EFFECTIVE SEGMENTATION OF MR BRAIN IMAGES USING HYBRID CLUSTERING MECHANISM AND SAVITZKY-GOLAY FILTER

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Abstract

Segmentation of MR brain image is quite useful in detection of tumors and further diagnosis. However, precise segmentation of tumors plays a significant role in diagnosing the patient more effectively. Previously, there are plenty of approaches was implemented and however they were failed to detect the exact tumor which led to the failure diagnosis. Therefore, an accurate detection of tumor is required for effective diagnosis. Here, this article presented an efficient segmentation of MR brain image tumors. Our approach includes a hybrid clustering mechanism with pre-processed by savitzky-golay filter (SGF). In addition, tumor area also estimated for better diagnosis of patient. Simulation results disclosed the superiority of proposed hybrid approach over conventional segmentation algorithms in terms of computational complexity and segmentation accuracy.

Keywords: Magnetic resonance imaging, Brain tumor, Thresholding, Fuzzy C-means, K-means, Hybrid clustering.

I. Introduction

In practical, functioning of organs in human body can be examined by employing magnetic resonance imaging (MRI), which impacts the diagnosis and treatment in various modalities even there is an uncertainty in the output of improved health [VI]. MRI technology is an enhanced system due to the absence of ionizing radiation when compared to computed tomography (CT) and it is used to identify tumors in human brain. Brain tumor is referred as an uncontrolled growth of brain cells in any section of it and led to a serious
damage to brain which later can also cause death. Early detection of tumors with higher accuracy is an important and challenging task. The term detection involves the separation or partition which can be obtained by segmentation concept. Segmentation of image can be done in many ways. Clustering is one of the most widely utilized technique for segmenting an image into several partitions or clusters depending on homogeneous information in an image. Segmentation can be utilized in several image processing applications such as enhancement, compression, object detection and identification, medical image processing and image retrieval systems. Many segmentation approaches have been introduced over past years [VIII]. An improved watershed segmentation algorithm, which renders quite enhanced performance over thresholding-based approaches is presented in [XII]. However, this has few limitations such as over segmentation and sensitive to false edges. Later, clustering was proposed to obtain better segmented outcome. Fuzzy C-means (FCM) is an algorithm that clusters the homogeneous pixels into a group. It operates based on the functions of membership values [X, XIV]. Though, it produces superior outcome over [XII], it requires larger computational duration since the allocation of membership value consumes more time. Later, hierarchical-based approaches were implemented and discussed in [I, III]. Afterwards, K-means was introduced to mitigate the computation time [XI]. This is being employed broadly, since it is quite easy and simple. Further, this is also quicker for meta data clustering [V, XIII], however it requires random selection of cluster elements and necessitate to update in each iteration for better accuracy. In addition, new cluster elements or centroids are updated in every iteration depending on the mean of existing cluster points, which results in floating point values. Hence, an optimization is required to find an integer value from the available floating-point values, which was addressed in [II], where authors utilized a pillar algorithm that optimizes the existing K-means clustering approach. Recently, few hybrid algorithms are presented to detect and extract a tumor from an MR brain images [IV, XI]. However, due to inaccurate segmentation of tumors, computational complexity and lack of stabilization, existing clustering algorithms addressed in literature were not good enough to segment tumors in MR brain images. Therefore, to address these issues, this article presented an enhanced hybrid clustering with SGF that denoises an image first and then applies hybrid clustering mechanism to detect and extract tumors from MR brain image with higher accuracy.

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Bhasker Dappuri et al
II. Proposed Algorithm

This section describes the proposed hybrid clustering mechanism with SGF. Figure 1 disclose the image segmentation with different clustering algorithms.

![Block diagram of MR brain image segmentation approaches](image1)

Fig. 1 Block diagram of MR brain image segmentation approaches

![Flow chart of algorithm 1](image2)

Fig. 2 Flow chart of algorithm 1
Hybrid clustering algorithm:

This section explains the procedure of proposed hybrid clustering mechanism that employs pre-processing using SGF which involves in elimination of unwanted information from an input MR brain image and later segments the pre-processed MR brain image with optimized K-means using enhanced fuzzy clustering algorithm. Block diagram of proposed hybrid clustering mechanism is depicted in Figure 3. Algorithm 1 and Algorithm 2 describes the pre-processing with K-means and optimization using enhanced fuzzy algorithm.
Algorithm 1: Preprocessing and segmentation with K-means

Step 1: Choose and read input image ‘I’.

Step 2: Apply SGF filtering as a pre-processing to remove any unwanted information.

Step 3: Now, the outcome of pre-processing is converted as data vector.

Step 4: Choose number of cluster points.

Step 4: Compute the distance of every picture element to cluster point.

Step 5: Select the cluster point that has a minimum value of distance.

Step 6: Group the homogeneous picture elements to their respective cluster point.

Step 7: Re-compute the new cluster points by calculating the average of grouped picture elements and reposition them with initial cluster points.

Step 8: Repeat the procedure until there are symmetrical cluster points.

Algorithm 2: optimization with enhanced fuzzy algorithm

Step 1: Read the outcome of algorithm 1.

Step 2: Segment by employing enhanced fuzzy approach.

Step 3: Obtain the segmented MR brain image which comprises of only tumor particles in it.

Step 4: Now, compute the estimated area of segmented tumor by finding number of white pixels in it as per digital imaging units.

Step 5: Finally, calculate the computation time.

Let us consider that segmented image \( S \) is having a size of \( i \times j \) and can be expressed as:

\[
S(i, j) = \sum_{i=1}^{N} \sum_{j=1}^{N} \left[ I_{i,j}(0) + I_{i,j}(1) \right]
\]  

(1)

Where number of rows and columns are referred as \( i \) and \( j \) respectively. Number of pixel elements in an image is denoted as \( N = 1,2,3,...,256 \). Black pixels which has a value of intensity as zero is denoted as \( I_{i,j}(0) \), similarly, white pixels with an intensity of one is referred as \( I_{i,j}(1) \). Therefore, computation of white pixels in a segmented image can be formulated as below:

\[
W = \sum_{i=1}^{N} \sum_{j=1}^{N} I_{i,j}(1)
\]  

(2)
Where number of white pixels are denoted as $W$. According to the digital imaging units [VII], one pixel can be represented as $0.264mm$. Hence, the area of tumor can be computed as:

$$A_{\text{Tissue}} = (\sqrt{W} \times 0.264)\text{mm}^2$$

(3)

III. Results and Discussion

This section explains the experimental analysis of proposed hybrid clustering mechanism, which is implemented in MATLAB environment with various test images with different sizes. Further, it is also compared with existing segmentation approaches to disclose the effectiveness of proposed hybrid clustering mechanism. Figure 4 shows the obtained segmentation outcome of proposed and existing segmentation approaches, where the segmented tumor of proposed hybrid clustering is more accurate compared to the existing clustering techniques. Similarly, segmented results of another sample MR brain image with tumor is shown in Figure 5. Performance evaluation with time complexity is demonstrated in Figure 6, where the execution time is computed in seconds. However, our proposed hybrid clustering consumes bit of more time over K-means, it produced a tumor with higher accuracy. Table 1 discloses that computed tumor area using Equation (2) as discussed in section 2.
Fig. 4 Obtained segmentation results (a) MR brain image (b) manual segmentation (c) FCM clustering (d) K-means clustering (e) proposed hybrid clustering

Fig. 5 Obtained segmentation results (a) MR brain image (b) manual segmentation (c) FCM clustering (d) K-means clustering (e) proposed hybrid clustering

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Bhasker Dappuri et al
Table I. Area of segmented tumor using proposed and conventional algorithms.

| S. No. | Clustered algorithm         | Area of the tumor (mm²)  |
|--------|-----------------------------|--------------------------|
|        |                             | Sample1       | Sample2       | Sample3       | Sample4       | Sample5       |
| 1      | Manual Segmentation         | 8.8035        | 18.3038       | 18.8829       | 19.6782       | 22.6656       |
| 2      | FCM clustering              | 13.6746       | 13.5954       | 13.4899       | 13.1497       | 18.9235       |
| 3      | K-means clustering          | 6.1291        | 13.7077       | 13.5363       | 13.2053       | 19.0721       |
| 4      | Proposed method             | 6.1462        | 12.1898       | 12.3602       | 11.6758       | 14.0442       |

IV. Conclusion

This article presented hybrid clustering mechanism with SGF and optimized K-means with enhanced fuzzy algorithm. In addition, tumor area also computed using number of tumor cells segmented. Comparative evaluation disclosed that proposed method performed superior over existing clustering approaches with higher accuracy and better tumor area computation for further diagnosis. Furthermore, this can be extended to 3D multi modal medical image segmentation with more effective and accurate clustering algorithms.
References

I. A.M. Usó, F. Pla and P.G. Sevila, “Unsupervised Image Segmentation Using a Hierarchical Clustering Selection Process”, Structural, Syntactic, and Statistical Pattern Recognition, vol. 4109, pp. 799-807, 2006.

II. A. R. Barakbah and Y. Kiyoki, “A Pillar algorithm for K-means Optimization by Distance Maximization for Initial Centroid Designation”, IEEE Symposium on Computational Intelligence and Data Mining, pp. 61-68, 2009.

III. A.Z. Arifin and A. Asano, “Image segmentation by histogram thresholding using hierarchical cluster analysis”, Pattern Recognition Letters, vol. 27, no. 13, pp. 1515-1521, 2006.

IV. A. Sehgal, et. al, “Automatic Brain Tumor Segmentation and Extraction in MR Images”, In Proc. of Inter. Conf. on Adv. in Sig.Proces., Pune, India, pp. 104-107, 2016.

V. E. A. Maksoud, M. Elmogy and R. A. Awadhi, “Brain Tumor Segmentation based on a Hybrid Clustering Technique”, Egyptian Informatics Journal, vol. 16, no. 1, 2015.

VI. H. P. A. Tjahyaningtijas, “Brain Tumor image segmentation in MRI images”, IOP Conf. Series: Materials Science and Engineering, vol. 336, 012012, 2018.

VII. http://www.unitconversion.org/typography/millimeters-to-pixels-x-conversion.html

VIII. J. E. A. L. Kostka, “A review of the medical image segmentation algorithms”, In: Peng SL., Dey N., Bundele M. (eds) Computing and Network Sustainability, Lecture Notes in Networks and Systems, vol 75, Springer, Singapore, May 2019.

IX. J. Selvakumar, A. Lakshmi and T. Arivoli, “Brain Tumor segmentation and its area Calculation in Brain MR images using K-means Clustering and Fuzzy C-means algorithm”, International Conference on Advances in Engineering, Science and Management, pp. 186-190, 2012.

X. M.H. F. Zarandia, M. Zarinbala and M. Izadi, “Systematic image processing for diagnosing brain tumors: A Type-II fuzzy expert system approach”, Applied soft computing, pp. 285-294, 2011.

XI. N. Dhanachandra, K. Maglem and Y. J. Chanu, “Image segmentation using K-means and subtractive clustering algorithm”, Procedia Computer Science, vol 54, pp. 764-771, 2015.

XII. T. Shen and Y. Wang, “Medical image segmentation based on improved watershed algorithm”, In: Proc. of 3rd Advanced Information
Technology, Electronic and Automation Control, Chongqing, China, IEEE, Oct. 2018.

XIII. T. W. Chen, Y.-L. Chen and S.-Y. Chien, “Fast Image Segmentation Based on K-Means Clustering with Histograms in HSV Color Space”, Journal of Scientific Research, vol. 44, no.2, pp.337-351, 2010.

XIV. Z. Beevi and M. Sathik, “An effective approach for segmentation of MRI images: combining spatial information with fuzzy c-means clustering”, European Journal of Scientific Research, vol. 41, no.3, pp.437-451, 2010.