Medical Image Segmentation: A Comparison Between Unsupervised Clustering and Region Growing Technique for TRUS and MR Prostate Images

Kiran Ingale†, Pratibha Shingare††, and Mangal Mahajan†††
kbi15.extc@coep.ac.in *pps.extc@coep.ac.in* *drmangalmahajan@gmail.com*
†Research Scholar, Department of E & TC Engineering, College of Engineering, Pune 411005 India
†† Faculty of Engineering, Department of E & TC Engineering College of Engineering, Pune 411005 India
†††Faculty of Medicine, Department of Radiology, Bharati Medical College and Hospital, Pune 411043 India

Summary
Prostate cancer is one of the most diagnosed malignancies found across the world today. American cancer society in recent research predicted that over 174,600 new prostate cancer cases found and nearly 31,620 death cases recorded. Researchers are developing modest and accurate methodologies to detect and diagnose prostate cancer. Recent work has been done in radiology to detect prostate tumors using ultrasound imaging and resonance imaging techniques. Transrectal ultrasound and Magnetic resonance images of the prostate gland help in the detection of cancer in the prostate gland. The proposed paper is based on comparison and analysis between two novel image segmentation approaches. Seed region growing and cluster based image segmentation is used to extract the region from trans-rectal ultrasound prostate and MR prostate images. The region of extraction represents the abnormality area that presents in men's prostate gland. Detection of such abnormalities in the prostate gland helps in the identification and treatment of prostate cancer

Key words:
Prostate cancer, Region Growing, Seeding, Prostate gland, Clustering, Image segmentation

1. Introduction

The prostate gland is found in men's reproductive system. The function of this prostate gland is to support secreting the seminal fluid with the help of prostate muscles [1][2]. Prostate cancer forms in the prostate gland when abnormal cells grow faster than normal prostate causing the formation of a malignant tumour. Detection of cancer cells in the prostate gland can be done using a PSA test, Biopsy and digital rectum examination. The symptoms of prostate cancer are symptoms such as prostatitis cancer, pain in the pelvic, pain and difficulties while urination, hematospermia and men's infertility.

In India, prostate cancer cases rising rapidly. This becomes top ten among the cancer symptoms found in Indians. As per PBRCs and Globocon's data, in 2018 new 25,693 cases found with 17,184 death cases. This cancer symptom covers all regions of India. It's predicted that the prostate cancer patients' cases will be doubled by the year 2020.

Detection, observation and treatment of prostate cancer were made using analysis of prostate gland that is produced using trans rectal images and magnetic resonance images. These images are called TRUS prostate and MR prostate images.

Segmentation is a computerized process of decomposing the image into sub regions that homogeneous in terms of an image characteristic. Homogeneous referred to as images with similar characteristics like features, intensity, etc. Segmentation can be studied as a pixel classification that results in the grouping of pixels that belongs to the same region with the same label. There are various methodologies to perform image segmentation namely region based, contour based, Threshold, and boundary based image segmentation.

Trans rectal imaging procedure alternatively referred to as prostate sonogram or endo-rectal ultrasound. The main use of the endo-rectal ultrasound procedure is to generate men's prostate gland to detect and diagnose [1]-[4]. Trans-rectal ultrasonography becomes a rapid growing, portable, efficient and low cost image modality technique.
Detection of prostate tumour using magnetic field based resonance imaging can be performed by DCEMR imaging temporal method.

Automatic and manual segmentation is two modes for performing image segmentation using mentioned methodologies. In manual segmentation mode, one needs to select the area where segmentation is to perform. Whereas automatic segmentation takes care of initialization and started performing segmentation.

Region oriented image segmentation methodology consists of two main processes namely region splitting and region merging [7]-[10]. These are an iterative process where image splitting divides an image into various regions that may satisfy the condition of homogeneity. Region merging is an opposite process in these homogeneous

Manuscript received May 5, 2021
Manuscript revised May 20, 2021
https://doi.org/10.22937/IJCSNS.2021.21.5.1

regions are allowed to merge to get desired image segmentation.

Cluster based unsupervised image segmentation converts a distinct set of data elements into a group of data that are homogeneous and exhibit similar characteristics. K-means cluster techniques groups the data elements by computing the distance between similar data points and centroids of each cluster.

2. Theoretical Consideration

There are two commonly used imaging platforms to produce prostate gland images that are trans rectal prostate imaging and MR prostate imaging. These platforms differ in there working principle and methodologies.

In MR imaging, principle of the electromagnetic field is used. The images of the prostate gland are produced by exposing the body to a strong electromagnetic field. The quality of images produces are of high resolution and are easy to understand. In trans rectal imaging procedure, the principle of the sonar system is used to collect the prostate gland images.

Detection of prostate cancer, observation and diagnosis is made by analyzing the prostate images using guided biopsy. Due to limited biopsy samples availability and low resolution, TRUS leads to inaccuracy and affects the treatment duration and diagnosis for a prostate cancer patient. Prostate cancer detection can be predicted using MR prostate imaging due to its high resolution.

2.1 Region of Interest Extraction

Extraction of the specific prostate region is called a region of interest. The extraction helps in calculating the shape and size of a tumour present in the prostate image. This can help the radiologist to identify the regions which are required examination medically.

In prostate TRUS imaging, the objective of extraction of the region of interest is to find the region present in the prostate which is likely to have prostate cancer. The region obtained should contain the region marked by experts

2.2 Region Growing Technique

Seeded region growing is an image segmentation technique. The seeding is used to start the process of segmentation. The seeding point may be automatic or manual. The main working principle of seed region growing is that the process starts using a single image's pixel and it continuously grows a region.

Region growing based image segmentation is used to extract the region from trans-rectal ultrasound prostate and MR prostate images.

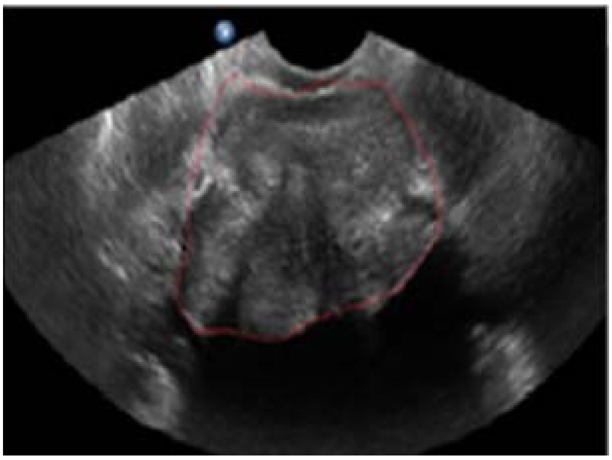

Fig. 1 Trans rectal ultrasound prostate image

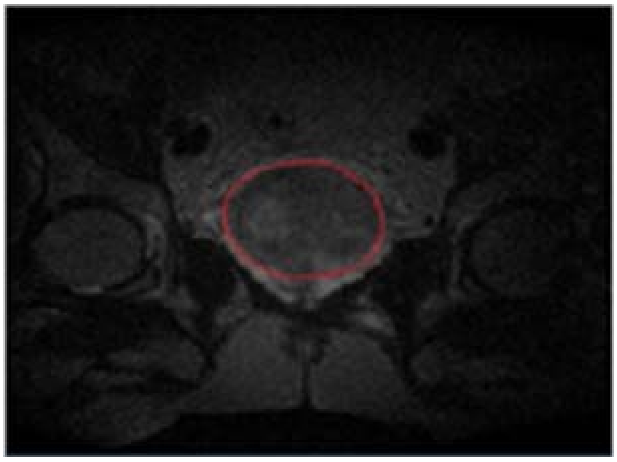

Fig. 2 Magnetic resonance prostate image

The region is the segmented area extracted from an image. This process includes all nearby pixels of images that shows homogeneity with starting a single image's pixel.

Vinicius R.P. Borges, Maria Cristing F. de Oliveira proposed region growing based Image segmentation for 2D microscopy digital images [7]. Microalgae images have been used for this purpose. The microalgae images are called microphytes or microscopic algae. The proposed paper shows the morphological feature extraction based on manual seed selection region growing provides efficient results in generating features than the conventional level set image segmentation.

Erwin, Saparudin in paper proposed performance analysis of seed point based region growing method [8]. Comparison is with image thresholding. Segmentation is done for Berkeley segmentation database (BSDS). The author concluded that the region growing segmentation procedure results in clear and more accurate boundaries detection than the thresholding technique implemented for the same objective.

I. Grinias, and Y. Mavrikakis published a paper on automatic seed region growing and clustering based segmentation process [9]. In this paper, an automatic segmentation technique is implemented using K-means clustering.

2.3 Region Growing Modelling

The seeded region growing requires seed points. The seed point is chosen to collect at least one image feature. It computes Euclidean distance between similar pixels and aggregating to create a segmented area that consists of a similar pixel group. The procedure for the extraction of Region of interest

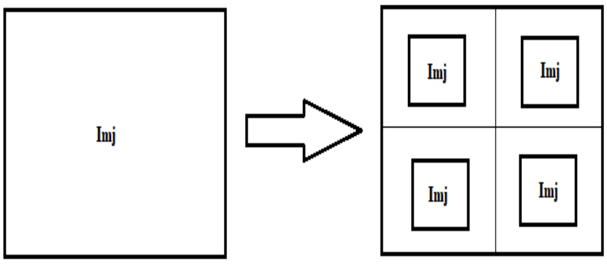

Fig. 3 Region split process

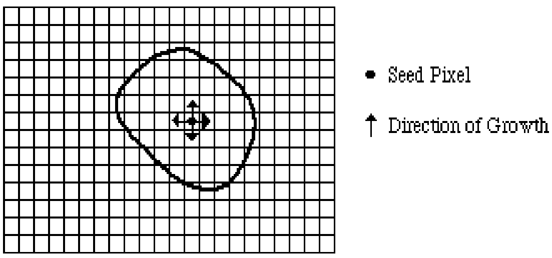

Fig. 4 Selection of seed point in image

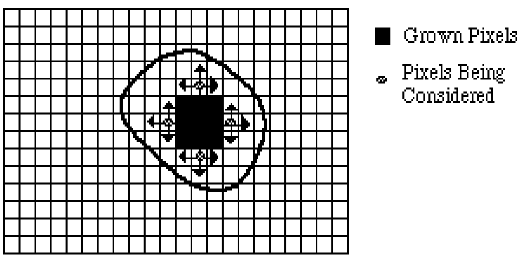

Fig. 5 Region growing process

using seed Region growing image segmentation can be given as follows:

1) Firstly, an input image is converted into the binary image array
2) Select the seeding point whose pixel is similar to pixel present nearest to seed pixel and it is denoted as s(p) and it is set to 1. The Euclidian distance between the two similar pixels is given by

$$\sigma(P,c) = \frac{min(\sum q\varepsilon W(P) d(qc_i))}{|W(P)|} \quad (1)$$

Where |W(p)| is the cardinality of a window W(p), C is the selected area to which pixel point p is assigned, using this we obtain homogeneous regions

3) The binary array is recalculated to extract the M distinct region that results from a seed point s(p)=1
4) Using the help of seed point, different small regions are generated. These regions are consumed by region growing
5) The small regions denoted by generated from the seed point extraction are expanded with the help of region growing algorithm
6) This small region has a pixel set used for the estimation of features of segmentation. The pixels are having similar features
7) For the dissimilar pixels which are adjacent to the small regions is referred to as unlabeled image pixel.
8) The region growing consists of the splitting and merging process. This process divides an image into uniform Regions The splitting process divides an input image into a number of small regions generated using manual seeding. The process of spitting continues till no further split occurs. The reverse process of image split to generate an extracted region Homogeneity defines uniformity in the splitting process.

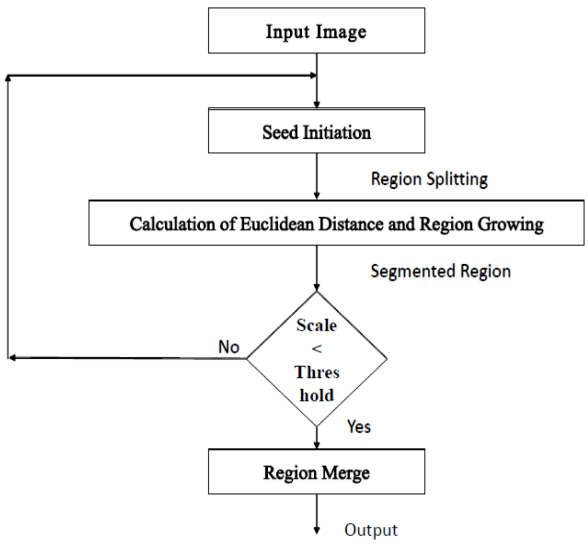

Fig. 6 Region growing and merging algorithm

For grey level images, a statistical homogeneous region is defined when the standard deviation of intensity is lesser than a threshold value. The standard deviation is given as

$$\sigma = \left[\frac{1}{n-1}\int_{j=1}^{n}(x_i - x)^2\right] \quad (2)$$

Algorithm for Region Split and region merge is given in fig.6

2.4 Unsupervised cluster based image segmentation

K-means is an unsupervised partitioned based cluster method to divide a dataset into a specified number of groups. In this k-means cluster method, partitioning exhibits for the collection of data into k data clusters. It provides a classification for the image's pixel data set into k number of adjacent clusters.

Unsupervised K-means consists of two modes. In the first mode, it performs the computation of the k centroid and in the second mode it takes every image pixel to the cluster which is the nearest centroid from the respective data set.

In image processing Euclidean distance is the most commonly used feature calculation characteristic in performing segmentation using cluster technique. Once the clustering is done it recomputed a new centroid for each cluster. The new centroid, Euclidean distance is recalculated between every centre of the cluster and every pixel data. K-means clustering performs iteration that minimizes the distances from each region to its cluster.

Md. Khalid Imam Rahmani, Naina Pal, Kamiya Arora, proposed a clustering based image segmentation based on k-means and using a fuzzy system [11]. A cluster process is used to find similar image areas present inside an image. The criteria for clustering are image features such as texture, shape and colour. This technique provides better segmentation.

Nameirakpam Dhanachandra, Yambem Jina Chanu, proposed k-means image segmentation with local histogram equalization for improving the quality of images for varying image size [21]. The purpose of local histogram equalization is to improve the image and improved image is applied to k-means segmentation. The author concluded that using the combination of histogram equalization and k-means cluster based technique results in a better quality of the image segmentation for the bigger size of images.

Dibya Jyoti Bora presented a clustering based image segmentation process. The technique of clustering allowed working on color space for this task [22]. The performance is depending on choosing a proper distance measure; the cosine distance measure is done. The segmented image is filtered using a Sobel filter. The filtered image is applied to a watershed algorithm to have the final segmented result for an input image. The performance for the proposed technique is evaluated using MSE and PSNR values.

There is a divisible clustering technique where the complete data set is converted into a cluster. This cluster then recursively splits to get efficient clustering. The clustering technique also has an agglomerative cluster method in which each data item recorded as a cluster. The k-means is a simple pixel cluster technique that has k clusters. It is an iterative process. These clusters are having individual centers. Consider the centre of the cluster as ci and feature vector xi. The cluster data generated by k-means cluster is given by an objective function.

$$\Phi(\text{cluster}, \text{data}) = \sum_{i\varepsilon cluster}\left\{\sum_{j\varepsilon cluster}(x_j - c_i)^T (x_j - c_i)\right\} \quad (3)$$

The new cluster can be defined easily using k-means segmentation. A k-means cluster based algorithm used for the extraction of a class of data set with known cluster centre. It is basically to cluster N data points with M dimensional feature space into clusters.

3. Experimental Consideration

This Research was conducted with images acquired with the approval of the Institutional Ethics Committee and with the informed consent of all subjects. The experiments were conducted on a Windows desktop with an Intel i5 CPU (3.4 GHz). The user interface was developed in MATLAB.

Axil T2-weighted MR images were obtained using a whole-body 1.5T GE Medical Systems (Singna HDxt) at an image size of 512 x 512. The 2-D TRUS images were acquired using Philips Medical Systems with CURVED LINEAR transducer probe. The 2-D TRUS image size was 600 x 800. TRUS and MR image database contained 400 images each.

The implementation of prostate cancer image extraction consists of two separate techniques. The process of region extraction is done by region growing and k-means clustering. These techniques are used for segmentation for TRUS prostate and MR prostate images

3.1 Seed Guided Region Growing Process

The seeding region growing has region split and region merge process. The split rapidly divides an input image into small homogeneous regions.

Split Phase: - A spilt phase provides the generation of a quadtree structure where nodes at each level result in the split of images into homogeneous sub images with regular interval size. The set of small regions in the equal and regular structure created by the Split process will be the set of input regions for the Merge phase.

Merge Phase: - In the region merge process, nearby small regions generated by Image split. The iteration process helps in merge the small regions generated by the split in order to build a large image. The process of merging will continue till no more merges are possible.

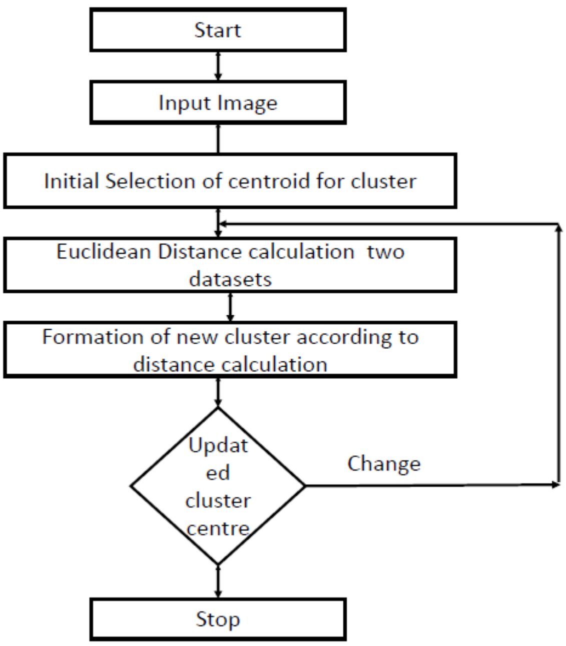

Fig. 7 K- Mean clustering algorithm

3.2 Unsupervised K-means Clustering

The clustering process is implemented as follows:

1) MR prostate and TRUS images are applied to noise, removal to obtain better extraction and segmentation. Noise has to be minimized and image for further Processing
2) Selection of centroid at the start for performing computation and iteration the k-means cluster process works on computation of Euclidean distances between the data sets of distinct classes created by defining clusters and each cluster must have a centroid value
3) Detection of prostate Boundaries and new cluster formation. The process of extraction of the prostate has a clustering technique is used in process of extraction of the prostate. Initially centroid and the cluster is initiated. Calculate the Euclidean distance between the data set of each class.
4) Extraction of Prostate Image After computation of Euclidean distance between the data points from data sets. The algorithm works along the boundaries where two distinct classes are produced. The final stage has two classes where one class represents the prostate and another class represents the background.

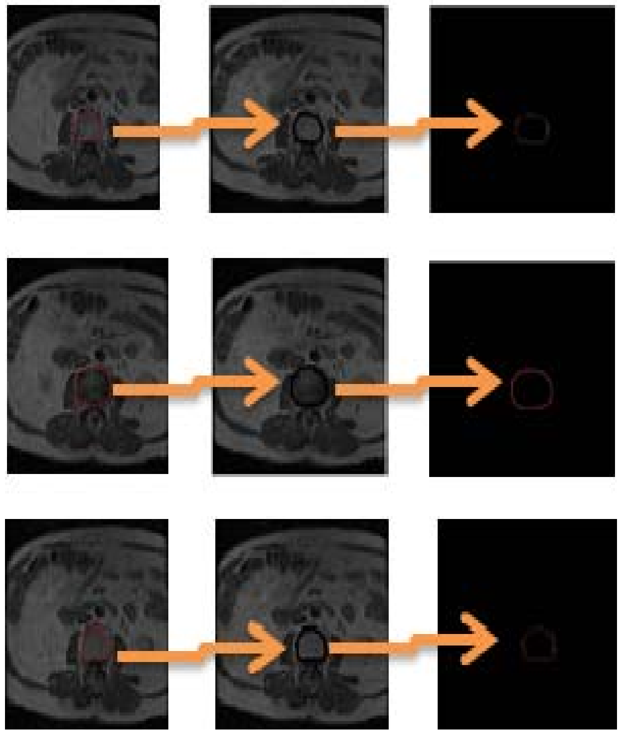

Fig. 8 Region Extraction from MR prostate images using Unsupervised Clustering Technique

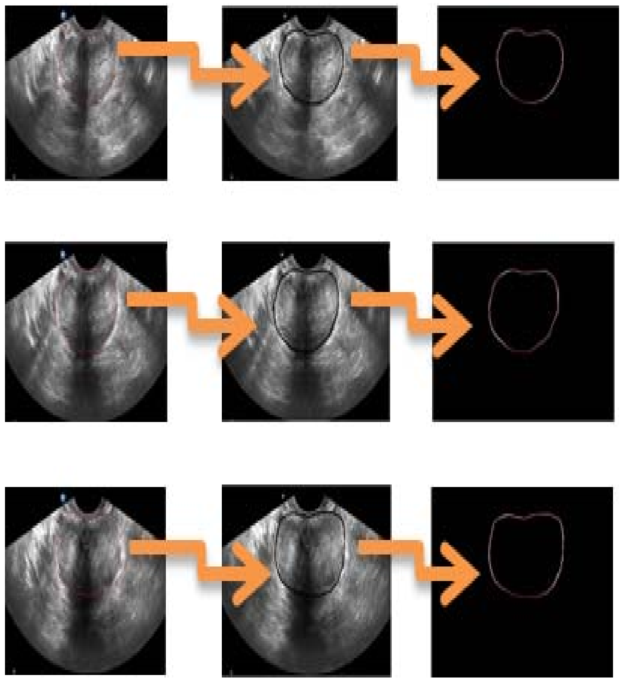

Fig. 9 Region Extraction from TRUS prostate images using Unsupervised Clustering Technique

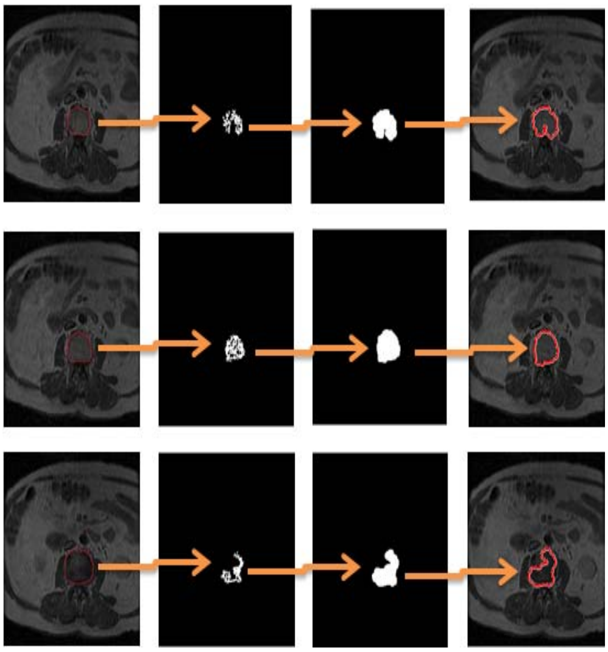

Fig. 10 Region Extraction using Region Growing Technique

3.3 Results and Analysis

The proposed method of comparison between k-means Custer and seeding region growing was evaluated for the patient's TRUS prostate and MR prostate images collected from Bharti Vidyapeeth Hospital Pune India. The study protocol was reviewed. The quantitative study has been done for the proposed method using performance parameters MSE, DSC, Specificity Sensitivity and Accuracy Values of performance parameters for all prostate images are shown in the table

Table 1: Performance parameters for MR prostate image using region growing technique

Images	MSE	Accuracy	SE	SP	DSC
391	0.08	6.97	2.44	1	0.54
392	0.06	5.13	0.17	1	0.11
393	0.06	5.11	0.11	1	0.03
394	0.05	5.55	0.13	1	0.05
395	0.06	5.83	0.25	1	0.20
396	0.05	3.02	2.24	1	0.63
397	0.07	4.88	3.74	1	0.70
398	0.06	3.50	2.31	1	0.50
399	0.05	3.45	2.35	1	0.62
400	0.05	3.59	2.21	1	0.49

Table 2: Performance parameters for TRUS prostate image using k-mean clustering technique

Images	MSE	Accuracy	SE	SP	DSC
391	181.20	75.55	100	0	1
392	179.72	73.00	100	0	1
393	181.30	73.75	100	0	1
394	181.46	73.69	100	0	1
395	180.65	73.86	100	0	1
396	181.68	74.64	100	0	1
397	177.75	74.13	100	0	1
398	178.66	74.42	100	0	1
399	176.27	74.84	100	0	1
400	176.27	72.84	100	0	1

Table 3: Performance parameters for MR prostate image using k-mean clustering technique

Images	MSE	Accuracy	SE	SP	DSC
391	188.1	95.35	100	0	1
392	185.36	95.03	100	0	1
393	182.47	94.99	100	0	1
394	181.89	94.56	100	0	1
395	182.82	94.41	100	0	1
396	221	99.20	100	0	1
397	216.05	98.80	100	0	1
398	216.3	98.76	100	0	1
399	218.33	98.87	100	0	1
400	218.83	98.58	100	0	1

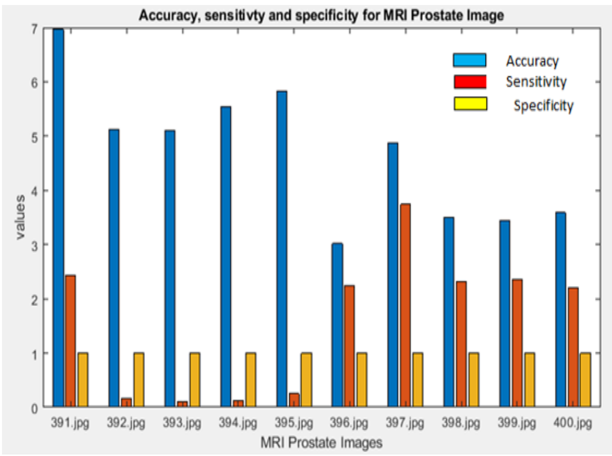

Fig. 11 Parameters for region growing technique for MR prostate images

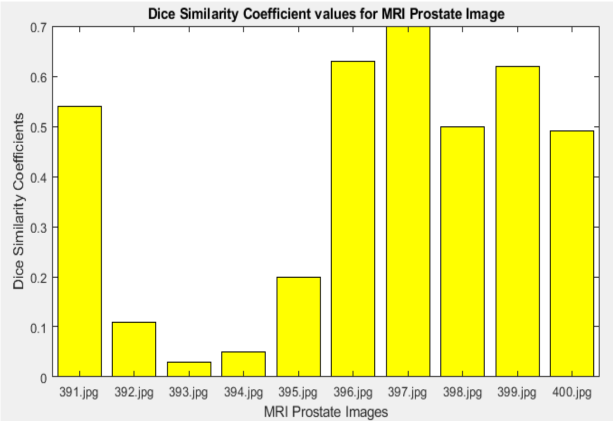

Fig. 12 Parameters for region growing technique for MR prostate images

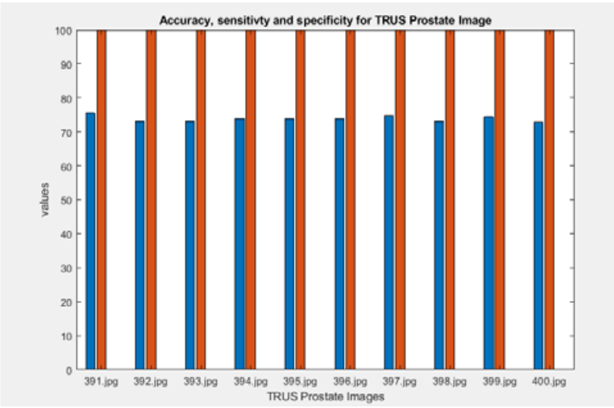

Fig. 13 Performance parameters for clustering technique for TRUS prostate images

4. Conclusion

Prostate cancer region extraction using manual seeded region growing technique and unsupervised cluster-based technique has been implemented. The performance parameters for each of these techniques presented and are compared. The size of an extracted region from the TRUS and MR prostate image depends upon the starting seeding point. The region grows along the seed point computing the nearby similar pixel data elements present in an image. The cluster technique generates the new small clusters and their centroids and produces small regions of similar image pixel data sets. It is concluded that the region extraction using the automatic unsupervised k-means cluster technique is efficient and more accurate than manual seed point region growing.

Acknowledgment

The authors would like to express gratitude to Bharati Vidyapeeth Medical College, Pune, for providing and an accurate delineations of trans-rectal ultrasound prostate images and MR images. we would also like to thank our colleagues for reviewing my work and providing very useful comments and suggestions.

References

[1] Sedelaar, J., JJMCH de la Rosette, Beerlage, H., Wijkstra, H., Debruyne, F., and Aarnink R.: *Transrectal ultrasound imaging of the prostate: review and perspectives of recent developments*. In: Prostate Cancer and Prostatic Diseases (1999) 2, 241-252 (1999)

[2] Ghosh, S., Olivera, A., Mart, R., Xavier L., Joan C., Vilanovac, Freixeneta, J., Mitraa, J., Sidibeb, D., Meriaudeaub, F.: *A Survey of Prostate Segmentation Methodologies in Ultrasound, Magnetic Resonance and Computed Tomography Images*. In: Preprint submitted to Computer Methods and Programs in Biomedicine, Elsevier April 11, (2012)

[3] Wang, Y., Dou, H., Xiaowei H., Zhu, L., Yang, X., Xu,M., Jing Q., Heng, P., Wang, T., Ni, D.: *Deep Attentive feature for prostate segmentation in 3 D Transrectal Ultrasound*. In: IEEE Transaction on Medical Imaging, arXiv 1907.01743v1 [eess.IV], Jul 3, (2019)

[4] Geng L., Li, S., Xiao, Z., and Zhang, F.: *Multi-Channel Feature Pyramid Networks for Prostate Segmentation, Based on Transrectal Ultrasound Imaging*. In: MDPI, Appl. Sci. 2020, 10, 3834, (2020)

[5] Ricardo Alonso Castillejos-Molina., MD., Fernando Bernardo Gabilondo- Navarro., MD.: *Prostate cancer*. In: Instituto Nacional de Ciencias M´edicas y Nutrici´on Salvador Zubir´an. Ciudad de M´exico, M´exico, vol. 58, no. 2, March-April (2016)

[6] Saini, K., Dewal, M., and Rohit, M.: *Ultrasound Imaging and Image Segmentation in the area of Ultrasound: A Review*. In: International Journal International Journal of Advanced Science and Technology Advanced Science and Technology Advanced Science and Technology Vol. 24 Vol. 24, November, (2010)

[7] Borges, V., Cristina, F., de, Oliveira., Silva, G., Fellow, Armando A., Hamann B.: *Region Growing for Segmenting Green Microalgae Images*. In: Journal of Latex Class files, Vol. 13, No. 9, September (2014)

[8] Erwin, Saparudin, Nevriyanto, A., Purnamasari, D.: *Performance Analysis of Comparison between Region Growing, Adaptive Threshold and Watershed Methods for Image Segmentation*. In: Proceedings of the International Multiconference of Engineers and Computer Scientists 2018 Vol I, IMECS 2018, March 14-16, 2018, Hong Kong (2018)

[9] Grinias, I., Mavrikakis, Y., and Tziritas.: *Region Growing Color Image Segmentation Applied to Face Detection*. In: Department of Computer Science, University of Crete

[10] Huang, Q., Sun, Y., Huang, L., and Zhang, P.: *The liver CT image sequence segmentation based on region growing*. In:5th International Conference on Advanced Engineering Materials and Technology, AEMT, (2015)

[11] Rahmani, Md., Pal, N., and Arora, K.: *Clustering of Image Data Using K-Means and Fuzzy K-Means*. In: (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 5, No. 7, (2014)

[12] Viji, A., and Jayaraj, L.: *Modified Texture, Intensity and Orientation Constraint Based Region Growing Segmentation*

of 2D MR Brain Tumor Images. In: The International Arab Journal of Information Technology, Vol. 13, No. 6A, (2016)

[13] Caponetti, L., Castellano, G., and Corsini.: *MR Brain Image Segmentation: A Framework to Compare Different Clustering Techniques*. In: MDPI, Information ,8, 138, (2018)

[14] Zhu, S., and Yuille.: *Region Competition: Unifying Snakes, Region Growing and Bayes/MDL for Multiband Image Segmentation*. In: IEEE Transactions on Multi Pattern Analysis and Machine Intelligence, Vol. 18, No.9 September (1996)

[15] Senthil, Kumar, K., Venkatalakshmi, K., and Karthikeyan, K.: *Lung Cancer Detection Using Image Segmentation by means of Various Evolutionary Algorithms*. In: Hindawi Computational and Mathematical Methods in Medicine Volume 2019, Article ID 4909846 (2019)

[16] Bora, D., Gupta, A.*: A Novel Approach Towards Clustering Based Image Segmentation*. In: International Journal of emerging Science and Engineering (IJESE) ISSN: 2319–6378, Volume-2 Issue- 11, September (2014)

[17] Bala, A., Sharma, A.: *Color Image segmentation using K-means Clustering and Morphological Edge Detection Algorithm*. In: International Journal of Latest Trends in Engineering and technology (IJLTET)

[18] Hamada, M., Kanat, Y., Abiche, A.: *Multi- Spectral Image Segmentation Based on the K-means Clustering*. In: International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-9 Issue-2, December (2019)

[19] Kesavaraja, D., Balasubramanian, R., Rajesh, R., and Sasireka, D.: *Advance Cluster Based Image Segmentation*. In: ICTACT Journal on Image and Video Processing, Volume: 02, Issue: 02, November (2011)

[20] Chena, Z., Qib, Z., Menga, F., Cuic, L., Shi, Y.: *Image Segmentation via Improving Clustering Algorithms with Density and Distance*. In: ScienceDirect (ELSEVIER), Information Technology and Quantitative Management (ITQM 2015), Procedia Computer Science 55 1015 – 1022, (2015)

[21] Dhanachandra, N., and Chanu, Y.: Image *Segmentation Method using K-means Clustering Algorithm for Colour image*. In: Advanced Research in Electrical and Electronic Engineering, p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 2, Issue 11 July- September pp. 68-72, (2015)

[22] Bora, D., and Gupta, A.: *A Novel Approach Towards Clustering Based Image Segmentation.* In: International Journal of Emerging Science and Engineering (IJESE), ISSN: 2319–6378, Volume-2 Issue- 11, September (2014)

Kiran Ingale received the B.E degree in Electronics and telecommunication from the North Maharashtra University, Jalgaon, India, in 2002 and M. Tech degree in Electronics and Telecommunication from the College of Engineering, Pune, Maharashtra, India, in 2008. He is currently working toward the Ph.D.at Savitribai Phule Pune University, Pune, Maharashtra, India. He is currently with Vishwakarma Institute of Technology, Pune as Assistant Professor from 2007 from onward, having total experience 13 years. His research interests include medical image analysis, image processing, segmentation and classification.

Dr. Pratibha Shingare was born on May 27th, 1976. She obtained her B.E, M.E, and Ph. D. (2009) in Electronics and Telecommunication from Pune University. She worked as a Lecturer in Private Engineering Colleges for seven years. She worked as a Professor of Electronics and Telecommunication in Maharshi Shikshan Sansthans Cummins College of Engineering for Women for two years. She joined Government College of Engineering Pune (COEP) from 2003 onwards, having total teaching work experience of 22 years. She awarded Prof. S. V. C. Ayyaya Scholarship for her Ph. D work. She published various papers in International Journals, International conferences and National conferences including transactions on IEEE Transactions on Pattern Analysis and Machine Intelligence, IEEE Transactions on Wireless Communications, International Federation of Automatic Control, Springer Proceedings etc. She is Reviewer for many international conferences, few journals. She is life member of ISTE. She visited Poland, Spain, and UK under academic linkages. She completed ISRO sponsored project Digital Elevation Model (DEM) Fusion as Principal Investigator.

Dr. Mangle Mahajan received the M.B.B.S degree from D. Y Patil Medical College, Kolhapur, Maharashtra, India. He also received DMRD and DNB. He is member of National Academy of Medical Sciences. Now he is working as a Professor, Department of Radiology, Bharati Medical College and Hospital, Pune, Maharashtra, India.