An Image Segmentation Using Improved FCM Watershed Algorithm and DBMF

Rupinder Kaur and Er. Garima Malik
Global Institute of Management and Emerging Technology, Amritsar, 143501, (Pb.) India
Email: rksheen@hotmail.com, garimamalik@ymail.com

***Abstract*—Image segmentation and evaluation are awfully not easy but significant tribulations in computer vision. In this article we have presented an improved FCM Watershed Algorithm for image segmentation. In this techniques, Decision based median filter used for noise removal, is best for salt and pepper noise reduction. Secondly, Fuzzy C-Means used for cluster selection and for final segmentation modified watershed segmentation used is integrated with FCM. The aim of this method is reduce the number of segments after proposed method and to overcome problem faced by this method which is over-segmentation and noise sensitivity. Computer simulations verify extensive improvement of this proposed method with existing methods in terms of PSNR, SSIM, CQM, MSE, RMSE and BER. These experimental results computed on MATLAB software with Image Processing toolbox.**

***Index Terms*—image segmentation, fuzzy C-means, watershed segmentation, decision based median filter, dynamic thresholding, morphology operation and masking**

I. Introduction

Image segmentation is most significant task in image processing is the middle layer of image engineering. Segmentation is important role of processing an image for dividing it into number of constituent regions or categories by assigning label to each and every pixel of an image which correspond to different objects or parts of objects so that each region may give information regarding an object or area of interest [1] and produces a binary image where pixel value "1" for object and "0" for background. All subsequent interpretation tasks, such as object recognition and classification, rely heavily on the quality of the segmentation process. There are varieties of applications of image segmentation such as the field of filtering noise from image, medical imaging, and locating objects in satellite images and in automatic traffic control systems, machine vision in problem of feature extraction and in recognition [2]. Different techniques are available to facilitate the performance of image segmentation such as pixel based, edge based, cluster based, region based, model based, color based and hybrid [3]. Amongst of them, watershed transform technique is commonly used in recent years for image segmentation.

In this research work, we are giving importance on the image segmentation with watershed segmentation. , it is a proposed method, which uses Decision based Median Filter, Fuzzy C-Means and Watershed Algorithm shown in Fig. 1.

Figure 1. Proposed method

II. Decision Based Median Filter

Median filters are the best filters for salt and pepper noise removal [4]. Decision based algorithms are used in median filters for more enhancements in filtering at high noise density as well. Decision based median filters [5] are used for this purpose. In this case, corrupted image is processed pixel by pixel and corrupted pixels are replaced with median value as formulated below:

If central pixel $P(m,n,k)$ in window is

$$0< P(m,n,k)<255) \quad (1)$$

Then its value is not changed.

$$\text{If } P(m,n,k) = 0 \text{ or } 255 \quad (2)$$

Then it is a corrupted pixel.

III. Improved Fuzzy C-Means

Fuzzy C-Means also call ISODATA is data clustering method. where each data points belonging to a cluster to a degree described by membership value [6]. FCM is used in many applications such as classification, segmentation, recognition etc. unlike K-means clustering method. Its performance is based on initial cluster centers and also suffers from noise and outliers. FCM algorithm allocates pixels to fuzzy clusters without labeling. Unlike the hard clustering methods otherwise also called as k-means clustering which force pixels to belong entirely to one class where this improved FCM allows pixels to belong to numerous clusters with changeable degrees of

Manuscript received November 2, 2014; revised January 14, 2015.

doi: 10.12720/joig.2.2.106-112

membership. Because of the additional flexibility, FCM called as Soft clustering method [7]. Fuzzy C cluster centerc_i, i = 1,…c. are calculated with following equation [8]:

$$C_1 = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}} \quad (3)$$

IV. Modified Watershed Algorithm

It is the most powerful method used for segmentation due to its advantages like simplicity, speed and complete division of an image. It is based on morphology operations. This method is similar with region growing method; it begins with Growing process from every regional minimum value and each creates single region after transform. It combines together both similar and dissimilar properties efficiently. It works very well when it distinguishes background location and foreground object in an image [9], [10].

The foremost disadvantage of watershed method is over-segmentation, very sensitive to noise and high computational complexity those make it unsuitable for real-time process [11].

To overcome over-segmentation, Adaptive threshold, adaptive masking, N-dimensional convolution, impose minima for morphological processing with watershed algorithm used called Modified Watershed Transform.

V. Related Research

Vijay Jumb *et al*. (2014) [12] described in his work on color image segmentation with K-Means clustering and Otsu's Adaptive thresholding in which foreground objects and background objects were differentiated clearly. Comparative results taken over Fuzzy C-means, Region growing and Hill climbing k- means and ensures accuracy and quality of various colored images.

Pinaki Pratim Acharjya *et al*. (2014) [13] advocated an valuable image segmentation approach for noisy images using Median filter and Morphology operations with watershed algorithm. statistical results taken to support this new approach of median filtering and morphological segmentation of noisy digital colored images on metrics PSNR, Entropy and MSE.

Rabul H. Lasker *et al*. (2013) [14] described a approach for removal of high density salt and pepper noise from colored image with Linear filter of variable window size (3x3, 5x5,7x7 and so on). Computer simulation had completed with verification of metrics like PSNR and Visual quality for improvements in this analysis.

Deepali Aneja *et al*. (2013) [15] revealed fuzzy c-means clustering that used only intensity values of clusters and compared with methods such as Fuzzy C-Means, Intuitionistic Fuzzy C-Means , and Type-II Fuzzy C-Means. it's main focus was on two images from by Bacteria and CT scan brain image. From bacteria image, clustering differentiates the bacteria from the background whereas from brain CT scan image, clustering is used to identify the abnormality region.

Ashraf Afifi *et al*. (2012) [16] presented a hybrid approach by joining together Fuzzy K-Means, Seed Region growing. This proposed method used intensity and automatic information for segmentation of medical images in variety of tissue types basically GM and WM. Its goal is to measure grey and white matter with sensitivity and specificity giving accurate and stable result and results taken over MRI images with higher robustness for discriminating regions.

Ashwin kumar (2011) [17]worked on new framework for color image segmentation with watershed algorithm using color image segmentation of automatic seed region growing on the basis of region with the combination of watershed algorithm. Its goal was to have an advantage of universal property and better treatment effects on colored images as well.

Yi Hong *et al*. (2009) [18] proposed a decision based median filter that replaced each noisy pixel with k-nearest noise free pixels. Experimental results were taken over four images and shown the effectiveness of this proposed approach. Along with comparison with AMF, SMF, RMF on varying noise density.

Yong Yang *et al*. (2007) [19] presented a novel extended FCM algorithm for image segmentation to overcome the noise sensitiveness of conventional Fuzzy C-means clustering algorithm. It was used by changing the objective function with penalty term of FCM, where penalty term behaved as regularizer in this approach.

VI. Objectives

The main objectives of our study emphases on Image segmentation using improved FCM Watershed algorithm and the DBMF are:

- To combine these three methods which provide best results individually and to check whether they provide best results together or not.
- To improve image filtering process by using DBMF.
- To improve the image segmentation and to reduce over -segmentation by integrating the decision based mean filter with integrated FCM watershed segmentation to enhance the results further.

VII. Proposed Method

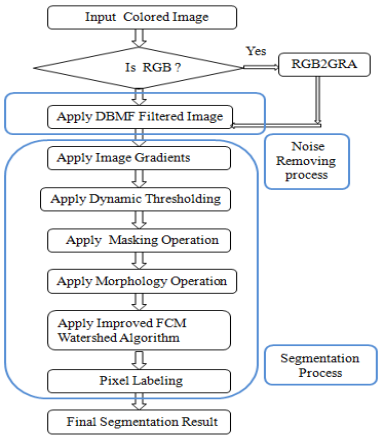

Figure 2. Flow chart

In this proposed approach, given steps are included to enhance the performance of image segmentation with FCM and Watershed segmentation more.

VIII. Simulation Results

In this section, Simulation results of Improved FCM Watershed Algorithm are taken over different images of different format and size are simulated in MATLAB software with image processing toolbox. Proposed method is compared with Region growing, Fuzzy C-Means and Watershed transform. Well, when we observe these images from different techniques. all methods gives different areas of segmentation depending upon image intensity, colour, shape etc. and results dissimilar segmentation depending upon their criterion.

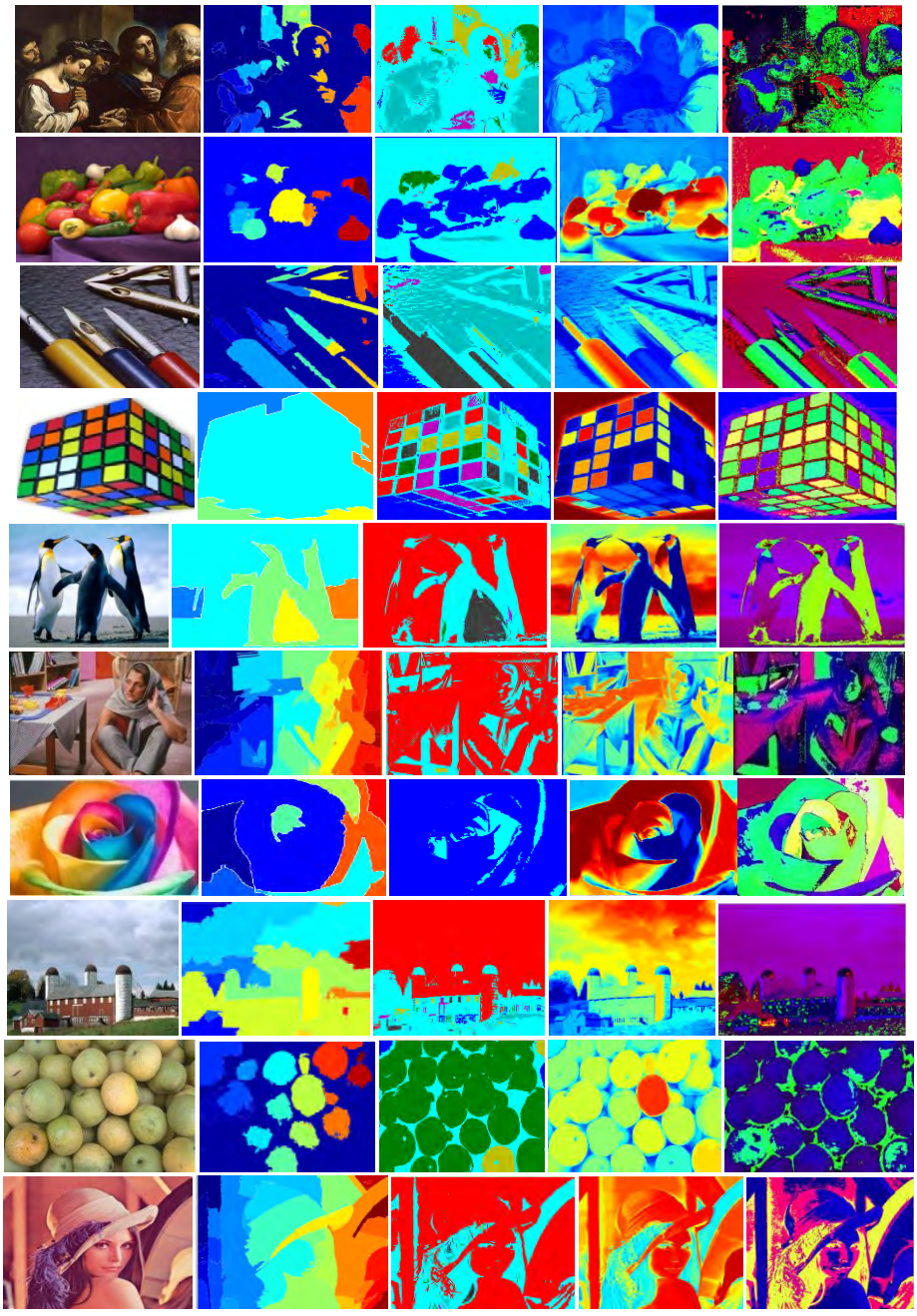

Figure 3. Comparison of existing methods with proposed method.

Fig. 3 shown the outcomes are fairly efficient with quite improved results than the existing methods. So this method has shown comparatively imperative improvement above presented methods.

IX. Performance Evaluation

This is the major section of this research paper that depicts that this existed proposed method is the best

method than available methods of image segmentation. Performance is measured over the

Parameters: PSNR, SSIM, CQM, MSE, RMSE, and BER.

TABLE I. PEAK SIGNAL TO NOISE RATIO

Test Images	RG	FCM	MWA	Proposed
People	33.2541	33.8540	33.8448	59.7896
Pepper	27.0193	30.5989	30.5989	57.4258
Pens	29.9347	32.8922	32.8783	66.3203
Dice	28.6150	31.7638	31.7537	75.1298
Lady	31.7908	31.7987	38.7725	60.1561
Penguins	29.0697	31.8909	31.8865	56.2985
Flower	29.1112	30.7824	30.7753	60.1519
Building	29.9347	31.3466	31.3413	54.8458
Pears	26.7280	31.0705	31.0611	55.8004
Lena	30.3946	30.3956	34.7720	58.9931

TABLE II. STRUCTURAL SIMILARITY INDEX MEAN

Test Images	RG	FCM	MWA	Proposed
People	0.0795	0.0036	0.0046	0.0949
Pepper	0.0476	0.0036	0.0051	0.2275
Pens	0.0786	0.0054	0.0035	0.1521
Dice	0.0117	0.0310	0.0134	0.0652
Lady	0.0519	0.0039	0.0028	0.1198
Penguins	0.1144	0.0944	0.1007	0.3825
Flower	0.0682	0.0968	0.0719	0.2599
Building	0.0104	0.0067	0.0054	0.5438
Pears	0.1213	0.0062	0.0032	0.2560
Lena	0.0041	0.0047	0.0807	0.2395

TABLE III. COLOR QUALITY MEASURE

Tested Images	RG	FCM	MWA	Proposed
People	31.5202	35.3934	35.3679	43.0743
Pepper	30.1234	31.8972	31.8953	36.5432
Pens	33.6079	34.3464	35.3254	41.4128
Dice	32.5286	32.5517	32.5416	42.4047
Lady	33.3501	33.1453	34.1356	37.0586
Penguins	31.6739	31.7275	31.7232	36.1205
Flower	32.1562	32.2901	32.2827	39.2833
Building	30.5256	31.8606	31.8584	33.7705
Pears	30.5201	32.1101	33.1060	34.7483
Lena	30.5976	32.5312	32.5329	39.6195

TABLE IV. MEAN SQUARE ERROR

Tested Images	RG	FCM	MWA	Proposed
People	30.9793	27.0003	27.0397	0.0688
Pepper	130.1810	57.0936	57.0939	0.0564
Pens	66.5283	33.6715	33.7790	0.0153
Dice	90.1531	43.6620	43.7630	0.0020
Lady	8.6942	43.3922	43.3111	0.0632
Penguins	81.1908	42.4425	42.4053	0.1537
Flower	53.6511	54.7317	54.8211	0.0633
Building	58.0591	48.0644	48.1228	0.2148
Pears	139.2140	51.2193	51.3299	0.1724
Lena	61.8416	59.8303	59.8444	0.0826

TABLE V. ROOT MEAN SQUARE ERROR

Tested Images	RG	FCM	MWA	Proposed
People	5.5659	5.1944	5.2000	0.2623
Pepper	11.4097	7.5560	7.5561	0.3443
Pens	8.1565	5.8027	5.8120	0.1237
Dice	9.4949	6.6077	6.6154	0.0448
Lady	2.9486	6.5812	6.5872	0.2514
Penguins	9.0106	6.5117	6.5150	0.3920
Flower	7.1201	7.3981	7.4041	0.2516
Building	7.6197	6.9328	6.9371	0.4634
Pears	11.7989	7.1568	7.1645	0.4152
Lena	4.6735	7.7350	7.7359	0.2875

TABLE VI. BIT ERROR RATE

Tested Images	RG	FCM	MWA	Proposed
People	0.0301	0.0295	0.0295	0.0167
Pepper	0.0370	0.0314	0.0327	0.0174
Pens	0.0334	0.0304	0.0304	0.0151
Dice	0.0349	0.0311	0.0315	0.0133
Lady	0.0258	0.0314	0.0315	0.0166
Penguins	0.0344	0.0311	0.0314	0.0178
Flower	0.0230	0.0325	0.0325	0.0166
Building	0.0328	0.0319	0.0319	0.0182
Pears	0.0374	0.0322	0.0322	0.0179
Lena	0.0288	0.0329	0.0329	0.0170

From all the Tables I, II, III, IV, V and VI, it is evident about the efficient results of proposed method are obtained for all the images of different size and format.

We observed higher values for PSNR, SSIM, CQM and lower values for MSE, RMSE and BER than all available methods, whereas these metrics are mandatory to get an image quality.

X. Comparative Analysis

Comparison of proposed method is well described from above tables individually. Whereas only the one image "People" is to be regard as comparison with all metrics in Table VII.

TABLE VII. Parametric Comparison over Image "People"

Parameters	RG	FCM	MWA	Proposed
PSNR	33.2541	33.8540	35.3679	59.7896
SSIM	0.0795	0.0036	35.3679	0.0949
CQM	31.5202	35.3934	35.3679	43.0743
MSE	30.9793	27.0003	27.0397	0.0688
RMSE	5.5659	5.1944	5.2000	0.2623
BER	0.0301	0.0295	0.0295	0.0167

Following Fig. 4, 5, 6, 7, 8, 9 also gives comparatives results over proposed method than other methods of segmentation.

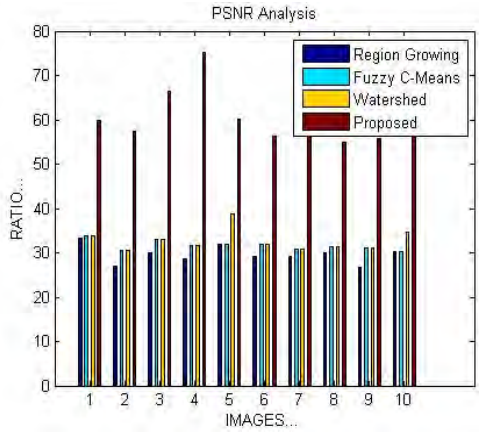

Figure 4. Peak signal to noise ratio

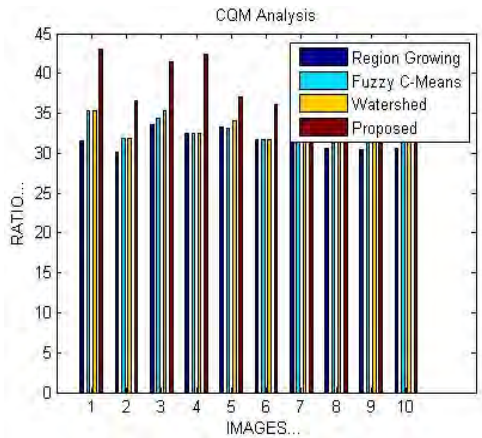

Figure 5. Color quality measure

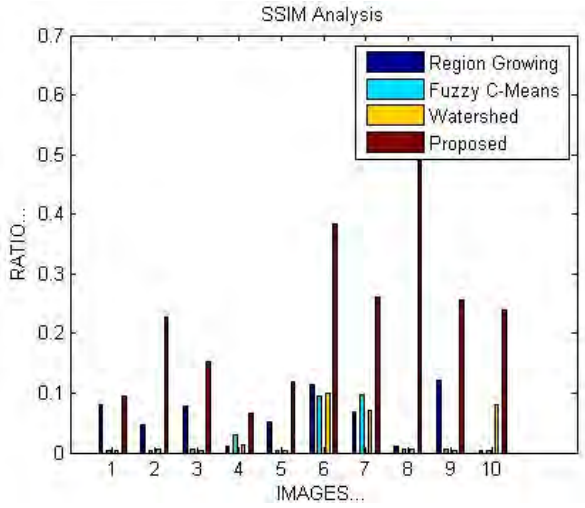

Figure 6. Structural similarity index mean

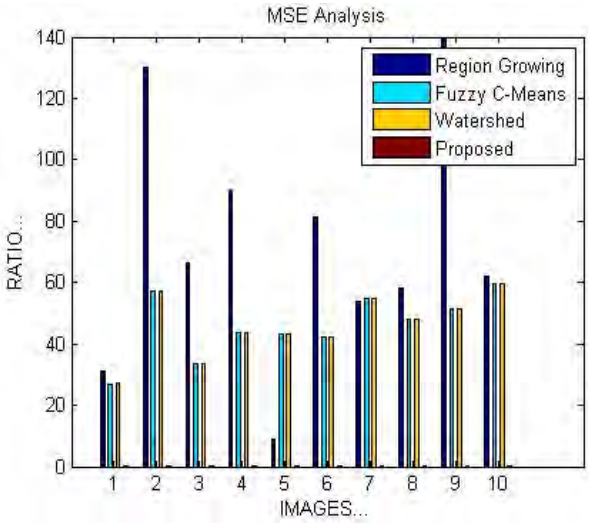

Figure 7. Mean square error

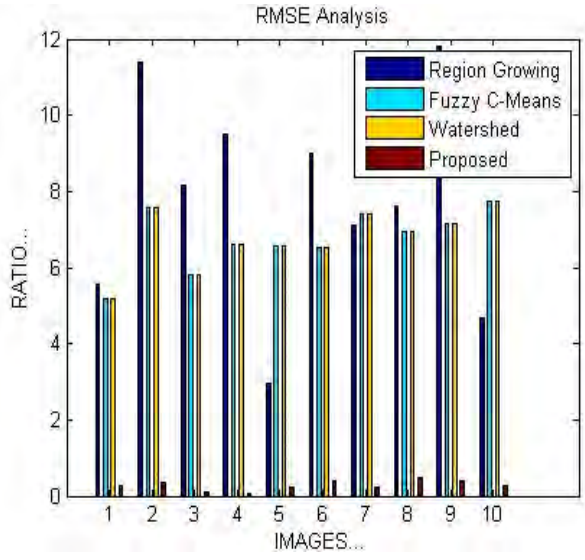

Figure 8. Root mean square error

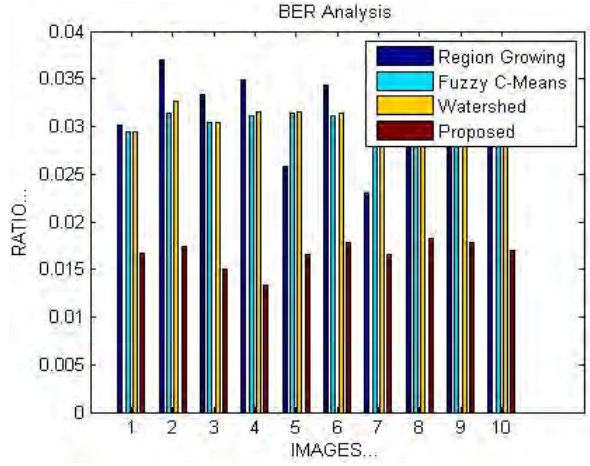

Figure 9. Bit error rate

A. *Comparitive Analysis of DBMF with Other Filtering Methods*

In comparative analysis, All existing filters has shown that the DBMF is quite effective among others and shows better results at 90% noise level as well.

TABLE VIII. PSNR AT DIFFERENT NOISE LEVELS OF TESTED IMAGE "PEOPLE"

Noise Density	Noisy Image	Median Filtered	Relaxed Median filter	Mean Filtered	DBMF
10	15.291	25.675	25.554	31.796	31.796
20	12.235	24.186	24.888	29.380	29.380
30	10.468	21.273	23.88	27.486	27.561
40	9.226	17.906	21.908	25.70	25.929
50	8.270	14.663	18.656	23.914	24.494
60	7.469	11.957	15.028	21.836	23.038
70	6.808	9.773	11.851	19.593	21.493
80	6.223	7.938	9.12	16.607	19.618
90	5.708	6.450	6.934	12.912	17.189

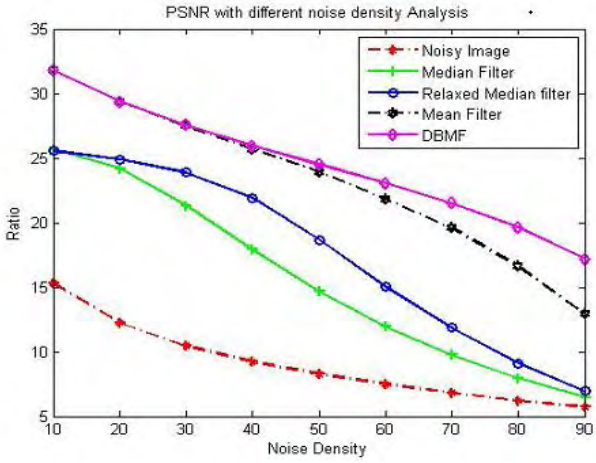

Figure 10. PSNR at different noise levels of tested image("People")

XI. CONCLUSION

Image segmentation is proposed in this thesis report. In this study, Decision based median filter is used for noise filtering and integrated with Improved FCM Watershed algorithm. Final segmentation is performed with Improved FCM Watershed algorithm. In performance analysis, it is clear that DBMF is best for Salt and Pepper noise filtering on different sizes or format of images and Improved FCM Watershed algorithm perform better than available methods such as Region growing, FCM, Modified watershed algorithm in terms of Image Quality Assessments: PSNR, SSIM, CQM and Accuracy measurements: MSE, RMSE, BER. This approach is implemented in MATLAB Software and tested on Barkley Database and on standard images. This method appears to be good also in case of speed and reduction of over segmentation. From experimental results, we can conclude that this proposed algorithm yield best results than the existing methods. In future work, this proposed method can be implemented on 3D images and for Image retrieval, segmentation and DBMF filtering can be more improved with other methods.

REFERENCES

[1] F. K. Siddiqui and V. Richhariya, "Efficient image segmentation approach through enhanced watershed algorithm," in *Proc. International Conference on Recent Trends in Applied Sciences with Engineering Application*, 2013, vol. 4.

[2] I. Singh and D. Kumar, "Performance evaluation of the masking based watershed segmentation," *International Journal of Computational Engineering Research*, vol. 4, 2014.

[3] I. Singh and D. Kumar, "A review on different image segmentation techniques," *Indian Journal of Applied Research*, vol. 4, 2014.

[4] P. Patidar and M. Gupta, "Image De-noising by various filters for different noise," *International Journal of Computer Applications*, vol. 9, 2010.

[5] A. Bhatia, "Decision based median filtering technique to remove salt and pepper noise in images," in *Proc. ITR International Conference*, 2013.

[6] M. C. J. Christ and R. M. S. Parvathi, "Segmentation of medical image using clustering and watershed algorithms," *American Journal of Applied Sciences*, 2011.

[7] A. A. Funmilola , O. A. Oke, T. O. Adedeji, O. M. Alade, and E. A. Adewusi, "Fuzzy k-c means clustering algorithm for medical image segmentation," *Journal of Information Engineering and Applications*, vol. 2, 2012.

[8] P. Sivasangareswari and K. S. Kumar, "Fuzzy c-means clustering with local information and kernel metric for image segmentation," *International Journal of Advanced Research in Computer Science & Technology*, 2014.

[9] I. Singh and D. Kumar, "A review on different image segmentation techniques," *Indian Journal of Applied Research*, vol. 4, 2014.

[10] U. Mittal and S. Anand, "Effect of morphological filters on medical image segmentation using improved watershed segmentation," *International Journal of Science & Engineering Technology*, vol. 4, 2013.

[11] H. Tan, Z. Hou, X. Li, R. Liu, and W. Guo, "Improved watershed algorithm for color image segmentation," in *Proc. Automatic Target Recognition and Image Analysis*, 2009, SPIE 7495,

[12] V. Jumb, M. Sohani, and A. Shrivas, "Color image segmentation using K-Means clustering and Otsu's adaptive thresholding,*"International Journal of Innovative Technology and Exploring Engineering*, vol. 3, 2014.

[13] P. P. Acharjya, S. Mukherjee, and D. Ghoshal, "Segmentation using median filtering and morphological approach,"

International Journal of Advanced Research in Computer Science and Software Engineering, vol. 4, 2014.
[14] R. Laskar, K. Banerjee, and D. Basak, "Removal of high density salt and pepper noise from color images through variable window size," in *Proc*. *International Conference on Circuits, Power and Computing Technologies*, 2013.
[15] D. Aneja and T. K. Rawat, "Fuzzy clustering algorithms for effective medical image segmentation," *International Journal of Intelligent Systems and Applications*, vol. 5, 2013.
[16] A. Afifi, "A hybrid technique based on combining fuzzy k-means clustering and region growing for improving gray matter and white matter segmentation," *International Journal of Advanced Computer Science and Applications*, vol. 3, 2012.
[17] A. Kumar and P. Kumar, "A new framework for color image segmentation using watershed," *International Institute for Science, Technology and Education*, vol. 2, 2011.
[18] Y. Hong, S. Kwong, and H. Wang, "Decision based median filter using K-Means noise free pixels," in *Proc*. *IEEE International Conference on Acoustic , Speech and Signal Processing*, 2009.
[19] Y. Yang and S. Y. Huang, "Image segmentation by fuzzy C-Means clustering algorithm with a novel penalty term," *Computing and Informatics*, vol. 26, 2007.

Rupinder Kaur completed her Bachelor of Technology B.Tech and pursuing Master of Technology M.Tech from Global Institutes of Management and Emerging Technology Amritsar, India.

Garima Malik received her Bachelor of Engineering B.E and completed Master of Technology M.Tech from Punjabi University Patiala, India. Presently she is working as Assistant Professor in Global Institutes of Management and Emerging Technology Amritsar, India.

