A Review of Brain Tumor Segmentation and Detection Techniques through MRI

Nikita Singh
Department of Computer Science engineering,
Collage of technology and engineering,
Udaipur, 313001, India

Naveen Choudhary
Department of Computer Science Engineering,
Collage of Technology and Engineering,
Udaipur, 313001, India

ABSTRACT
The most common imaging technique for brain is MR imaging it is a non-invasive method. Brain tumors are mainly classified as benign or malignant tumors depending on their growth pattern. The manual analysis of brain tumor on MRI is time consuming and subjective Intensity inhomogeneity is very challenging task image segmentation to avoid thus type of problem, in this paper describe the very efficient and accurate segmentation techniques. This paper presents a comprehensive review of the methods and techniques used to detect brain tumor through MRI image segmentation.

Keywords
MRI brain tumor, segmentation techniques, feature extraction, classification.

1. INTRODUCTION
In the current clinical inflation medical imaging is becoming a very important aspect for many applications from diagnosis to treatment. At present, the diagnosis of patient is not done without the use of imaging technologies. In modern medicine, various medical images- MRI ,Ultrasound, CT, Scintigraphy, SPECT, PET, X-ray etc play an important role in process of disease diagnosing and treating and have become major evidence to ensure disease [36]. Magnetic resonance (MR) imaging has several advantages over other medical imaging modalities such as a useful non invasive technique for assisting in clinical diagnoses, due to its high contrast resolution across the entire field of view, multispectral characteristics[16] and ability to provide rich information about human soft tissue[23]. MRI has provided useful information in the field of like reparative surgery, radiotherapy treatment planning, stereotactic neurosurgery [11].

Segmentation of MR brain images is the first step of quantitative analysis. In medical imaging analysis field [8][15], segmentation is very challenging for both normal and abnormal tissues of the brain that have complicated structures. While segmentation methods have been successful on normal Tissues, but in the abnormal tissues theoretical and experimental work still remains [23]. Brain tumor vary greatly in size and position, variety of shape and appearance properties, intensities overlapping with normal brain tissue.[17] Over the last 15-16 years, researchers has been focused on semi-automatic and fully automatic methods for detecting and segmenting brain tumors from MRI scans[14].

The accurate and automatic segmentation of brain MRI image is of great interest for assessing tumour growth and enhancing computer-assisted surgery, planning radiation therapy, and constructing tumour growth models[37].

Difficulties in segmentation of brain MRI: the problems of MRI include- Noise, Intensity inhomogeneity, Shading artefact, Partial volume.

There are still some challenges such as accurate and reproducible segmentation and characterization of abnormalities using intelligent algorithms due to the variety of shapes, locations and image intensities of different brain tumors.

This paper presents a review of the methods and techniques used during brain tumor detection through MRI image segmentation. This paper focuses on developing a automated brain tumor detection and segmentation system. This will enhance the detection and visualization of brain tumors from the output of MRI scans.

There are diverse motivations for the development of methods for automatic medical image segmentation. Every year, new brain MRI automatic segmentation algorithms are published.

This survey describes different segmentation methods for brain MRI images. This paper is organized as follows. Section II discusses various automatic segmentation methods and techniques. Section III concludes this survey.

2. REVIEW OF TECHNIQUES FOR BRAIN SEGMENTATION
The purposes of this study an automated detection and segmentation techniques for the extraction of brain tumor region and separation of tumor on the MR image. This MR image helps to overcome the time taking process of manual segmentation of large datasets.

2.1. Fuzzy based methods
Fuzzy logic is a set of mathematical principles for knowledge representation based on degrees of classical binary logic. In brain tumor segmentation fuzzy systems allow for the development of methods to perform the tasks related to intelligent human behaviours.

Dunn suggested image segmentation using fuzzy c-means (FCM) clustering algorithm [1] [25]. FCM implementated by many researchers and provide improved version for segmentation for brain MRI.

In this method Arakeri *et al*. [39] After FCM researcher to overcome the intensity inhomogeneities in FCM proposed modified version of MFCM. Accuracy is one of the important factors for brain image segmentation applications, they preferred computational techniques. MFCM is applied to the approximate image to segment the tumor and contain more detail of the images. [12]

Rajendran proposed fuzzy logic processing using c-means clustering on MR images for brain tumor segmentation [30].

FCM algorithm fails to deal with significant properties of images, which leads to strong noise sensitivity. To overcome this weakness, proposed a new clustering algorithm named PCM. possibilistic membership, are very sensitive to the choice of the additional parameters of PCM, which directly decide the clustering accuracy.

To overcome the weakness of the original PCM algorithm combined the objective function of PCM and FCM into a new objective function and PFCM, which can be interpreted as PCM and FCM, respectively, in some special cases where some proper parameter were adopted Xuan ji *et al.* [34] [35].

Pal *et al*. [24] Proposed EPFCM method, distance metric in PCFM is modified in such a way that includes memberships, both local non local spatial neighbourhood information to overcome the noise effect in MRI brain medical images

Table 1 Overview of fuzzy based methods

Proposed methods	***Remark***
FCM	❖ To improve the segmentation performance tremendously. ❖ This improves the segmentation ❖ Performance dramatically. ❖ Poor contrast, noise and intensity inhomogeneities can affect the results
MFCM	❖ Best for segmentation. ❖ Less computational time. ❖ Converges ❖ To overcome the intensity inhomogeneities in FCM proposed modified version of FCM.
FPCM	❖ Fuzzy rule-based system identification. ❖ Generates typical values when clustering unlabeled data ❖ Ignores the noise sensitivity deficiency of FCM ❖ Overcomes the coincident clusters problem of PCM

2.2. Thresholding based Methods

In thresholding approach image segmentation is based on gray level intensity value of pixels. Thresholding procedure determining a intensity value which breaks the desired sections. Then segmentation achieved by grouping pixels greater intensity into one single section of threshold and all other pixels into another section.

Prastawa *et al*. [13] proposed automatic brain tumor segmentation from MRI. This paper identifies the presence of edema. In this Robust estimation and outlier detection gives new concept for detecting abnormalities in the brain.

Rastgarpour *et al*. [32] Image segmentation through thresh holding is considered to be a simple and powerful approach to segment the images that have light objects on dark background.

Kang *et al.* [26] Thresh holding is a technique which is based on image space region, that is, on characteristics of image.

Laxman *et al*. [22] present a method to characterize technique using marker controlled watershed segmentation method and used region property (parameters are used). Bhat *et al*. [28] proposed watershed and active contour algorithm combining techniques used to overcome computational complexity and insensitive to noise.

R.B.dubey *et al.* [33] in this paper comparing three methods for evaluating their relative performance in the segmentation of tumor.

Aliaksei maistrou [19] Another way of modelling active contours, that was initially presented by Osher and Sethian in [3], implements Level Set methods. Cumulative idea and main difference between the Snakes method and Level Set methods is that in all Level Set methods an active contour is presented implicitly through a value of scalar function.

The level set method used as numerical technique for tracking interfaces and shapes has been increasingly applied to image segmentation in past decade. Contour based level set method represents as the zero level set of a higher dimensional function, is called a level set function. In the level set representation, the image segmentation problem can be solved and formulated by well established mathematical theories, including calculus of variation and partial differential equations (PDE). Also represent contours/surfaces with complex topology. Level set method segmentation can be categorized into two classes: region based model and edge based models.

Chunming Li *et al*. [20] [31] proposed variation level set approach to segment the brain MR images in the presence of intensity inhomgenety. In this paper level set method is apply to overcome the MR image intensity inhomogenety during brain tumor segmentation.

Another LI *et al.* [21] this paper proposed new variational level set formulation in which the regularity of the level set function is intrinsically maintained during level set evaluation.

Table 2 Overview of Thresholding based methods

Proposed methods	***Remark***
Threshold and outlier detection	❖ The detecting technique uses a concept to detect difference between normal and abnormal space. ❖ Intensity features used
Level set evolution	❖ Best for segmentation. ❖ Less computational time. ❖ Useful for image with intensity inhomogeneity, ❖ Give good performance for images with weak object boundaries.

Marker controlled watershed	❖ Noise and local irregularity from the noisy images has to be removed by efficient filtering method in order to improve the image quality. ❖ Thresholed values dependent on shape and size of tumor. ❖ Exclude a number of non significant minima.

2.3 Region Growing based Methods

Region growing is the simplest region-based segmentation that groups pixels or sub-region into larger regions based on pre-defined criteria. The pixel aggregation starts with a set of seed points in a way that the corresponding regions grow by appending to each seed points those neighbouring pixels that similar properties

Such as:

- Gray level
- Texture
- Color
- shape

Region growing is not often used alone because it is not sufficient to segment brain structures accurately and robustly. Pohle suggested that region growing can be an integrated technique using multi-level sets of boundary information [9].

As compared to edge detection method, segmentation algorithms based on region are very simple and strongly immune to noise [18]

Sato, lakare *et al.* [6] proposed a gradient magnitude based region growing algorithm for accurate segmentation. In this paper gradient magnitude based region growing algorithm solves the partial-volume-effect problem on the boundary.

Region splitting:

- start from a set of seed points
- Region splitting starts with the whole image as a single region
- Subdivides it into subsidiary regions recursively
- While a condition of homogeneity is not satisfied.

Region merging:

- Opposite of region splitting
- Way of avoiding over-segmentation.
- Take small regions and merge the region that have similar characteristics
    - Gray level
    - Variance.

Tien Lin [41] In This paper author can be extracted from digitalized images by variety of ways. Fractal based features are in the problem of texture classification.

Carlos S *et al.* [38] suggest fast parameter free region growing segmentation. In this paper adaptively sample contrast measure, and in the normalizing strategy that allows for generalization of the contrast sampling rate.

Table 3 Overview of region growing based methods

Proposed methods	***Remark***
Fractal wavelet texture feature[27]	❖ It has no availability of multimodality MR images data
Texture feature	❖ Good results and also achieved very accurate results of segmentation which Effectively extract the tumor region from brain MR images.
Seed-based region growing	❖ This is used by a human or automatically by avoiding areas of high contrast ❖ Used for large gradient
Fast marching – based region growing	❖ Accurate results of segmentation which effectively extract the tumor region from brain MR images.

2.4 Clustering based Methods

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups. Farley *et al* [5] suggest dividing the clustering methods into main groups: hierarchical and partitioning methods. Han *et al.* [10] suggest categorizing the methods into additional three main categories: density-based methods, model-based clustering and grid based clustering Partitioning methods relocate instances by moving them from one cluster to another, starting from an initial partitioning.

The simplest and most commonly used algorithm, employing a squared error criterion is the K-means algorithm. *K-mean* is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The *K-mean* clustering is a popular approach to partition d- dimensional data into K clusters such that an objective function providing the desired properties of the distribution of feature vectors of clusters in terms of similarity and distance measures is optimized. A generalized *K-mean* clustering algorithm initially places K clusters at arbitrarily selected cluster centroids *vi = 1, 2…k* and modifies centroids for the formation of new cluster shapes optimizing the objective function. The *K-means* clustering method optimizes the sum-of squared- error-based objective function.

Haung *et al.* [4] presented the K-prototypes algorithm which is based on the K-mean algorithm but removes numeric data limitation while preserving it efficiency. Kaufmann *et al.* [2] presents another method to minimize the SSE in *k-medoids*.

Hoppner *et al.* [7] suggests a soft clustering schema. In this each pattern is associated with every cluster using membership function called fuzzy set.

Table 4 Overview of clustering based methods

Proposed methods	***Remark***
k-mean clustering[40]	❖ Its produce tighter clusters than hierarchical clustering, especially if the clusters are globular. ❖ Partitions to reduce the number of false edges and over-segmentation
Cluster index. *K-means* [29]	❖ The color converted segmentation with K-means clustering algorithm ❖ The regions of the brain related to tumors can be correctly separated from colored image.
Fuzzy clustering(FCM)	❖ ❖ This improves the segmentation performance dramatically.
Local correntropy-based *k-mean* cluster. Wang [42]	❖ Cluster algorithm can be robust to the outliers. ❖ To solve the distortion occurred by noise and intensity inhomogeneity.

3. CONCLUSION

This survey mainly focuses on the study of brain tumor segmentation on MR images. a simple and effective algorithm for automatic tissue classification. The method has been applied to the segmentation of MR brain structures with intensity inhomgeneities and noise. Among all methods discussed for MR brain. A segmentation technique is more effective, more robust for different level of noise, less iteration steps and more accurate for both 2D and 3D brain MR image segmentation. Moreover, for good initialization thereby allowing fully automated application.

4. REFERENCES

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

[2] Kaufman, L. and Rousseeuw, P.J., 1987, Clustering by Means of Medoids, In Y. Dodge, editor, Statistical Data Analysis, based on the L1 Norm, pp. 405- 416, Elsevier/North Holland, Amsterdam.

[3] Stanley Osher and James A. Sethian. "Fronts propagating with curvature dependent speed: Algorithms based on Hamilton-Jacobi formulations" J. Computational Physics, 79(1):1249, 1988

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

[5] Fraley C. and Raftery A.E., How Many Clusters? Which Clustering Method? Answers Via Model-Based Cluster Analysis, Technical Report No. 329. Department of Statistics University of Washington, 1998.

[6] Mie Sato*, Sarang Lakare, Ming Wan, Arie Kaufman, Masayuki Nakujima "A Gradient Magnitude Based Region Growing Algorithm For Accurate Segmentation" IEEE 2000.

[7] Hoppner F. , Klawonn F., Kruse R., Runkler T.," Fuzzy Cluster Analysis" Wiley, 2000.

[8] Pham DL, Xu C, Prince JL (2000) "Current methods in medical image segmentation". Annu Rev Biomed Eng 2:315–337

[9] Pohle R, Toennies KD; "Segmentation of medical images using adaptive region growing, proceedings of SPIE -Medical Imaging" Vol. 4322, 2001, pp. 1337-1346.

[10] Han, J. and Kamber, M. "Data Mining: Concepts and Techniques" Morgan Kauf- mann Publishers, 2001.

[11] 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, VOL. 21, NO. 8, AUGUST 2002

[12] Lei Jiang, Wenhui Yang. "A Modified Fuzzy C-Means Algorithm for Segmentation of Magnetic Resonance Images" Proc. VIIth Digital Image Computing: Techniques and Applications, Sun C., Talbot H., Ourselin S. and Adriaansen T. (Eds.), 10-12 Dec. 2003, Sydney.

[13] Marcel Prastawa , Elizabeth Bullitt , Sean Ho , Guido Gerig. "Medical Image Analysis" 8 (2004) 275–283.

[14] Alan Wee-Chung Liew and Hong Yan. "Current Methods in the Automatic Tissue Segmentation of 3D Magnetic Resonance Brain Images" Current Medical Imaging Reviews, 2006, 2, 000-000

[15] Liew AWC, Yan H (2006) "Current methods in the automatic tissue segmentation of 3D magnetic resonance brain images" Current Med Imaging Rev 2(1):91–103

[16] Jun Kong1, 2, Jianzhong Wang1, 2, Yinghua Lu Jingdan Zhang1, Yongli Li1, Baoxue Zhang2 "A Novel Approach for Segmentation of MRI Brain Images" IEEE MELECON 2006, May 16-19, Benalmádena (Málaga), Spain

[17] Dana Cobzas, Neil Birkbeck, Mark Schmidt "3D Variational Brain Tumor Segmentation using a High Dimensional Feature Set" IEEE 11th international conference on c Computer Vision, 2007. ICCV 2007.

[18] H. Zhang, J. E. Fritts, S. A. Goldman, "Image Segmentation Evaluation: A Survey of unsupervised methods", computer vision and image understanding, pp. 260-280, 2008.

[19] Aliaksei Maistrou "Level Set Methods - Overview" Computer Aided Medical Procedures, TUM May 17, 2008.

[20] Chunming Li, RuiHuang, Zhaohua Ding, Chris Gatenby, Dimitris Metaxas, and John Gore "A Variational Level Set Approach to Segmentation and Bias Correction of Images with Intensity Inhomogeneity" MICCAI 2008, Part II, LNCS 5242, pp. 1083–1091, 2008

[21] Chunming Li, Chenyang Xu, Senior Member, IEEE, Changfeng Gui, and Martin D "Distance Regularized Level Set Evolution and Its Application to Image

Segmentation" IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 19, NO. 12, DECEMBER 2010

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

[23] Yangqiu Song, Changshui Zhang, Jianguo Lee, Fei Wang, Shiming Xiang and Dan Zhang "Semi-supervised discriminative classification with application to tumorous tissues segmentation of MR brain images" Pattern Anal Applic (2009) 12:99–115.

[24] Pal N.R, Pal K, Keller J.M. and Bezdek J.C, "A Possibilistic Fuzzy c-Means Clustering Algorithm", IEEE Transactions on Fuzzy Systems, Vol. 13, No. 4, Pp. 517–530, 2005.

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

[26] W. X. Kang, Q. Q. Yang, R. R. Liang, "The Comparative Research on Image Segmentation Algorithms", IEEE Conference on ETCS, pp. 703-707, 2009.

[27] Iftekharuddin, Khan M., Jing Zheng, Mohammad A. Islam, and Robert J. Ogg. "Fractal-based brain tumor detection in multimodal MRI." Applied Mathematics and Computation 207, no. 1 (2009): 23-41.

[28] Subramanya Bhat, Sanjeev Kunte R "A mixed model based on Watershed and Active contour algorithms for brain tumor segmentation" 2010 International Conference on Advances in Recent Technologies in Communication and Computing 978-0-7695-4201-0 2010 IEEE

[29] Juang, Li-Hong, and Ming-Ni Wu. "MRI brain lesion image detection based on color- converted K-means clustering segmentation." Measurement 43.7 (2010): 941-949.

[30] 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, Vol. 61, No. 2, 2011, pp. 305-313.

[31] Chunming Li, Rui Huang, Zhaohua Ding, J. Chris Gatenby, Dimitris N. Metaxas, "A Level Set Method for Image Segmentation in the Presence of Intensity Inhomogeneities With Application to MRI" IEEE Transactions on image processing, VOL 20, NO. 7, JULY 2011.

[32] 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. I, IMECS 2011, March 16-18, 2011, Hong Kong.

[33] R. B. Dubey M. Hanmandlu, Shantaram Vasikarla "Evaluation of Three Methods for MRI Brain Tumor Segmentation" 2011 Eighth International Conference on Information Technology: New Generations 978-0-7695-4367-3/ 2011 IEEE.

[34] Ze-Xuan Ji,Quan-SenSun ,De-ShenXia "A framework with modified fast FCM for brain MR images segmentation" Pattern Recognition 44 (2011) 999–1013

[35] Ze-Xuan Ji, Quan-Sen Sun∗, De-Shen Xia "A modified possibilistic fuzzy c-means clustering algorithm for bias field estimation and segmentation of brain MR image" Computerized Medical Imaging and Graphics 35 (2011) 383–397

[36] Ms. Nikita Singh, Mrs Alka Jindal "A Survey of Different types of Characterization Technique in Ultra sonograms of the Thyroid Nodules" Published in international journal for computer science and informatics volume 1 issue 4. 2012, pg no.112-115, ISSN: 2231-5292(Print).

[37] A.Rajendrana, R. Dhanasekaranb, "Fuzzy Clustering and Deformable Model for Tumor Segmentation on MRI Brain Image: A Combined Approach" International Conference on Communication Technology and System Design 2011 Procedia Engineering 30 (2012) 327 – 333

[38] Carlos S. Mendoza, Carmen Serrano "Fast parameter-free region growing segmentation with application to surgical planning" Machine Vision and Applications (2012) 23:165–177

[39] Megha. P. Arakeri · G. Ram Mohana Reddy "Computer-aided diagnosis system for tissue characterization of brain tumor on magnetic resonance images" Springer-Verlag London 2013.

[40] P. Dhanalakshmi & T. Kanimozhi "Automatic Segmentation of Brain Tumor using K-Means Clustering and its Area Calculation ISSN (Print) : 2278-8948, Volume-2, Issue-2, 2013

[41] Hsuan- tien in "texture classification using fractal- based features and support vector machines"

[42] Lingfeng Wang n, Chunhong Pan "Robust level set image segmentation via a local correntropy-based K-means clustering" Pattern Recognition 47 (2014) 1917–1925.