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Comparative Analysis of various thresholding techniques, region based techniques and watershed technique for Image segmentation of Satellite and MRI Images

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Abstract – *Image segmentation is a process of partitioning an image into multiple parts for making it more meaningful and easy to analyze. Image segmentation is frequently used for medical image analysis as well as locating objects in satellite images like roads, crops, etc. In this paper, various techniques like thresholding based, region based, K-means and marker controlled watershed algorithm have been compared for satellite as well as MRI images of brain which may prove useful for extracting region of interest from images.*

Keywords- *thresholding, niblack, sauvola, k-means, mean-shift, n-cut, marker-controlled watershed*

I. INTRODUCTION

Image segmentation partitions a digital image into multiple sets of pixels consisting of regions of interest. The result of image segmentation is sets of pixels which collectively cover the whole image. The simplest method for image segmentation is thresholding in which selection of threshold level plays the key role in classifying the image into segments. Graph cut technique is another region based method to partition an image into parts. Normalized cut is a technique which can identify similarities within groups and dissimilarities between groups of pixels. K means is method to separate the region of interest from the background. Mean shift is also a powerful clustering technique for image segmentation. Watershed transformation is also an important technique to partition an image into segments by considering it as a topographic surface and then classification on basis of pixels having high gradient intensities.

II. THRESHOLDING BASED IMAGE SEGMENTATION TECHNIQUES

The simplest techniques based on thresholding select a threshold value based on some criterion. This threshold value is used to convert a gray level image to a binary image for extracting important regions of interest.

A. Otsu's method of global thresholding

This method automatically performs thresholding by assuming image to be classified into classes. One set of pixels belong to the foreground and another set of pixels belong to the background of an image.

B. Mean gray level technique for thresholding

In this method, the threshold selected for thresholding is the mean of all the intensities of the image. This method is not useful for an image added with noise as it will provide an incorrect estimate of threshold for segmentation.

C. Two peaks technique for thresholding

This method is based on threshold selection based on histogram of an image which consists of two peaks one indicating foreground and another background separated by a valley between them.

D. Thresholding based on edge pixels

By calculating laplacian of all pixels in an image, regions of intensity changes can be highlighted. Histogram based on pixels with large laplacians (edge pixels) is created to calculate the threshold for segmentation.

E. Iterative method for thresholding

In this method, the mean gray level is calculated and selected as initial threshold for the image and thresholding is performed. Then, the average values of pixels above threshold and pixels below threshold are calculated separately. Then, new threshold is selected based on average of both the calculated average values and again thresholding based on this value is performed. The method is iteratively performed until both the average values for pixels above threshold and pixels below threshold become equal.

F. Thresholding based on black pixels

Based on assumption that percentage of black pixels is constant in images, thresholding is done by assigning low gray level valued pixels belonging to background.

G. Adaptive thresholding

This method takes into account the variations in pixel values due to illumination changes. Hence, this method is robust against illumination variations for correct threshold selection.

H. Niblack's local thresholding technique

This method calculated a local threshold within a small window of an image. This local threshold is based on local mean and standard deviation of pixels in the window from local mean.

I. Sauvola's local thresholding technique

This method calculates the local threshold based on local mean and maximum value of standard deviation of pixels from local mean within a small window of the image.

III. REGION BASED SEGMENTATION TECHNIQUES

A. Interactive segmentation based on graph cuts

Interactive segmentation imposes hard constraints like foreground region as well as background region. This type of segmentation also imposes soft constraints like properties of the region boundary as well as region's properties.

B. N cut segmentation

This method is based on affinity measure which is high between elements within a region and low between elements across a region.

C. Mean shift segmentation

This method is a powerful and iterative algorithm which calculates the mean within a small window of an image and then shifts the center of the window at the mean and repeats the mean calculation till convergence.

D. K-means clustering

This method performs least square partitioning and divides an image into K groups. Then, mean of each cluster is calculated followed by calculating the distance of each point from the cluster mean. The point is assigned to the cluster to which it is nearest. The above two calculations are iterated until the group errors cannot be further lowered.

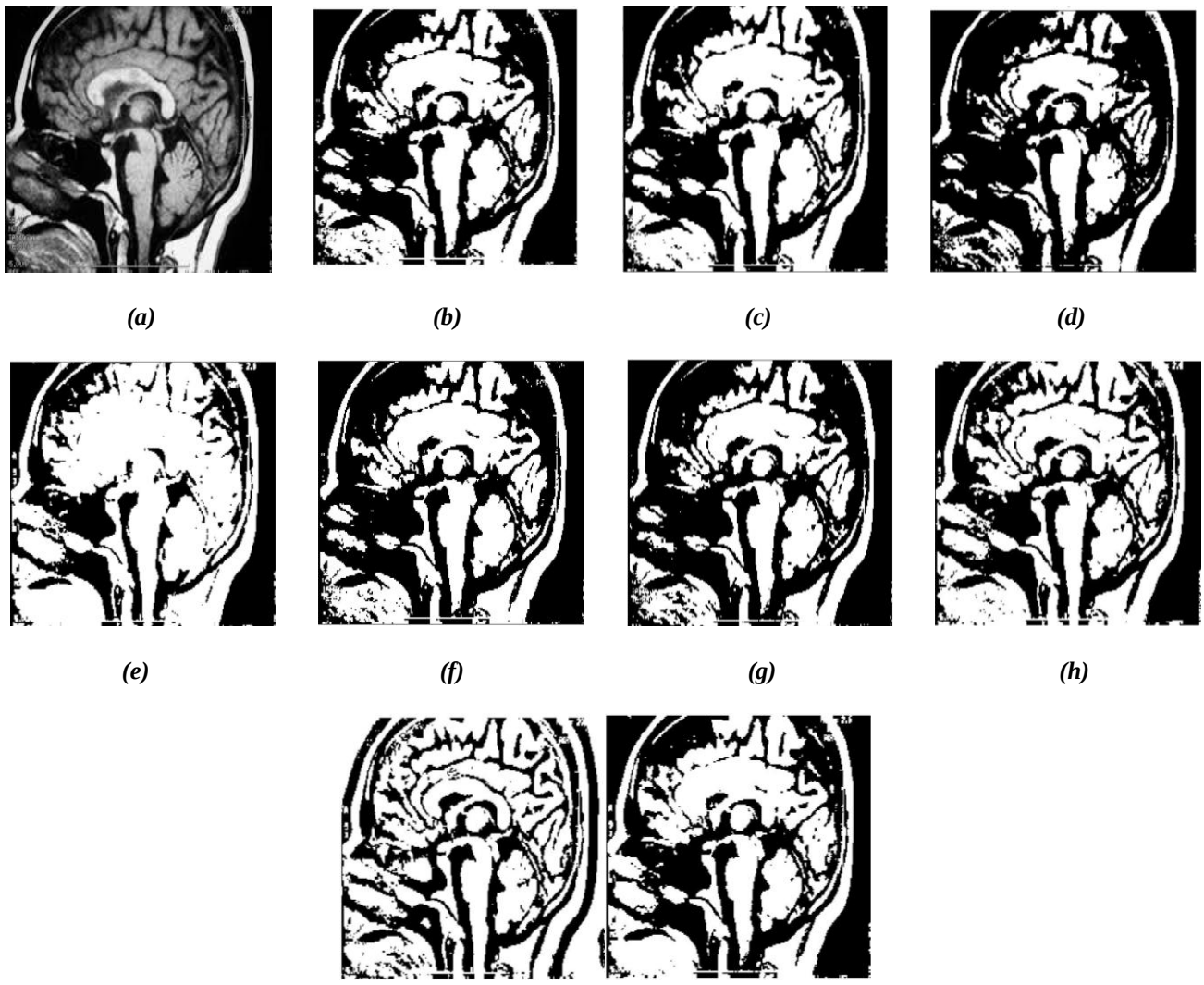
IV. WATERSHED SEGMENTATION

Watershed transformation changes an image into another image having watershed lines and catchment basins which considers bright areas to be high and dark areas to be low.

A. Marker Controlled watershed segmentation

This method is a special watershed transform in which foreground as well as well as background markers are computed after segmentation. Then segmentation function is modified such that it has minima at foreground and background locations. Again watershed segmentation is performed with modified segmentation function which can identify touching objects in the image.

V. EXPERIMENTAL RESULTS

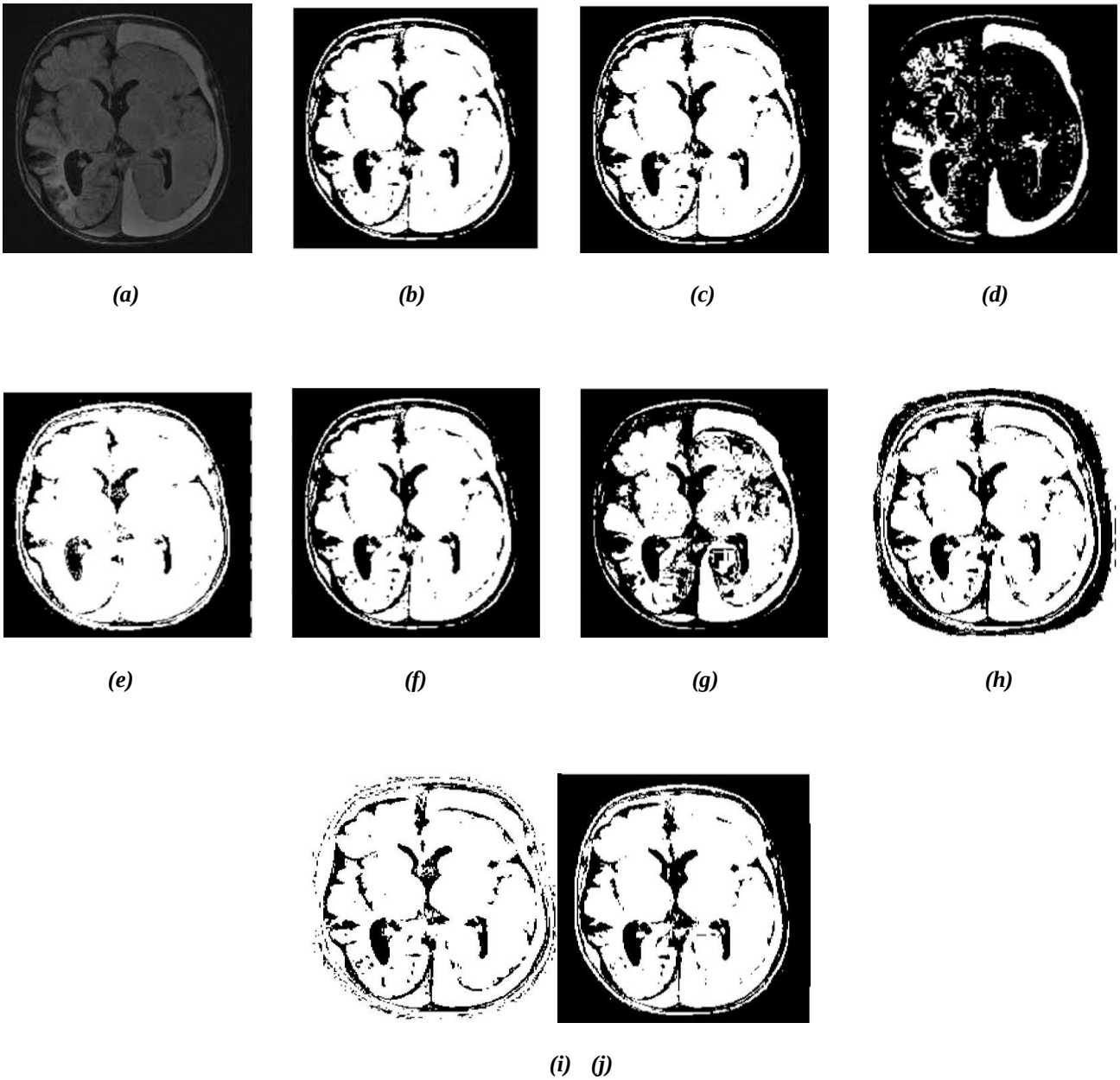


(a) *(b)* *(c)* *(d)*

(e) *(f)* *(g)* *(h)*

(i) *(j)*

Figure 1 (a) Original MRI Image 1 (b) Otsu's method (c) Mean gray level (d) Two peaks (e) Edge pixels (f) Iterative thresholding (g) Black pixels (h) Adaptive thresholding (i) Niblack's technique (j) Sauvola's technique



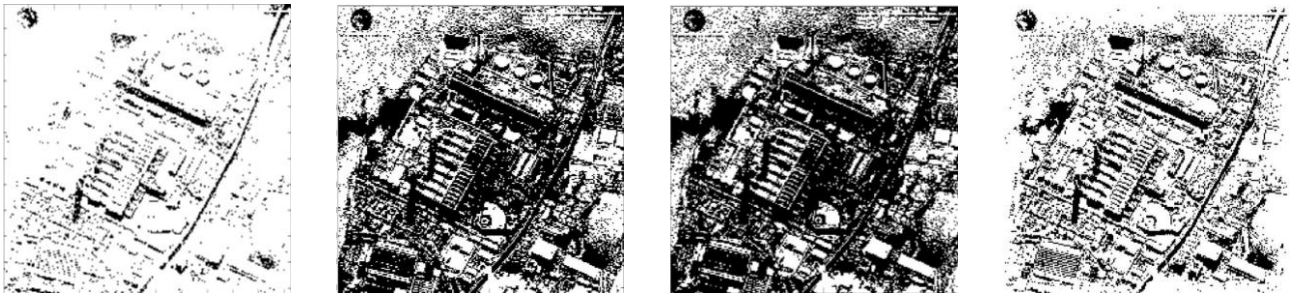
(a) *(b)* *(c)* *(d)*

(e) *(f)* *(g)* *(h)*

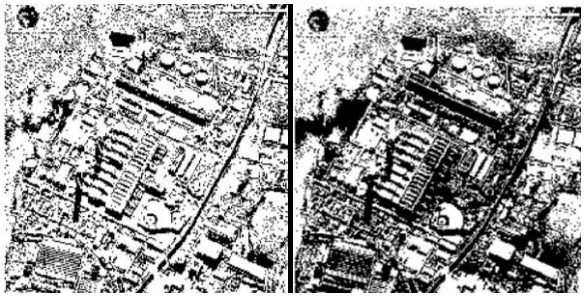
(i) *(j)*

Figure 1 (a) Original MRI Image 2 (b) Otsu's method (c) Mean gray level (d) Two peaks (e) Edge pixels (f) Iterative thresholding (g) Black pixels (h) Adaptive thresholding (i) Niblack's technique (j) Sauvola's technique

(a) *(b)* *(c)* *(d)*

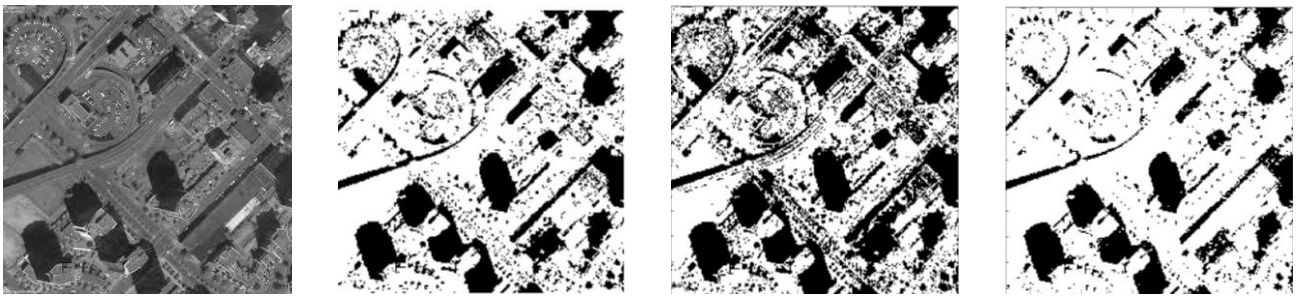


(e) *(f)* *(g)* *(h)*

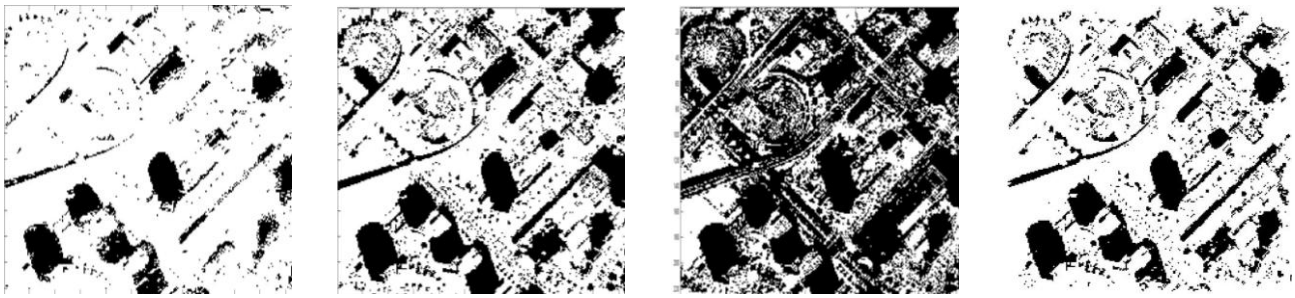


(i) *(j)*

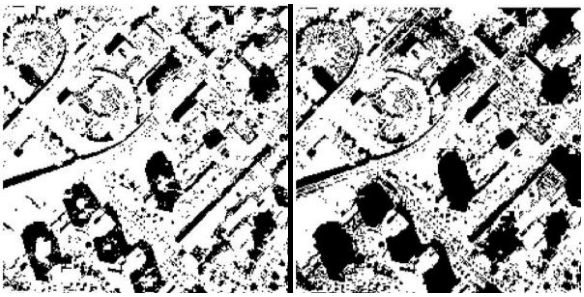
Figure 3 (a) Original Satellite Image 1 (b) Otsu's method (c) Mean gray level (d) Two peaks (e) Edge pixels (f) Iterative thresholding (g) Black pixels (h) Adaptive thresholding (i) Niblack's technique (j) Sauvola's technique



(a) *(b)* *(c)* *(d)*

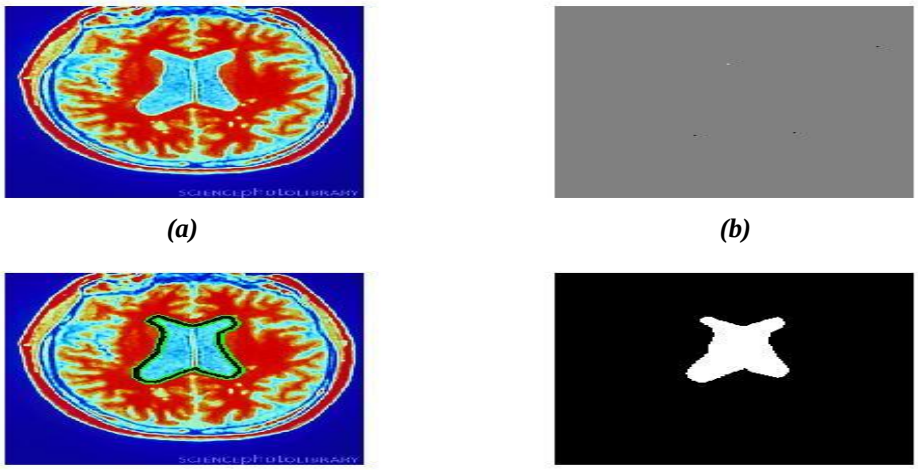


(e) *(f)* *(g)* *(h)*



(i) (j)

Figure 4 (a) Original Satellite Image 4 (b) Otsu's method (c) Mean gray level (d) Two peaks (e) Edge pixels (f) Iterative thresholding (g) Black pixels (h) Adaptive thresholding (i) Niblack's technique (j) Sauvola's technique



(a) *(b)*

(c) *(d)*

Figure 5. Interactive segmentation using graph cuts (a) Original MRI image 5 (b) Seeds (c) Segmented Image represented with boundary (d) Segmented Image

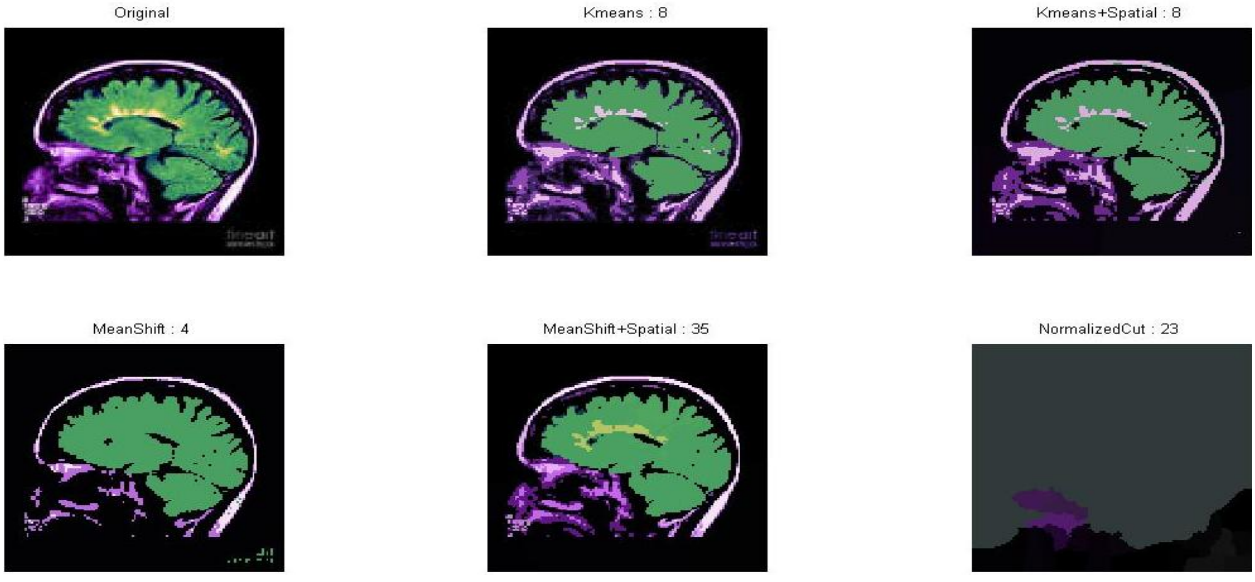
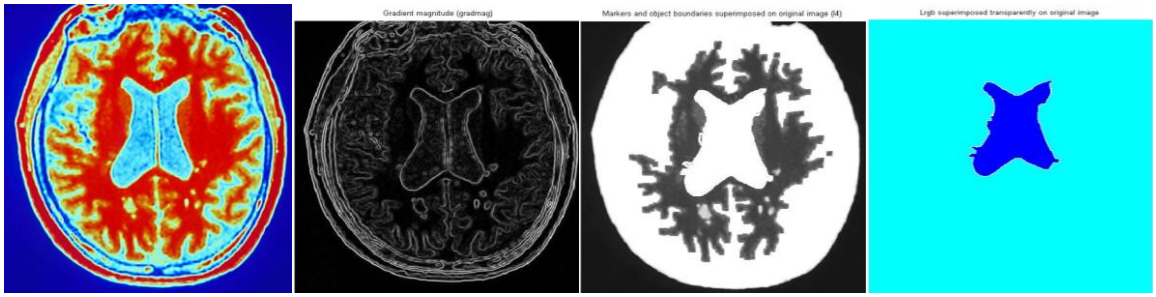


Figure 6. Comparison between k-means (color), k-means (color and spatial similarity), mean shift (color), mean shift (color and spatial similarity), and normalized cut segmentation techniques



(a) ***(b)*** ***(c)*** ***(d)***

Figure 7. Marker controlled watershed segmentation(a) Original MRI Image 6 (b) Gradient magnitude (c) markers and object boundaries superimposed on original image (d) Lrgb superimposed transparently on original image

VI. CONCLUSION

In this paper, various global as well as local thresholding techniques for image segmentation have been discussed for MRI and satellite images. Local thresholding techniques prove to be better than global thresholding techniques. Region based techniques are preferred for color images and have been implemented on color MRI images. Interactive graph cut based segmentation gives better results for region of interest extraction. Similar result is obtained from marker controlled watershed segmentation.

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