Implementation and quality measures of graph theory model based image segmentation process in medical application

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Abstract: This research work simplified the representation of an image into more significant and easier way to analyse the image segmentation process by applying graph theory using color spatial clustering with consensus region merging. The color spatial clustering with consensus region merging is compared with other traditional and graph theory model to analyse the various quality measures calculated for the input of magnetic resonance imaging (MRI) scan and X-Ray images which will be useful in medical imaging for better analysis during diagnosis. From quality measures, the proposed method shows good quality image parameters as it has lower MSE, NAE values.

1. INTRODUCTION

The digital image processing is used for recognition of shapes and objects in an image. In this regard, it leads to object recognition; segments have played an important role. Segments are homogeneous, contiguous components of images. However, the demarcation of segments is still a significant concern for the quality of results. Over the past several decades, the image segmentation and grouping are a challenging task for computer vision. Among many different segmentation techniques, graph theoretical approaches are helpful in practical applications especially in medical imaging like cancer and tumor cells. Graphs are used to model many problems of the real word in various fields [1]. Graph theory is considered as the most powerful tool in order to explain the algorithms based on image processing, and the result of graph theory helps to analyse the methods [2]. Many researchers carried out a study on image process and submitted the vital background data on graph-cuts and also examined the scope of the work, including the pros and cons of versatile combinatorial algorithm [3-5]. Berkeley’s database helps to analyses the results on two points PSNR (Peak Signal to Noise Ratio) and RI (Rand Index) [6]. With the help of imaging data, there is a necessity for models capable of representing potentially large populations and exploiting different types of information [7]. As a huge amount of medical image data need sophisticated software that combines high-level graphical user interfaces as well as robust and fast interactive image analysis. The consensus region merging (CRM) algorithm consists in computing independent random segmentations using random region merging (RRM), and then combine the sample outcome into single overall segmentation [8].
2. EXPERIMENTAL SETUP AND METHODS

The experiments conducted on validating the proposed method as color spatial clustering with consensus region merging for segmenting the image using MATLAB tool. The graph cut based segmentation approach is combination of spatial clustering and region merging process. Here the image has been divided into two parts as foreground and background. The background subtraction associates the global and local threshold approach towards increasing the accuracy and computation efficiency. It offers effective results in the segmentation process and permits to automatic segmentation once the foreground color is static as well as gradually increases the processing speed. On the other hand, the background might be characterized as regional maxima, at that time it has been extracted from the image sequence. In addition, to extract the regional minima or maxima from gray-scale images via morphological reconstruction process, without obstructing substances shape or size. Image segmentation is categorized into, i) Traditional or Classical methods, ii) Graph theory methods, iii) combination of traditional and graph theoretical methods [9]. In this present work, color spatial clustering with consensus region merging algorithm is proposed and implemented.

2.1. Segmentation process and proposed method
Segmentation is defined as the process of segmenting an image into different sections which are usually used for the digital image to find patterns and some other relevant information. This study is broadly divided into three processes [10]. First, deals with analysis and implementation of the existing traditional approaches such as OTSU threshold technique [11], K-means segmentation [12], Split-and-merge methods, minimal spanning trees, Euler graph, and greygraph cut and Fuzzy Clustering method. Second, concentrates on the proposed novel approach and implementation using MATLAB simulation software. The third, deals with the comparison of efficiency and performance of traditional and proposed methods for medical images such as MRI scan and X-rays.

2.2. Pseudo Code of Proposed Algorithm: color spatial clustering with CRM
// Input: Graph with number of segmentations (length)
// Output: Segmented output after cluster with region merging.
For i = 1: length
    Iter=1: length % cluster
    For i=no. of pairs
        Check the value of predicate P with respect to its neighbouring regions
        Sort the edge
        Each time an edge e is merged, add 1 to n
        If predicate P is true,
            Segmentation S is constructed.
            Return S
    End if
End for

3. RESULTS AND ANALYSIS
The results of the given input images for various methods and their quality measures are recorded and compared with proposed color spatial clustering with CRM images shown in Figure 1 and Figure 2.
3.1. Image segmentation output of proposed model – X-ray and MRI images

**Figure 1.** Color spatial cluster with consensus region merging: X-Ray image
(a) Color image. (b) Clustered image. (c) Segmented CRM image.

**Figure 2.** Color spatial cluster with consensus region merging: MRI scan image
(a) Color image. (b) Clustered image. (c) Segmented CRM image.

3.2. Image quality measures
Image quality is that particular characteristic seen in images where perceived measures such as image degradation. Image quality evaluation method: a) Objective measurement b) Subjective measurement.
In this work, the quality measures have been evaluated with the following parameters Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Average Difference (AD), Normalized Absolute Error (NAE), Laplacian Mean Square Error (LMSE), Root Mean Square Error (RMSE) of each selected method, namely, threshold, K-means clustering, split and merging, minimal spanning tree, Euler graph, grey graph cut and fuzzy with combined segmentation approach [13].

3.2.1. Parameters for analysis. The results from the various segmentation methods have been calculated and tabulated as follows for the MRI scan image and X-Ray image in Table 1 and Table 2 respectively. The comparison table is given with data extracted from the image segmentation methods. There are few parameters clearly shows that quality of the image is improved with color spatial cluster with consensus region merging technique.

### Table 1. Comparison of quality measures of MRI scan image

| Segmentation Methods                             | MSE    | PSNR  | AD    | MD    | NAE   | LMSE  | RMSE  |
|-------------------------------------------------|--------|-------|-------|-------|-------|-------|-------|
| Threshold                                       | 47.84  | 1.33  | 203.2 | 251   | 0.984 | -0.75 | 218.74|
| K-means clustering                              | 49.02  | 1.22  | 205.75| 254   | 0.996 | -0.15 | 221.4 |
| Split and merge                                 | 9.10   | 18.53 | -4.441| 0     | 0.021 | 0.127 | 30.17 |
| Minimal spanning tree                           | 4.94e+04 | 1.19  | 206.54| 255   | 1.000 | 6.06e-04 | 222.26|
| Euler Graph                                     | 4.90e+04 | 1.22  | 205.72| 254   | 0.995 | 6.40e-04 | 221.36|
| Grey Graph cut                                  | 3.20e+03 | 13.07 | 29.31 | 241   | 0.141 | 0.214 | 56.61 |
| Fuzzy with graph theory approach                | 2.60e+03 | 13.96 | 39.68 | 137   | 0.218 | 0.129 | 51.05 |
| Color spatial cluster with consensus region merging | 6.10  | 2.63  | -2.481| 0     | 0.121 | 0.103 | 26.17 |

From the color spatial cluster with CRM output of quality measure, it is found that MSE value is comparatively small (approx. 6) for both MRI scan and X-Ray images. The lower of MSE value refers to the higher image quality. Also, the same for normalised absolute error value of proposed method, relatively less as small value of NAE gives good quality image [14].

### Table 2. Comparison of quality measures of X-Ray image

| Segmentation Methods                             | MSE    | PSNR  | AD    | MD    | NAE   | LMSE  | RMSE  |
|-------------------------------------------------|--------|-------|-------|-------|-------|-------|-------|
| Threshold                                       | 2.39e+04 | 4.33  | 109.92| 251   | 0.983 | 8.68e-04 | 154.75|
| K-means clustering                              | 2.45e+04 | 4.22  | 111.87| 254.01| 0.996 | 1.59e-04 | 156.77|
| Split and merging                               | 2.71e+03 | 13.78 | 13.11 | 0     | 0.116 | 0.223 | 52.13 |
| Minimal spanning tree                           | 2.45e+04 | 4.23  | 109.93| 255   | 1.000 | 0.0079 | 156.52|
| Euler Graph                                     | 2.45e+04 | 4.22  | 111.87| 254   | 0.996 | 6.58e-04 | 156.75|
| Grey Graph cut                                  | 10.7450 | 37.81 | 0.759 | 87    | 0.0068| 0.014  | 3.278 |
| Fuzzy with graph theory approach                | 1.74e+03 | 15.71 | 24.90 | 125   | 0.272 | 0.131 | 41.786|
| Color spatial cluster with consensus region merging | 6.73  | 3.81  | 0.557 | 67    | 0.168 | 0.140 | 3.178 |
4. CONCLUSION

In this paper, a novel method is applied as color spatial clustering with consensus region merging algorithm which is used for image segmentation for the selected input MRI scan and X-Ray images as sample. It has been implemented with traditional and graph theory model. The primary significance of using this approach for formulating the segmentation on a graph model and does not required iscretization by the features of combinational operators. The idea of image segmentation is to separate pixel values into a couple of groups, black as foreground and white as background. By using color spatial clustering with consensus region merging method, major quality measure parameters calculated and compared with the other methods for further analysis. From all the parameters presented here can be used to improve the same for future assessment as this proposed method shows few improvements in the quality of the image parameters with lower MSE, NAE values. Since still there are few flaws in the proposed algorithm as PSNR, LMSE need to be improved.

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