ Linear classification problems. ○ providing good size of training data	○ SVM is not very scalable in dealing with large number (billions) of training data. ○ Not work very well multiple classes.
KNN	○ Very simple classifier. ○ lead itself very easily ○ easily integrate a new data into an trained system	○ It requires large memory size. ○ Heavy computational load. ○ It doesn't handle high number ofdimensions well
Bayesian	○ it is highly scalable ○ best classification for decision making	○ Information theoretically infeasible. ○ Computationally infeasible. ○ Unautomatic.
ANN	○ Ability to find nonlinear relationships between data set values. ○ Ability to find predictive values ○ Use for multiple training algorithms.	○ Need right way to NN operate ○ Processing time is high.
FCM	○ Ability to handle overlapped data. ○ Ability of more than one cluster center for data point	○ A priori specification of the number of clusters. ○ Euclidean distance gives unequal distance matrix.
K-mean	○ Computationally fast.	○ Need to understand K-values ○ Not works for global cluster ○ It does not work well with clusters
MRF	○ Identical behaviour ○ Depend on local behaviour image	○ Computationally infeasible ○ Difficulty to calculate Estimated Parameters.
Random forest	○ Good Learning algorithm ○ Ability to handle large databases. ○ Ability to work on unbalanced data sets.	○ Noise sensitive ○ Random forest are not reliable for type of data(where data include different no. of level)
LBM	○ Ability to avoid Statistical noise ○ Use of Flow parameters	○ Difficulty in curve grids. ○ Less no. Of software have been developed.
Harris based detection	○ Good for corner detection ○ The best known and most widely used key point **detector**.	○ The corner detector needs an improved adaptive threshold and the shape of mask can be improved.
Particle Swarm Optimization (PSO)	○ No overlapping ○ higher optimization ability	○ Problems with non-coordinate system not work properly. ○ Less regular with speed and the

direction.

3. Conclusion

This review paper mainly focuses on the various type of detection techniques which is highly required for medical image analysis. The advance computer applications or technologies and CAD had facilitated the brain tumor detection. Medical imaging and diagnostic radiology is the very important area in the field of medical. In this paper, we discussed about the various new and existing algorithms for CAD Scheme. CAD scheme covers the segmentation, feature extraction and classification algorithms. Among all these technique is useful for medical image analysis and to automate the manual work. In literature review segmentation and classification techniques are more efficient, more robust for noisy images, good for reducing iterations, ability of low false positive and high true positive detection rate lesser classification time or CPU time and more accurate in all dimensional MRI brain infected or non infected image.

Reference

[1]. Dunn, J. C. "A Fuzzy Relative of the ISODATA Process and Its Use in Detecting Compact Well-Separated Clusters". Journal of Cybernetics, 1973, Vol. 3, No.3, pp. 32-57.

[2]. Tsai, C., Manjunath, B.S. and Jagadeesan, R. "Automated segmentation of brain MR Images". Pergamon Pattern Recognition, 1995, Vol 28, No 12.

[3]. Tu JV. "Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes". J Clin Epidemiol,1996, Nov:49 (11):1225-31

[4]. Huang, Z. "Extensions to the k-means algorithm for clustering large data sets with categorical values". Data Mining and Knowledge Discovery, 1998, vol 2(3), pp. 283 – 304.

[5]. J. L. Marroquin, B. C. Vemuri, S. Botello, F. Calderon, and A. Fernandez-Bouzas . "An Accurate and Efficient Bayesian Method for Automatic Segmentation of Brain" MRI IEEE TRANSACTIONS ON MEDICAL IMAGING, 2002,VOL. 21, NO. 8.

[6]. Herlidou-Meme, S., Constans, J. M., Carsin, B., Olivie, D., Eliat, P. A., Nadal-Desbarats, L. "MRI texture analysis on texture test objects, normal brain and intracranial tumors". Magnetic Resonance Imaging, 2003, 21(9), 989–993.

[7]. Siyal, M. Y., & Yu, L. "An intelligent modified fuzzy c-means based algorithm for bias estimation and segmentation of brain MRI. Pattern Recognition Letters"2005, 26(13), 2052–2062.

[8]. Chaplot, S., Patnaik, L.M. and Jagannathan, N.R. "Classification of magnetic resonance brain images using wavelets as input to support vector machine and neural network." Biomedical Signal Processing and Control, 2006, vol. 1, pp. 86–92.

[9]. Kong,J., Wang, J., Yinghua Lu Jingdan Zhang, Li, Y.,Zhang. B. "A Novel Approach for Segmentation of MRI Brain Images" IEEE MELECON, 2006, May 16-19, Benalmádena (Málaga), Spain

[10]. Zhang Y., Xiong Z., Mao J., and Ou L. "The study of parallel k-means algorithm. Proceedings of the 6th World Congress on Intelligent Control and Automation, 2006, pp. 5868-5871

[11]. Cherkassky, V., & Mulier, F. "Learning from data: Concepts, theory and methods (2nd ed.)". John Wiley and Sons(2007).

[12].AnneSchistadSolberg,http://www.uio.no/studier/emner/matnat/ifi/INF4300/h09/undervisningsmateriale/segmentation-2009.pdf

[13]. Arimura, H., Magome, T., Yamashita, Y., & Yamamoto, D. "Computer-aided diagnosis systems for brain diseases in magnetic resonance images Algorithms" 2009, 2(3), 925–952.

[14]. Merisaari, H., Parkkola, R., Alhoniemi, E., Teräs, M., Lehtonen, L., Haataja, L. "Gaussian mixture model-based segmentation of MR images taken from premature infant brains" Journal of Neuroscience Methods (2009); 182(1), 110–122.

[15]. Song. Y., Zhang. C., Lee, J., Wang, F., Xiang. Z., and Zhang. D. "Semi-supervised discriminative classification with application to tumorous tissues segmentation of MR brain images" Pattern Anal Application, 2009, 12:99–115.

[16]. Singh, L., Dubey, R.B., Jaffery, Z.A. and Zaheeruddin. "Segmentation and Characterization of Brain Tumor from MR Images" IEEE International Conference on Advances in Recent Technologies in Communication and Computing , 2009, 978-0-7695-3845-7.

[17]. Ratan, R., Sharma, S., & Sharma, S. K. "Brain tumor detection based on multi-parameter MRI image analysis" ICGST International Journal on Graphics, Vision and Image Processing GVIP, 2009, 9(3), 9–17.

[18]. Yu Chen. Lattice Boltzmann Method based Medical Image Segmentation, 2009, IEEE, 978-1-4244-4131-0.

[19]. Carlos S. Mendoza, Acha, B., Serrano, C., Gómez-Cía, T. "Fast parameter-free region growing segmentation with application to surgical planning. Machine Vision and Applications" 2010, 165–177, 00138-0274.

[20]. Dahshan, EI. A.EI., Hosny, T. and Salem, A.M. "Hybrid intelligent techniques for MRI brain images classification'' Elsevier Digital Signal Processing, 2010, 20, pp. 433–441.

[21]. Donoso, R., Veloz, A., & Allende, H. "Modified expectation maximization algorithm for MRI segmentation" I. Bloch, & R. M. Cesar, Jr. (Eds.), CIARP, 2010, LNCS 6419 (pp. 63–70).

[22]. Karnan, M. and Logeshwari, T. "An Improved implementation of Brain tumor detection using segmentation based on soft computing" International Journal of Cancer research and Experimental oncology, Academic Journals, 2010, Vol.2(1), pp.6-14.

[23]. Zhang, Y., Wang, S., & Wu, L. "A novel method for magneticresonance brain image classification based on adaptive chaotic PSO" Progress in Electro magnetics Research, 2010 109, 325–343.

[24]. A. Rajendran and R. Dhanasekaran. A hybrid Method Based on Fuzzy Clustering and Active Contour Using GGVF for Brain Tumor Segmentation on MRI Images, European Journal of Scientific Research (2011);Vol. 61, No. 2, pp. 305-313.

[25] Li, B.N., Chui, C.K., Chang, S. and Ong, S.H. Integrating Spatial Fuzzy Clustering with Level Set Methods for Automated Medical Image Segmentation. *Computers in Biology and Medicine, (2011);* vol. *4*1, pp. 1–10.

[26]. Li, C., Huang, R., Ding, Z., Gatenby, J.C. and Metaxas, D.N. A Level Set Method for Image Segmentation in the Presence of Intensity Inhomogeneities with Application to MRI. IEEE Transactions on image processing (2011); vol 20, no.7.

[27]. Kazerooni, A.F., Ahmadian, A., Serej, N.D., Saligheh Rad,H., Saberi, H., Yousefi, H., Farnia, P.Segmentation of Brain Tumors in MRI Images Using Multi-scale Gradient Vector Flow. 33rd Annual International Conference of the IEEE EMBSBoston, Massachusetts USA (2011); 978-1-4244-4122-8.

[28]. Sachdeva, J., Kumar, V., Gupta, I., Khandelwal, N. and Ahuja, C.M. Multiclass Brain Tumor Classification using GA-SVM. IEEE development in E-system engineering (2011); 978-0-7695-4593-6.

[29]. Rastgarpour, M. and Shanbehzadeh, J. Application of AI Techniques in Medical Image Segmentation and Novel Categorization of Available Methods and Tools, Proceedings of the International Multi Conference of Engineers and Computer Scientists (2011); vol 1, IMECS.

[30]. Yang, W. and siliang, M. Automatic detection and segmentation of brain tumor using fuzzy classification and deformation model. IEEE 4th International Conference on Biomedical Engineering and Informatics (BMEI) (2011);978-1-4244-9352-4.

[31]. Zhang, Y., Dong, Z., Wu, L., & Wang, S. A hybrid method for MRI brain image classification. Expert Systems with Applications (2011); 38(8), 10049–10053.

[32]. Zhang, N., Ruan, S., Lebonvallet, S., Liao, Q., & Zhu, Y. Kernel feature selection to fuse multi-spectral MRI images for brain tumor segmentation. Computer Vision and Image Understanding (2011); 115(2), 256–269.

[33]. EE641 Digital Image Processing II: Purdue University VISE - November 14, (2012)https://engineering.purdue.edu/~bouman/ece641/notes/pdf/DiscreteMRFs-model-views.pdf

[34]. Saikumar, Tara., Yugander, P., Murthy P.S, and Smitha B. Improved Fuzzy C-Means Clustering Algorithm Using Watershed Transform on Level Set Method for Image Segmentation , International Journal of Machine Learning and Computing(2012); Vol. 2, No. 1,.

[35]. Singh N, Jindal A. A Survey of Different types of Characterization Technique in Ultra sonograms of the Thyroid Nodules" Published in international journal for computer science and informatics(2012); volume 4 (1), pp.112-115, 2231-5292.

[36] Singh, N., Jindal, A. Ultra sonogram Images for Thyroid Segmentation and Texture Classification in Diagnosis of Malignant (Cancerous) or Benign (Non-Cancerous) Nodules International Journal of Engineering and Innovative Technology (IJEIT) (2012);Volume 1, Issue 5.

[37]. Zexuan, Ji., Sun, Q., Xia, Y., Chen, Q., Xia, D., & Feng, D. Generalized rough fuzzy c-means algorithm for brain MR image segmentation. Computer Methods and Programs in Biomedicine, (2012); 108(2), 644–655.

[38]. Arakeri, M. P. and Reddy, R.M. Computer-aided diagnosis system for tissue characterization of brain tumor on magnetic resonance images. SIViP Springer-Verlag London (2013); 1863-1711.

[39]. Balla-Arabé, S,. Gao, X, and Wang, B. A Fast and Robust Level Set Method for ImageSegmentation Using Fuzzy Clustering and Lattice Boltzmann Method. IEEE TRANSACTIONS ON CYBERNETICS(2013); VOL. 43, NO. 3.

[40]. Fred W. Prior. Predicting a Multi-Parametric Probability Map of Active Tumor Extent Using Random Forests. Conf Proc IEEE Eng Med Biol Soc, (2013); 6478–6481.

[41].Charfi, S., Lahmyed, R., Rangarajan, L. a novel approach for brain tumor detection using neural network. impact: international journal of research in engineering & technology (impact: ijret)(2014); issn(e): 2321-8843; issn(p): 2347-4599 vol. 2, issue 7, pp. 93-104.

[42]. El-Sayed A. El-Dahshan, Heba M. Mohsen , Kenneth Revett , Abdel-Badeeh M. Salem Computer-aided diagnosis of human brain tumor through MRI: A survey and a new algorithm. Expert Systems with Applications (2014);41, 5526–5545.

[43]. Hoseyni, F., Haghipour, S., And Sorkhabi, A. Improvement of Segmentation on MRI Images Using Fuzzy Clustering C-Means And Watershed Marker Control Algorithm. Indian J.Sci.Res(2014); 4(3): 447-451.

[44]. Mathew, J., Vijayakumar, R. Comparative Analysis Of Parallel K Means And Parallel Fuzzy C Means Cluster Algorithms. International Journal of Science, Engineering and Technology Research, (2014);Volume 3, Issue 9.

[45]. M. C. Jobin Christ, S. Sivagowri, P. Ganesh Babu. Segmentation of Brain Tumors using Meta Heuristic Algorithms. OPEN JOURNAL OF COMMUNICATIONS AND SOFTWARE (2014); Volume 1, Number 1.

[46]. Singh N, Choudary N. A Review of Brain Tumor Segmentation and Detection Techniques through MRI. International Journal of Computer Applications (2014); (0975 – 8887) Volume 103 – No.7.

[47]. Yang, Y. , Zhaoa, Yi., Wub, B., Wang H. A fast multiphase image segmentation model for gray images, Computers and Mathematics with Applications (2014); 67, 1559–1581.