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AUTOMATED ANALYSIS OF DIABETIC NEPHROPATHY USING IMAGE SEGMENTATION TECHNIQUES FOR RENAL BIOPSIES IMAGES

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ABSTRACT

Diabetic nephropathy is a significant cause of chronic kidney disease and end-stage renal failure globally. Much research has been conducted in both basic science and clinical therapeutics, which has enhanced understanding of the pathophysiology of diabetic nephropathy and expanded the potential therapies available. The computational technology enhanced towards medical research, substantial research work has been done towards analysis of Diabetic nephropathy. It is a challenging task as 100% detection of Nephropathy disease with regular pathological procedure is not possible[1]. We propose a solution to the problem of segmentation of the renal Biopsies images for the analysis.

This research work examined the analysis of diabetic nephropathy in the context of computational contour based, otsu, k-mean and watershed image segmentation approach. The performance of image segmentation techniques has been done using PSNR and SNR statistical approach. This research work extended towards the comparative performance of image segmentation techniques. The watershed segmentation scheme is robust and effective. The rate of recognition can be further improved by increasing the size of the database and by considering better statistical measure.

Keyword;- *Diabetic nephropathy, Contour-Based Segmentation, Otus segmentation, K-mean segmentation, watershed segmentation, SNR, PSNR.*

1. INTRODUCTION

Segmentation plays a vital role in medical image processing. Image Segmentation is the partition or separation of the image into dissimilar regions of related attributes. Medical Image processing is one of the most active research topics from the past few decades. Accuracy of Medical image segmentation remains a challenging task even though a lot of work has been done on this topic. As there is no universal solution for this problem. Here we have proposed method which is the modification of the original Chan-Vese algorithm [2], with different values of the smoothness [3] terms are varied for better output. The energy minimization of the region-boundaries has been involved in this work [4].

The proposed method is applied to provide a solution for the medical background diabetic nephropathy, which is considered to be the leading cause of end-stages renal disease. Diabetic nephropathy includes gradually increasing proteinuria (excretion of excess proteins in the urine) accompanied by blood pressure, with a progressive turn down in GFR [5]. There is also a significantly increased risk of cardiovascular disease.

Traditionally, these changes had been accredited to possessions on mesangial cells and endothelial cells, the cells that sustain the capillary loops. Nevertheless, more modern investigation advises that the podocytes may be major significant factor in causing diabetic glomerulosclerosis. The most important consequence of glomerulosclerosis is that it causes a leaky filtration membrane consequently there is unusually increased filtration of protein. Important factors are the loss of podocytes and the disruption of their cytoskeleton, which consequences in a change in podocyte shape known as podocyte effacement. Proteinuria thus results in damage to the renal tubules with further loss of nephrons.

This paper is structured as follows: section II depicts the review on related work. Section III is explaining methodology and data source used in this paper. Section IV illustrates performance evaluation. Section V describes experimental analysis with observation. Section VI is highlighting discussion and conclusion followed by references.

2. RELATED WORK

In the current era of research the medical image processing is very broad field, which covers image analysis techniques and clinical imaging devices such as radiological imaging which includes radiography, ultrasound, thermograph, nuclear medicine and functional imaging [6].

Large efforts have been taken for automation of Diabetic nephropathy. But work need to be done in performance improvement using the different computational techniques. Diabetic nephropathy is a micro vascular disease of the glomerular that affects patients with type 1 and

2 diabetes. Pathological changes in the glomerular include diffuse thickening of the GBM accompanied by steady decline of the glomerular filtration rate. The pathogenesis of this alteration is poorly understood. It correlates with proteinuria and may be related to abnormal podocyte function [7]. The renal corpuscle includes Bowman's capsule and glomerulus where the filtering of selected blood components occurs[8]. The filtering action within glomerular is performed by endothelial cells, the glomerular basement (GBM). Researcher of medical science has done much more research effort but there is still need the computational algorithm for automated detection of Diabetic nephropathy.

3. METHODOLOGY

For this research database plays an important role. In this experiment we used the slandered dataset which has already preprocessed by medical community.

3.1 DATABASE COLLECTION

For the research of Diabetic Nephropathy database play an important role. The database needs standard preprocessing operation. Renal histological images are used for this experiment which contains microscopic structure of the kidney. In this work images are used from National Center for Biotechnology Information (NCBI) .It is part of the United States National Library of Medicine (NLM), a branch of the National Institutes of Health. The NCBI is located in Bethesda, Maryland and was founded in 1988 through one of legislation .The NCBI houses a series of databases relevant to biotechnology and biomedicine and an important resource for bioinformatics tools and services. Major databases include GenBank for DNA sequences and PubMed, a bibliographic database for the biomedical literature. Other databases include the NCBI Epigenomics database PubMed is one of it .It is a database developed by NCBI National Library of Medicine (NLM), it works as a part of the NCBI Entrez retrieval system. It was primarily designed to provide the access to references and abstracts from biomedical and life sciences journals. PubMed provides links that allow access to the full-text journal articles of participating publishers. MEDLINE database is the primary data source for PubMed which includes the fields of medicine, dentistry, nursing, health care system, veterinary and the preclinical sciences .PubMed Central(PMC) was launched in February 2000, it is a free archive and serves as a digital counterpart to NLM's extensive print journal collection. PMC provides permanent access to all of its content and is managed by NLM[9,10].

3.2 IMAGE SEGMENTATION

Image segmentation means division of an image into meaningful structures. It is process of extracting and representing information from the image to group pixels together with region of similarity [11]. The goal of segmentation as \to divide an image into parts that have a strong correlation with objects or areas of the real world contained in the image [12]. Computation complexity is one of the important criteria for image segmentation which should be considered carefully when real time image segmentation is required.

3.2.1 Contour based image segmentation

Contour-based approaches usually start with a first stage of edge detection, followed by a linking process that seeks to exploit curvilinear continuity. Boundaries of regions can be defined to be contours. If one enforces closure in a contour-based framework then one can get regions from a contour-based approach [13,14]. The difference is more one of emphasis and what grouping factor is coded more naturally in a given framework. In contour-based approaches, often the first step of edge detection is done locally. Subsequently efforts are made to improve results by a global linking process that seeks to exploit curvilinear continuity. A criticism of this approach is that the edge/no edge decision is made prematurely. To detect extended contours of very low contrast, a very low threshold has to be set for the edge detector. This will cause random edge segments to be found everywhere in the image, making the task of the curvilinear linking process unnecessarily harder than if the raw contrast information was used. Contour analysis (e.g. edge detection) may be adequate for untextured images, but in a textured region it results in a meaningless tangled web of contours.

3.2.2 K-mean Image segmentation

K-means algorithm is the one of the simplest clustering algorithm and there are many methods implemented so far with different method to initialize the centre. And many researchers are also trying to produce new methods which are more efficient than the existing methods, and shows better segmented result. Some of the existing recent works are discussed here. Researcher were introduced a new efficient approach towards ^-means clustering algorithm[15]. They proposed a new method for generating the cluster center by reducing the mean square error of the final cluster without large increment in the execution time. It reduced the means square error without sacrificing the execution time. Many comparisons have been done and it can conclude that accuracy is more for dense dataset rather than sparse dataset.

Clustering is a method to divide a set of data into a specific number of groups. It's one of the popular method is k-means clustering. In k-means clustering, it partitions a collection of data into a *k* number group of data[16,17]. It classifies a given set of data into *k* number of disjoint cluster. ^-means algorithm consists of two separate phases. In the first phase it calculates the *k* centroid and in the second phase it takes each point to the cluster which has nearest centroid from the respective data point. There are different methods to define the distance of the nearest centroid and one of the most used methods is Euclidean distance. Once the grouping is done it recalculate the new centroid of each cluster and based on that centroid, a new Euclidean distance is calculated between each center and each data point and assigns the points in the cluster which have minimum Euclidean distance. Each cluster in the partition is defined by its member objects and by its centroid. The centroid for each cluster is the point to which the sum of distances from all the objects in that cluster is minimized. So ^-means is an iterative algorithm in which it minimizes the sum of distances from each object to its cluster centroid, over all clusters.

3.2.3 Otsu segmentation

In computer vision and image processing, Otsu's method, is used to automatically perform clustering-based image thresholding,[18] or, the reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pair wise squared distances is constant), so that their inter-class variance is maximal. Consequently, Otsu's method is roughly a one-dimensional, discrete analog of Fisher's Discriminate Analysis[19].

3.2.4 Watershed segmentation

Watershed algorithms based on watershed transformation have mainly two classes. The first class contains the flooding based watershed algorithms and it is a traditional approach where as the second class contains rain falling based watershed algorithms. Many algorithms have been proposed in both classes but connected components based watershed algorithm [20] shows very good performance compared to all others. It comes under the rainfalling based watershed algorithm approach. It gives very good segmentation results, and meets the criteria of less computational complexity for hardware implementation. There are mainly three stages as indicated by Figure 1 for watershed based image segmentation approach. First stage is defined as pre-processing, second stage as watershed based image segmentation and last stage as postprocessing.

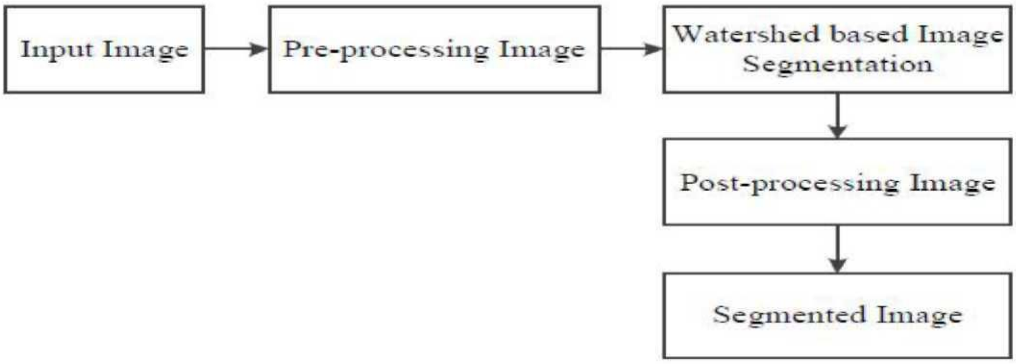

Figure 1: Block diagram of watershed segmentation algorithm

4 Performance Evaluation

PSNR is used to measure the quality of reconstructed image from segmentation technique.. The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs , PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality, in some cases it may not. PSNR is most easily defined via the mean squared error[21].

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Mean Square Error

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

Here, MAXI is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAXIis 2B-1. For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and by three.

5. EXPERIMENTAL ANALYSIS

The experimental results were tested on three sample of image. The comparison of these methods is done to analyze their average performances. The experiment of this research work was done using the contour based, k-mean , otsu and watershed image segmentation techniques. The robustness of these methods was tested on the basis of mean square

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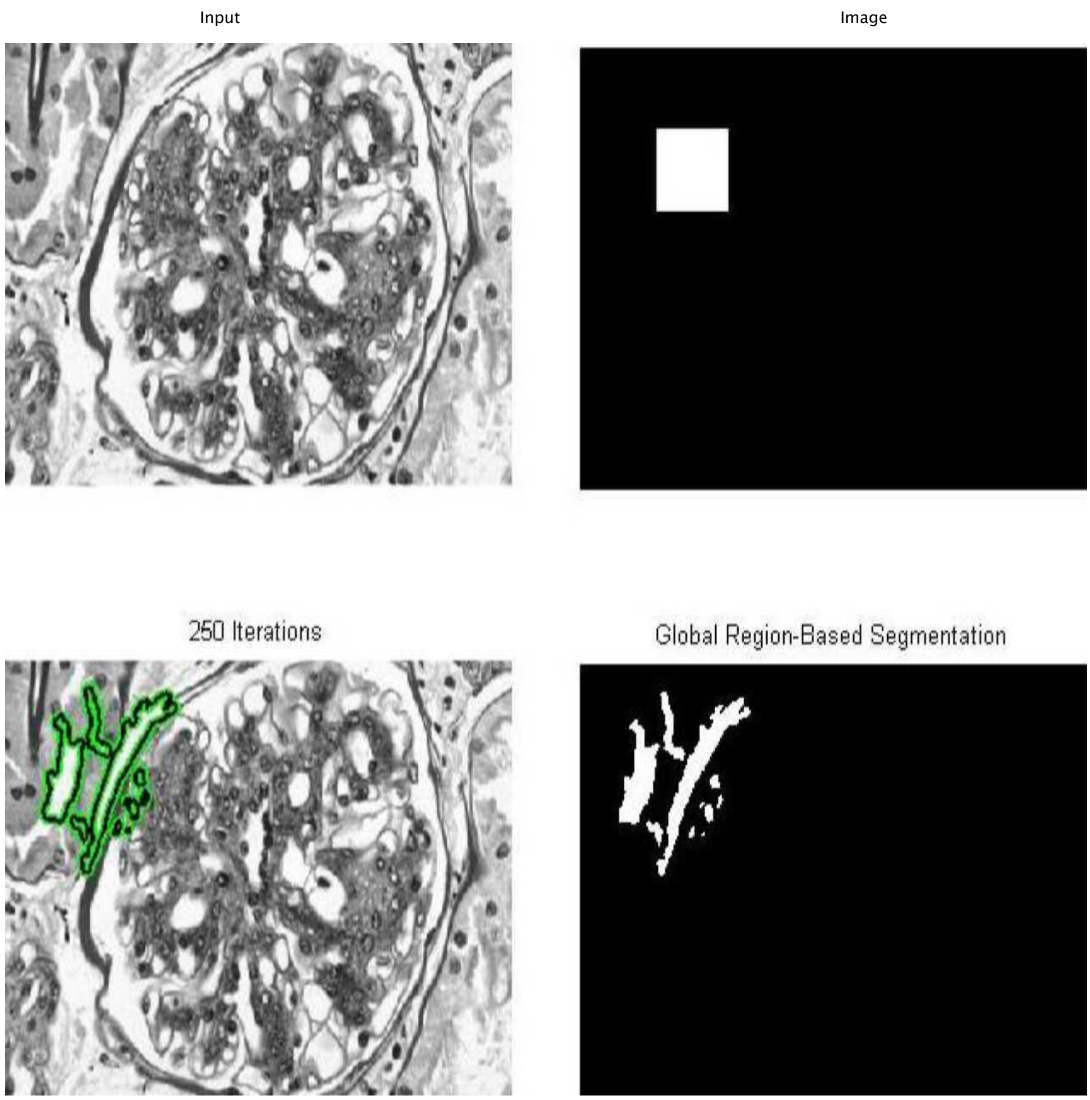
error(MSE) and peak signal to noise ratio (PSNR) statistical measure approach. The average performance of each method is observed. The graphical results of contour based segmentation techniques for image 1, image 2 and image 3 shown in figure 2, figure 3 and figure 4 respectively. Graphical results of K-Mean Image segmentation technique for all three images are described in table 1. Table 2 illustrates the graphical results of otus image segmentation technique for all images. The graphical results of watershed segmentation techniques are shown in table



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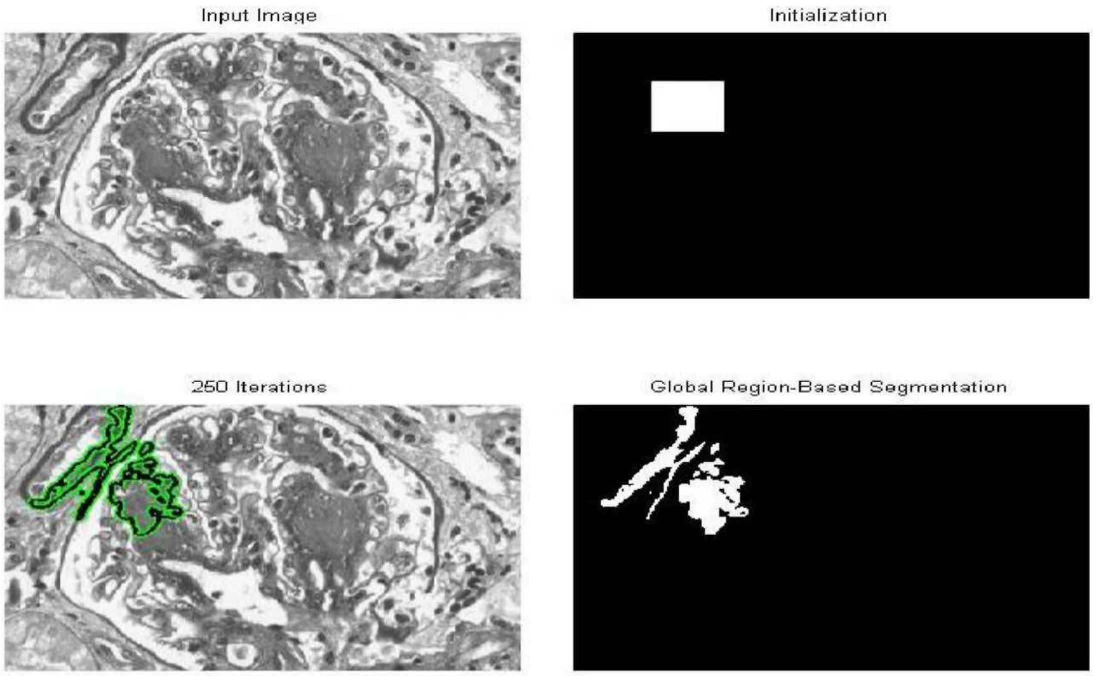


Figure 3: Graphical results of Contour based segmentation technique for image 1

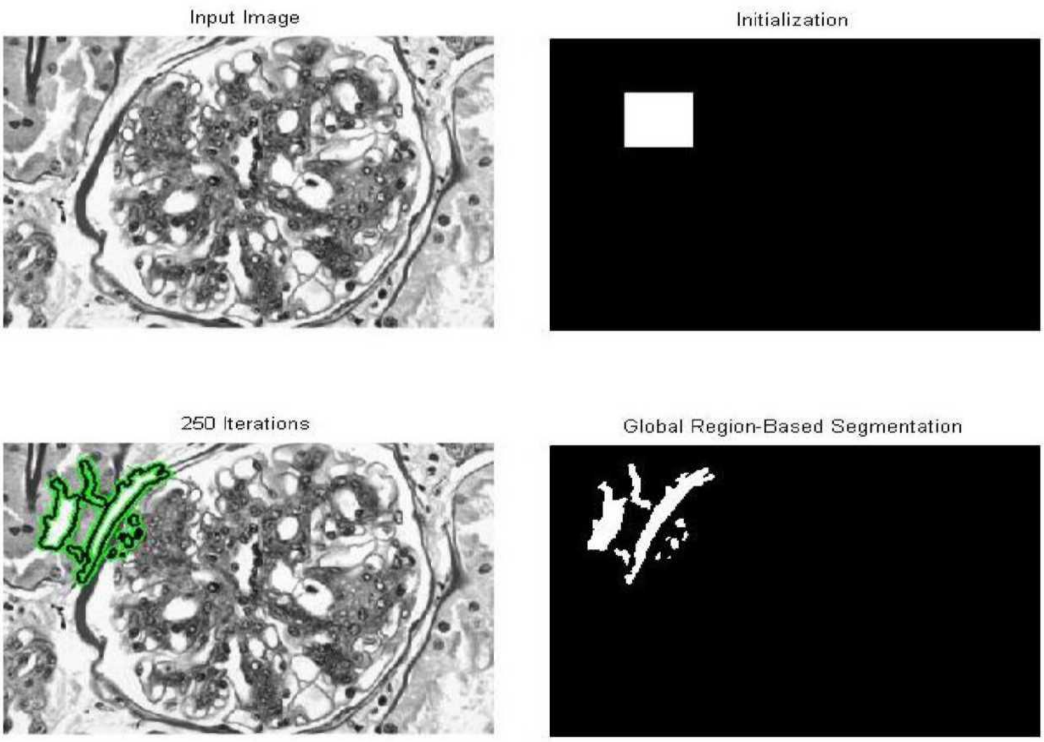


Table 1: Graphical results of K-Mean Image segmentation technique for all three images

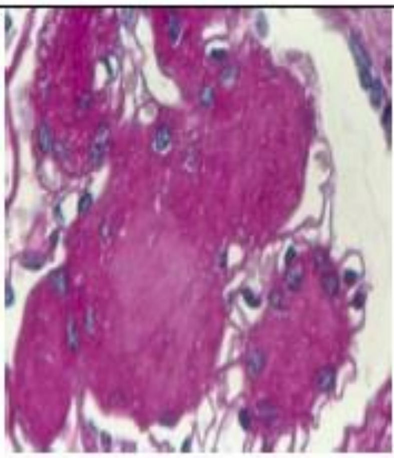
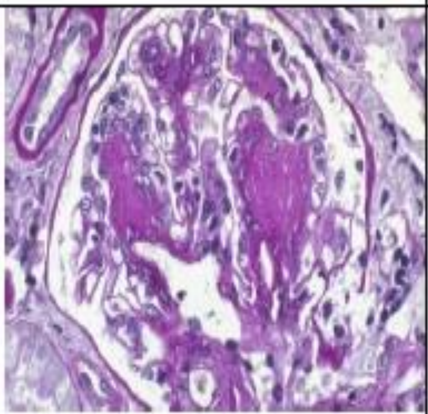
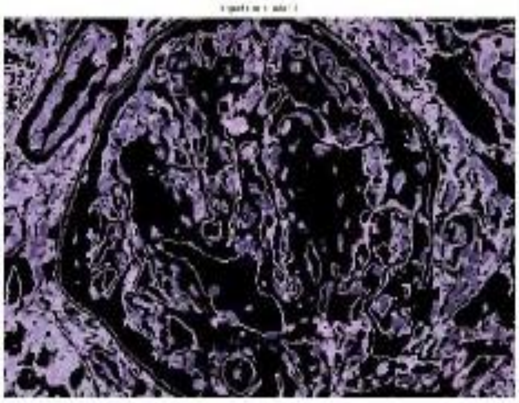
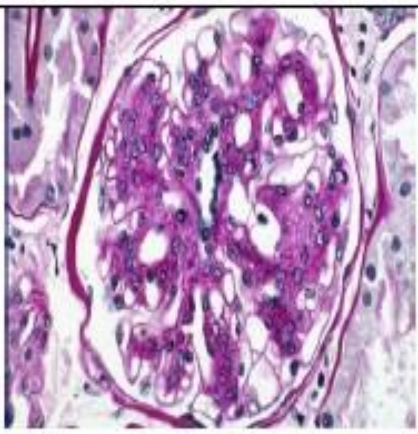
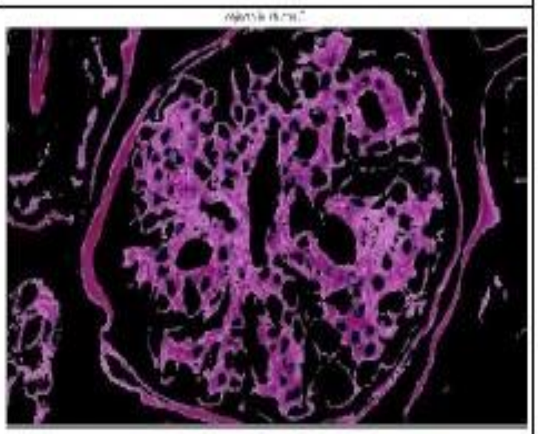
Image	Original Image	K-mean segmented image
Image 1		
Image 2		
Image 3		

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Table 2: Graphical results of Otsu Image segmentation technique for all three images

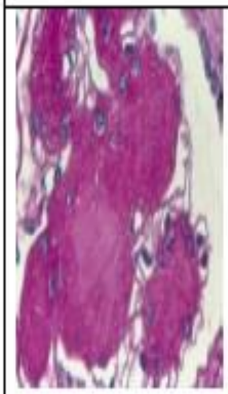
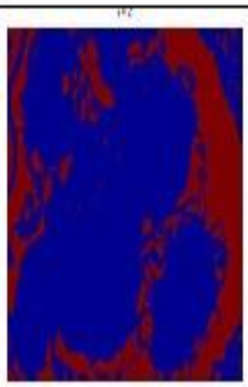
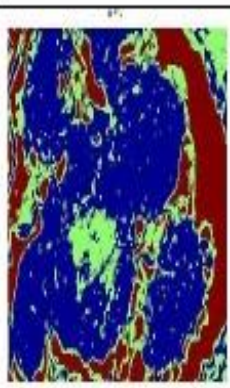
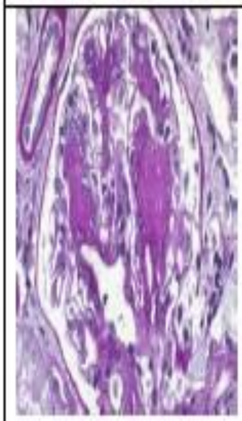
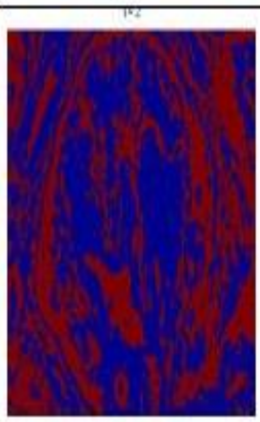
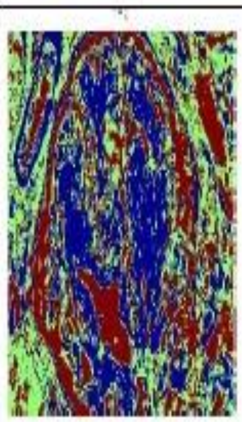
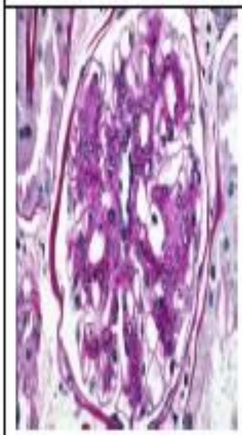
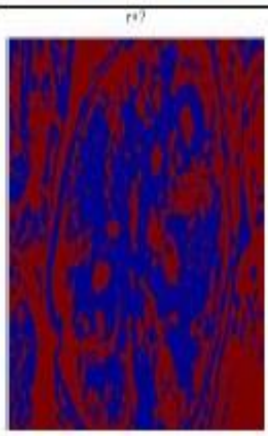
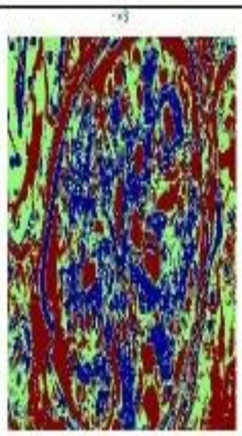
Original image	Otus Image segmentation		
	Threshold n=2	Threshold n=3	Threshold n=4
			
			
			

Table 3: Graphical results of Watershed Image segmentation technique for all three images

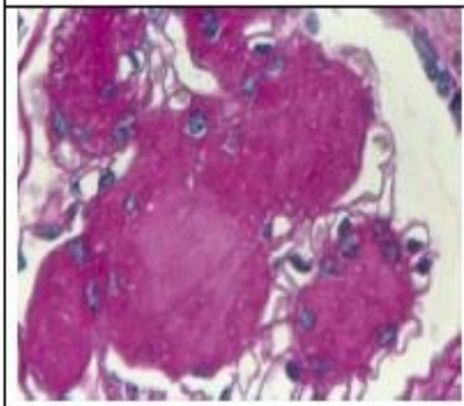
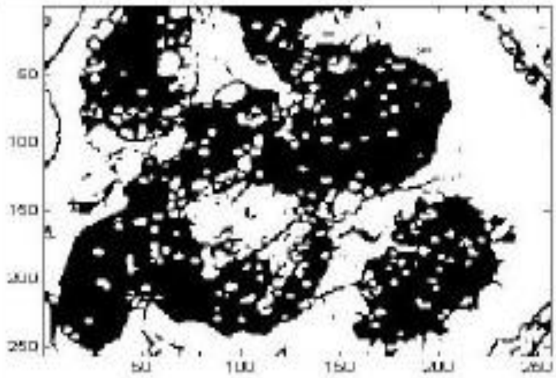
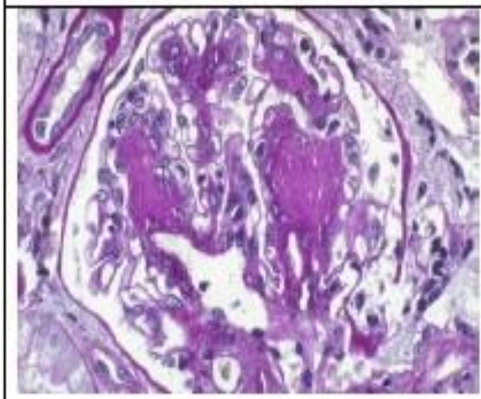
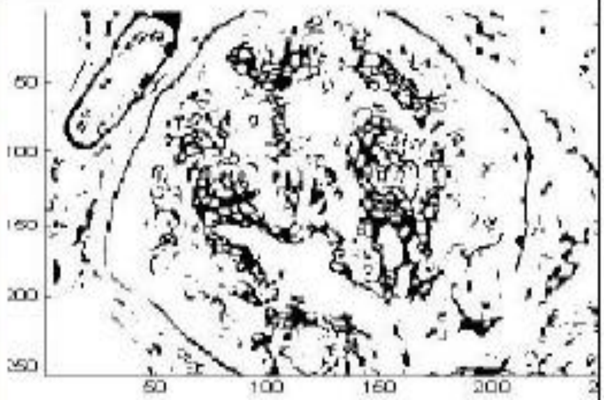
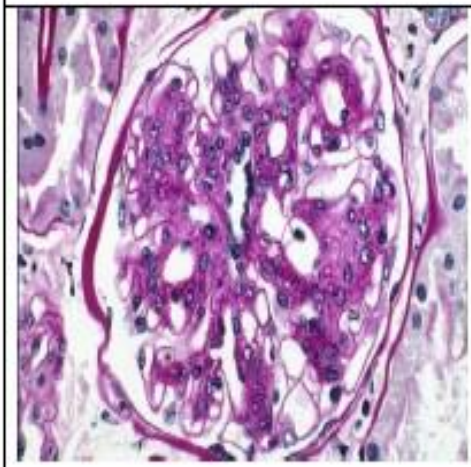
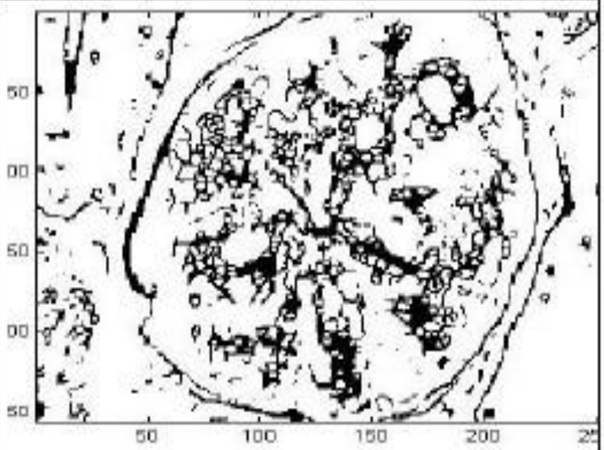
Original Image	Watershed segmented Image
	
	
	

Table 4 and Table 5 illustrate the statistical PSNR and MSE results for all segmentation techniques respectively.

Table 4: Peak to signal Noise Ratio of all segmentation techniques compare with original image

Sr.No	**Original**	**Contour Based**	**Otsu method**	**K-Mean**	**Watershed**
1	Image 1	64.146	81.123	60.945	84.239
2	Image 2	73.755	78.234	71.098	78.321
3	Image 3	75.586	72.980	77.800	76.789
Average		**163.096**	**183.684**	**157.976**	**188.156**

Table 5: Mean square error of all segmentation techniques compare with original image

Sr.No	Original	Contour Based	Otsu method	K-Mean	Watershed
1	Image 1	0.0252	0.0789	0.0654	0.09
2	Image 2	0.0043	0.0067	0.0021	0.0012
3	Image 3	0.0036	0.0039	0.0056	0.0026
Average		0.0307	0.0869	0.069367	**0.0169**

6. DISCUSSION AND CONCLUSION

From the above experiment table 4 and table 5, it is observed that is the PSNR value is high then the reconstruction of the segmented image is highly dominant. From above table the PSNR values of watershed segmentation is high and MSE values are low that means, it is observed that the watershed segmentation technique is more robust and dominant than k-mean, contour based and otus segmentation techniques.

The watershed segmentation scheme is robust and effective. This would be of befit to the patients for early and effective diagnosis. The rate of recognition can be further improved by increasing the size of the database and by considering better statistical measure.

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