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Extraction of Cancer Cells from MRI Prostate Image Using MATLAB

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Abstract*— Medical Image Processing is one of the most challenging and emerging topics in today's research field. Processing of Magnetic Resonance Imaging (MRI) is one of the parts in this field. In recent years, multispectral MRI has emerged as an alternative to Ultrasound (US) image modality for clear identification of cancer in Breast, Prostate and Liver etc,. In order to analyze a disease, Physicians consider MR imaging modality is the most efficient one for identification of cancer present in various organs. Therefore, analysis on MR imaging is required for efficient disease diagnosis. This paper describes the proposed strategy to detect and extraction of Prostate cancer cells from patient's MRI scan image of the Prostate organ. This proposed method incorporates with some noise removal functions, segmentation and morphological functions which are considered to be the basic concepts of Image Processing. Detection and extraction of cancer cells from MRI Prostate image is done by using the MATLAB software.

***Index Terms*—Image Preprocessing, Magnetic Resonance Imaging, MATLAB, Morphological Operations, Prostate Cancer.**

I. INTRODUCTION

Cancer is defined as the abnormal growth of tissues. Prostate cancer is a form of cancer that develops in the prostate, a gland in the male reproductive system. Most prostate cancers are slow growing [1]. The cancer cells may spread from the prostate to other parts of the body; particularly, the bones and lymph nodes. Rates of detection of Prostate cancer vary widely across the world [2]. The Prostate cancer is the second leading cause of cancer-related death in the United States among men and is the most commonly diagnosed cancer in American males [3].

Magnetic Resonance Imaging (MRI) is an advanced medical imaging technique used to produce high quality images of the parts contained in the human body MRI imaging is often used when treating brain, prostate cancers, ankle, and foot. From these high-resolution images, we can derive detailed, anatomical information to examine human organ development and discover abnormalities. Nowadays there are several methodology for classifying MR images, which are fuzzy methods, neural networks, atlas methods, knowledge based techniques, shape methods and variation segmentation. MRI consists of T1 weighted, T2 weighted and PD (proton density) weighted images and are processed by a system which integrates fuzzy based technique with multispectral analysis [4]. Multispectral MRI dataset consists of images that represent the morphological and functional response of prostate gland. Features are directly the pixel intensities of multispectral MR images. Prostate MR Image consists of two regions of interest; Transition Zone (TZ), Peripheral Zone (PZ), and only PZ region is considered because majority of the prostate cancer occurs in PZ [5], [6].

Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content, but they decrease it if entropy is an information measure. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task [7]. Pre-processing of MRI images is the primary step in image analysis which perform image enhancement and noise reduction techniques which are used to enhance the image quality, then some morphological operations are applied to detect the cancer cells in the image. The morphological operations are basically applied on some assumptions about the size and shape of the cancer and in the end the cancer cells are mapped onto the original gray scale image with 255 intensity to make visible the cancer in the image. The algorithm has been tried on number of patients MRI data of Prostate cancer images.

The organization of the paper is as follows. Section II describes the proposed methodology, in detail with preprocessing of prostate MRI image using High Pass and Median Filtering, Thresholding and Watershed Segmentation methods for Segmentation of given image and computing some morphological operations to identify the cancer cells in given MRI Prostate image. Section III shows the results of the proposed experiments

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using a multispectral prostate MRI dataset. Finally, section IV illustrates the conclusion and the future work of this proposed method.

II. METHODOLOGY

The System Design of the proposed method is shown in Figure 1.

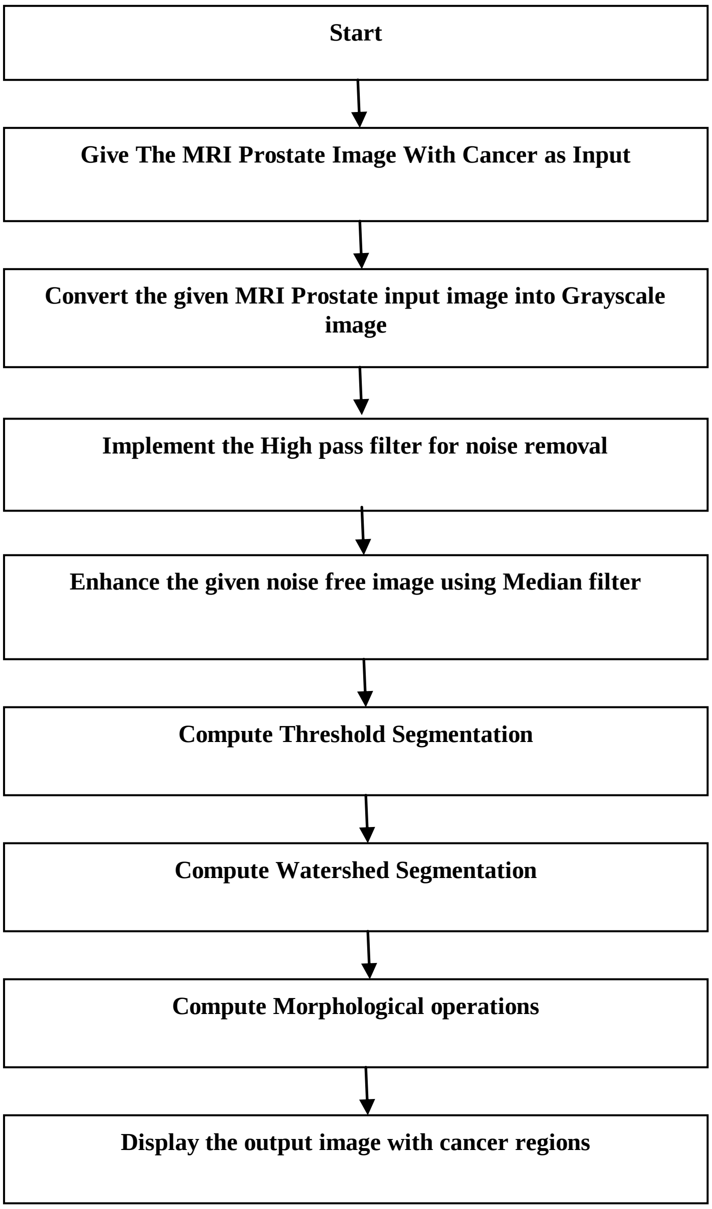

Fig 1. System Design

The System design for the proposed method in Fig 1 is explain below in detail.

A. Dataset

Approximately 70% of the prostate is composed of glandular tissue, and 30% consists of non glandular tissue. For anatomic division of the prostate, the zonal compartment system developed by McNeal is widely accepted [7], [8]. According to this system, glandular tissue is subdivided into the central and the peripheral gland. The central gland is composed of a transitional zone and periurethral tissue, and the peripheral gland is composed of peripheral and central zones (Fig 2). The peripheral zone includes the posterior and lateral aspects of the prostate and accounts for most of the glandular tissue (70%). It is the zone in which 70% of prostate cancers arise. The

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transitional zone accounts for 5% to 10% of the glandular tissue of the prostate. Cellular proliferation in the transitional zone results in benign prostatic hyperplasia. In addition, 20% of prostate cancers arise in the transitional zone.

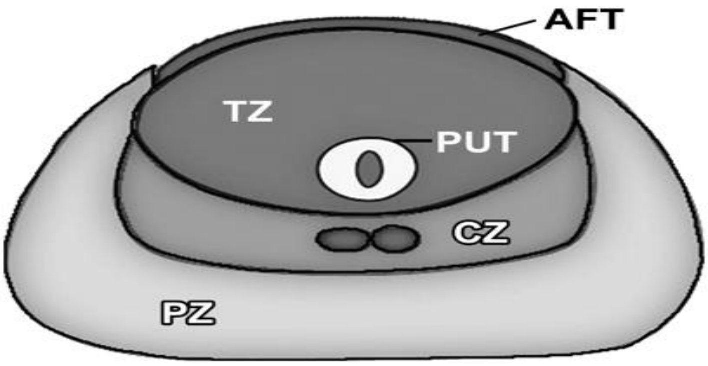

Fig 2. Schematics Show The Anatomy Of The Prostate in Traverse (A) and Sagittal (B) Planes. AFT = Anterior Fibromuscular Tissue, CZ = Central Zone, ED = Ejaculatory Duct, NVB = Nero Vascular Bundle, PUT = Peri Uritheral Tissue, PZ = Peripheral Zone, U = Urethra, TZ = Transitional Zone.

B. Grayscale Imaging

MRI images are magnetic resonance images which can be acquired on computer when a patient is scanned by MRI machine. We can acquire MRI images of the part of the body which is under test or desired. Generally when we see MRI images on computer they looks like black and white images. In analog practice, gray scale imaging is sometimes called "black and white," but technically this is a misnomer. In true black and white, also known as halftone, the only possible shades are pure black and pure white. A grayscale (or gray level) image is simply one in which the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. In fact a `gray' color is one in which the red, green and blue components all have equal intensity in RGB space, (the brightness levels of the red (R), green (G) and blue (B) components are each represented as a number from decimal 0 to 255, or binary 00000000 to 11111111. For every pixel in a Red-Green-Blue (RGB) grayscale image, R = G = B. The lightness of the gray is directly proportional to the number representing the brightness levels of the primary colors. Black is represented by R = G = B = 0 or R = G = B = 00000000, and white is represented by R = G = B = 255 or R = G = B = 11111111) and so it is only necessary to specify a single intensity value for each pixel, as opposed to the three intensities needed to specify each pixel in a full color image. Grayscale is a range of shades of gray without apparent color. The darkest possible shade is black, which is the total absence of transmitted or reflected light. The lightest possible shade is white, the total transmission or reflection of light at all visible wavelengths. So because of the above reasons first we convert our MRI image to be pre-processed in grayscale image.

C. Sharpening an Image Using High Pass Filter

A high pass filter is the basis for most sharpening methods. An image is sharpened when contrast is enhanced between adjoining areas with little variation in brightness or darkness. A high pass filter tends to retain the high frequency information within an image while reducing the low frequency information. The kernel of the high pass filter is designed to increase the brightness of the center pixel relative to neighboring pixels. The kernel array usually contains a single positive value at its center, which is completely surrounded by negative values.

D. Median Filter for Image Enhancement

This method is used to remove salt and pepper type of noises. Salt and Pepper noise Equation is given in equation (1). Each pixel in an image has the probability of p/2 (0<p<1) being contaminated by either a white dot (salt) or a black dot (pepper).

$$Y(i,j) = \begin{cases} 255, & \text{probability } (p/2) \\ 0, & \text{probability } (p/2) \\ X(i,j), & \text{probability } (1-p) \end{cases} \qquad (1)$$

X: noise free image, Y: noisy image

This type of noise consists of random pixels being set to black or white (the extremes of the data range). Median filtering is similar to using an averaging filter, in that each output pixel is set to an "average" of the pixel values in the neighborhood of the corresponding input pixel. In median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image. [9]

E. Segmentation by Thresholding Method

Image segmentation is the process of partitioning the digital/ medical image into multiple regions that can be associated with the properties of one or more criterion. It is an initial and vital step in pattern recognition - a series of processes aimed at overall image understanding. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s) [10].Thresholding is the simplest Image Segmentation method. This method is based on threshold value to convert the gray level image into a binary image. The key of this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry including the maximum entropy method, Otsu's method (maximum variance), and et al k-means clustering can also be used.

F. Watershed Segmentation

A watershed is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys. Intuitively, a drop of water falling on a topographic relief flows towards the "nearest" minimum. The "nearest" minimum is that minimum which lies at the end of the path of steepest descent. In terms of topography, this occurs if the point lies in the catchment basin of that minimum. A grey-level image may be seen as a topographic relief, where the grey level of a pixel is interpreted as its altitude in the relief. A drop of water falling on a topographic relief flows along a path to finally reach a local minimum. Intuitively, the watershed of a relief corresponds to the limits of the adjacent catchment basins of the drops of water. In image processing, different watershed lines may be computed. In graphs, some may be defined on the nodes, on the edges, or hybrid lines on both nodes and edges. Watersheds may also be defined in the continuous domain [10] .There are also many different algorithms to compute watersheds. There are also many different algorithms to compute watersheds. One of the most common watershed algorithms was introduced by F. Meyer in the early 90's is called as Meyer's flooding Watershed Algorithm. The following are the steps which briefly describe about the algorithm:

1. A set of markers, pixels where the flooding shall start, are chosen. Each is given a different label.
2. The neighboring pixels of each marked area are inserted into a priority queue with a priority level corresponding to the gray level of the pixel.
3. The pixel with the highest priority level is extracted from the priority queue. If the neighbors of the extracted pixel that have already been labeled all have the same label, then the pixel is labeled with their label. All non-marked neighbors that are not yet in the priority queue are put into the priority queue.
4. Redo step 3 until the priority queue is empty. The non-labeled pixels are the watershed lines.

The algorithm works on a gray scale image. During the Successive flooding of the grey value relief, watersheds with adjacent catchment basins are constructed. This flooding process is performed on the gradient image, i.e. the basins should emerge along the edges.

G. Morphological Operations

Morphological image processing is a collection of nonlinear operations related to the shape or morphology of features in an image. As per the statement of Wikipedia, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood: A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in

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the input image. The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one:

1. The matrix dimensions specify the size of the structuring element.
2. The pattern of ones and zeros specifies the shape of the structuring element.
3. An origin of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

For the implementation of this proposed system real time patient data is taken for analysis. As cancer in MRI image have intensity more than that of its background so it become very easy to locate and extract it from a MRI image. The results obtained from each module are discussed in detail in the following subsections.

A. Pre-Processing Using High Pass And Median Filtering

The work flow diagram for Pre-processing of the proposed method is given in Figure 3.

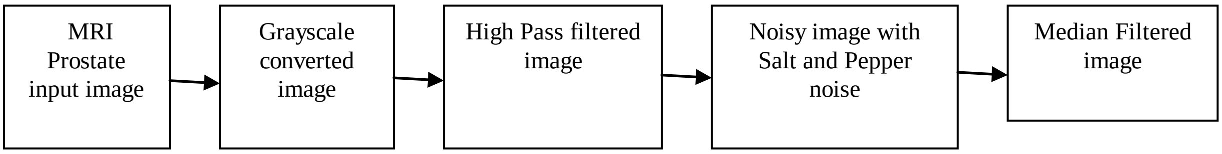

Fig 3. Work flow diagram for Pre-processing of Noisy MRI image

The MRI Prostate image with clearly mentioned Peripheral Zone (PZ) region is given in Fig 4.

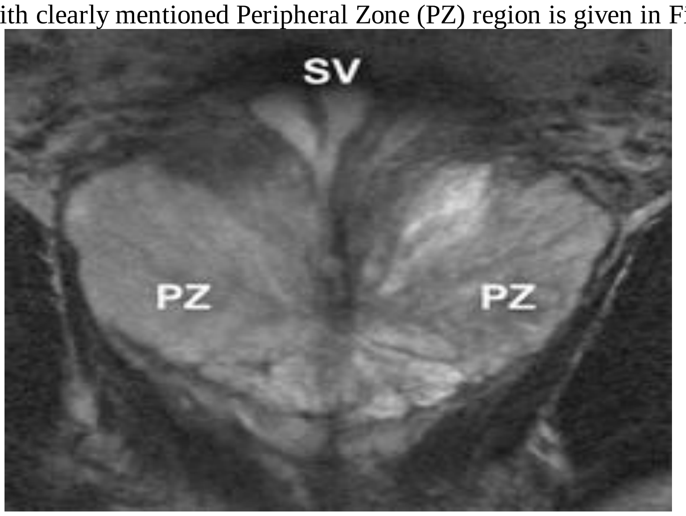

Fig 4 MRI Prostate Image with PZ Region

The Input MRI Prostate image for the proposed system is given in Fig 5

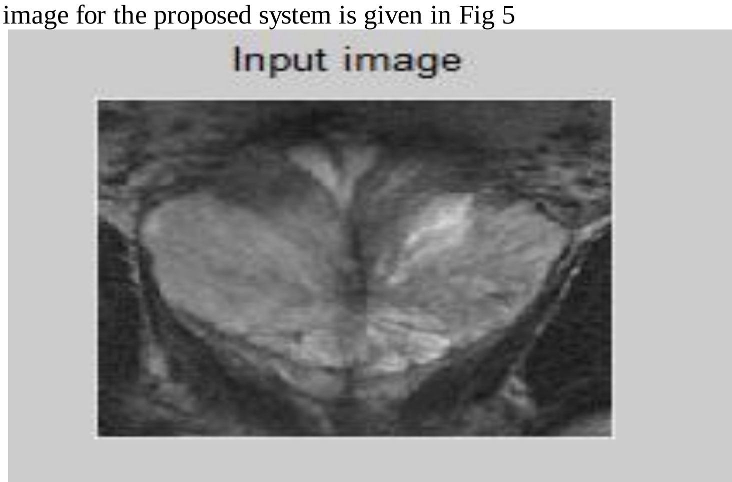

Fig 5 Input MRI Prostate Image

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The Gray scale converted image from the given MRI Prostate input image is given in Fig 6.

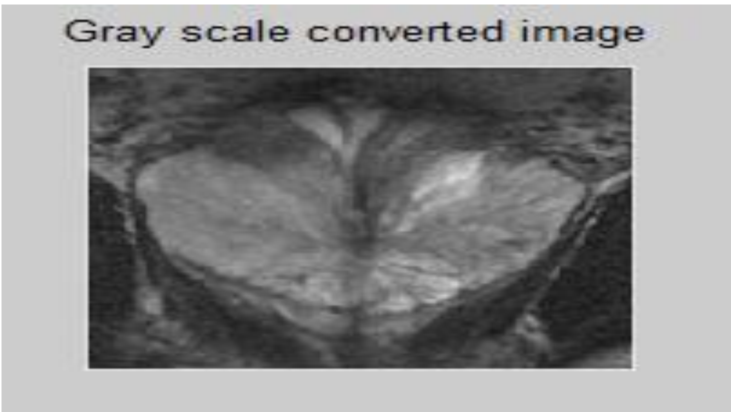

Fig 6. Gray Scale Converted MRI Prostate Image

The result of high pass filtered MRI Prostate image is given in Fig 7. This is implemented to remove the noise which are present in the given MRI Prostate input image.

Fig 7 High Pass Filtered MRI Prostate

The next step is the preprocessing is the enhancement of given MRI Prostate input image. For this enhancement process, the proposed system uses Median Filtering method. In this method the Salt and Pepper type of noise is added to the given input image to remove different type of noises and also to produce a noise free input image.

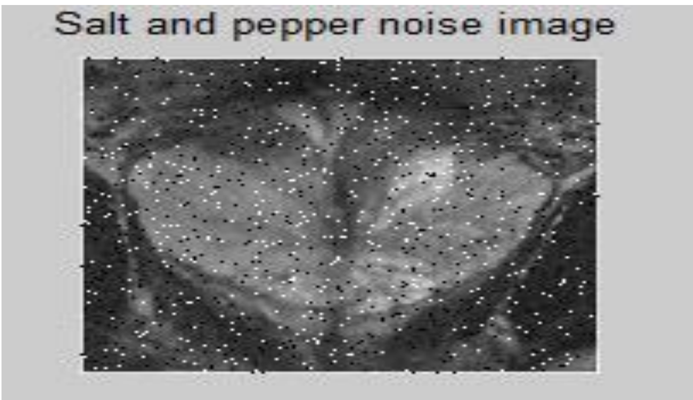

Fig 8. MRI Prostate Image with Salt and Pepper Noise

The above mentioned Fig 8 shows the MRI Prostate input image with salt and pepper noise.

Fig 9. Median Filtered MRI Prostate image

Median Filtered MRI Prostate image is given in Fig 9. From Fig 1 to Fig 9, the first stage in the proposed system i.e., Preprocessing of given MRI Prostate input image is implemented and the results are shown in each steps.

B. Segmentation Results

The work flow diagram for Pre-processing of the proposed method is given in Fig 10.

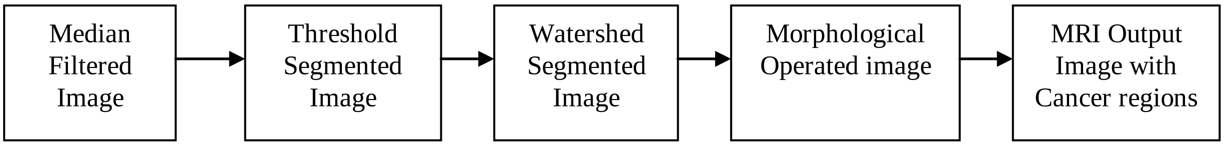

Fig 10. Work Flow Diagram for Segmentation of MRI Image

The implementation and the result of the second stage in the proposed system i.e., Segmentation is shown as follows:

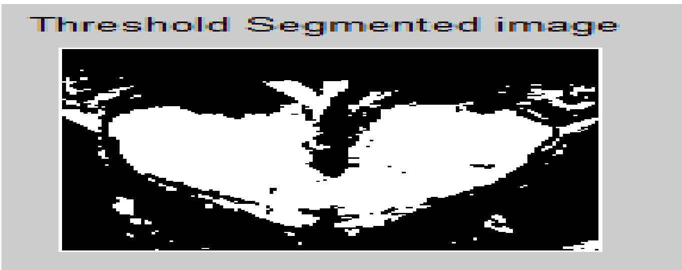

Fig 11. Threshold Segmented MRI Prostate image

The Median Filtered MRI Prostate image is given as an input for Segmentation process based on Thresholding method. The output of the Threshold Segmentation method is shown in Fig 11.

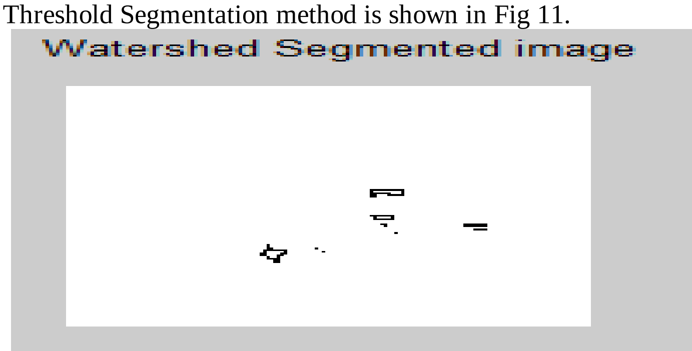

Fig 12. Watershed Segmented MRI Prostate image

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The output of the Watershed Segmentation method is shown in Fig 12. This output clearly shows the non labeled pixels in the form of watershed lines in the given input MRI Prostate image.

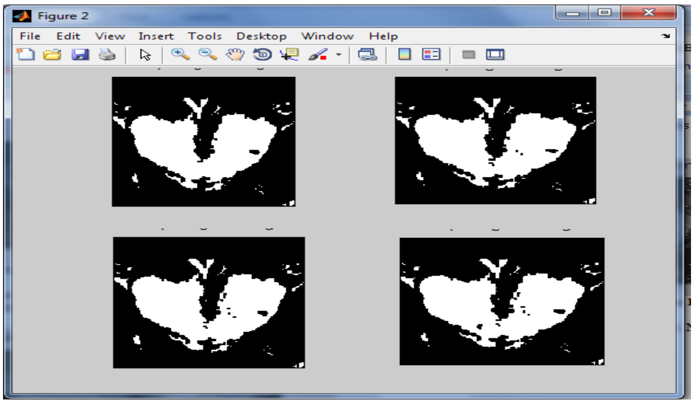

Fig 13. Morphological Operated MRI Prostate Image

Fig 13 shows the output of the MRI Prostate image implemented by Morphological operations. The structuring element with the pixel intensity values of 0 are represented as black colored regions surrounded by the neighborhood pixels with the intensity values of 1 in the PZ region of the given MRI Prostate Input image. The Fig 13 clearly represents that more number of Cancer cells are present at the Right side PZ region when compared with the Left side PZ region of the given MRI Prostate image.

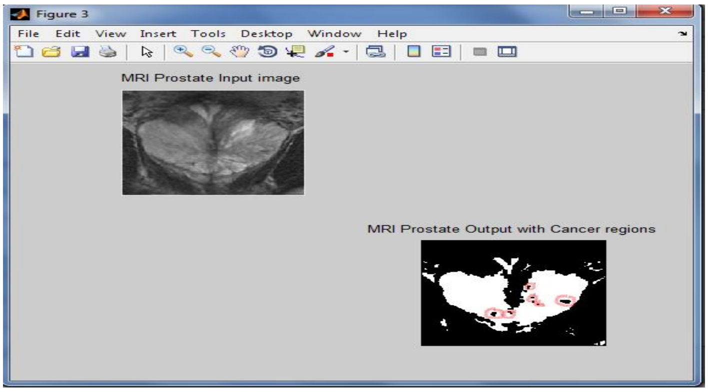

Fig 14. MRI Prostate Input and Output image

The MRI Prostate input and output images of the proposed system are shown in Fig 14. The Cancer cell regions present in the given MRI Prostate image are highlighted in the MRI Prostate output image.

IV. CONCLUSION AND FUTURE WORK

The proposed method is carried out in two sequences of steps. They are: Pre-processing of Noisy input image using High pass and Median Filtering and Segmentation by Threshold Segmentation, Watershed Segmentation and Morphological operations on given MRI Prostate Image. The extracted cancer cell regions from the given image are highlighted in the final output of the MRI Prostate image. The proposed system can be extended for some other modality of images like CT, Ultra Sound etc., for different organs of human such as Breast, Brain and so on. This proposed system finds its application in the Medical field and other research areas.

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