Development of Noise free hybrid segmentation approach in MRI Processing

Kimmi Verma, Shabana Urooj, Ritu Vijay

Abstract: ***Brain tumor is the second most common reason of the death happening in humans. The growing field of image processing consistently allows living organs and organisms to be explored non-invasively. The aim of this paper is to highlight the presence of noise in a MR image, kind of noises and their effects. The development of hybrid segmentation followed by filtering technique for high variation of noise in MR images is done. For further analysis removal of noise plays a key role in processing the information of an image. Various Filters such as Mean filter, Median Filter, Adaptive filter are examined and applied for the removal of Gaussian Noise, Salt and Pepper Noise, Speckle noise and are also compared in terms of RMSE and PSNR values.***

Index Terms: ***MR Image, Gaussian Noise, Salt and pepper Noise, Speckle Noise, Adaptive Filter, Mean Filter, Median Filter, RMSE, PSNR.***

I. INTRODUCTION

In the growing field of Science and technology, with all latest medical diagnostic aids comprehensive explanation of medical image is a challenging task in terms of time and accuracy during diagnosis. Focusing on brain tumor growth prediction, the task becomes more challenging due to abnormal color and shape of tumor region. In order to fulfil the need of an hour, correct interpretation of data with more accuracy in terms of a robust method is required. Previous work of many researchers considered limited noise in an image. Considering that images with large variation of noise is being taken for the analysis purpose. Successful treatment of brain tumor is only possible if there could be early detection of brain tumor using computer aided techniques for tumor analysis [5]. The performance of the computer aided techniques for early detection of brain tumor can be improved with the development of noise free hybrid segmentation approach in tumors. Information can be extracted through MR image if image is noise free. The main objective of this paper is to identify the best filtering technique in noise varying MR images. Best filtering technique can be achieved on the basis of two statistical parameters RMSE (Root Mean Square Error) and PSNR (Peak Signal to Noise ratio).

II. PROCESSING

Processing is performed on the MR image after removal of brain surface. It involves de-noising which is done with the help of de-noising filters.

A. *De-noising*

During the transmission and reception of signals, unwanted signals also transmitted with it known as noise. De-noising is performed to improve image quality. In case of image as data to be transmitted or received, the major factors that affect the amount of noise are light levels and temperature sensing sensors. During the process of transmission, input images get corrupted easily due to the interference present in the system path used for signal transmission. To extract the desired inputs from images, the removal of noise is the preliminary step [1].

B. *Types of Noises*

There may be multiple type of noises present in an image as unwanted information existing that degrades the content of information. The process of noise removal depends largely on the type of noise present. Images are corrupted in the form of noise functions like Gaussian noise, Impulse noise, Speckle noise. These Noise types are described as below:

i. Gaussian Noise

Gaussian noise is modelled as statistical noise that can be described as probability density function in the form of normal distribution and further termed as Gaussian distribution.

ii. Impulse Noise

Impulse noise is triggered by sudden, sharp disorders in the data transmission of the image and appears as randomly scattered black or white or both pixels over the image. An image containing impulse noise will have dark pixels in bright regions and vice versa. Hence it is alternatively called as salt & pepper noise [4]. This noise type can be caused by non-responsive pixels, analogue to digital converter errors or any other error in signal transmission.

iii. Speckle Noise

Speckle noise affects all multiple characteristics of imaging which are required for easy deciphering of image, including ultra sound imaging. It is caused by coherent processing of background scattered signals from many distributed targets. Speckle noise mainly spreads due to uneven texture that may contains some relevant information. In medical field, visual interpretation is more important of those images that contains noise before filtering [9]. As after filtering, information contained with noise may get lost. Thus, it becomes essentially important to develop such filters which can

Revised Manuscript Received on June 12, 2019.

Kimmi Verma, Department of ECE, GGSIP University, Delhi Technical campus, Greater Noida, India.
Shabana Urooj, School of Engineering, Gautam Buddh University, Greater Noida, India.
Ritu Vijay, Department of Electronics, Banasthali University, Rajasthan.

remove noise efficiently and can preserve the features which are important for the radiologists for diagnosis.

III. DE-NOISING FILTERS

When the research in the field of image processing started, the primary tools used for image enhancement and restoration were the linear filters. Linear filters are considerably simple and were easy to design and implement. However, with development in this field new methods and tools were developed to remove noises from the images. Filtering tools are used in this work for noise removal are described as below:

A. Mean filter

It is the simplest filter to design and quite easy for implementation for image noise reduction. They reduce noise in an image by reducing the intensity within pixels this filter also smoothens the image.

B. *Median Filter*

Median filter is more computed than mean filter and is used for preserving important detail of the image. This filter considers one pixel as central pixel, its neighboring pixels and its surroundings for selection of filtering value for the image [2]. The filtering value is calculated using median of surrounding pixels instead of mean value, this process is repeated for each pixel. The median of the value is calculated by sorting the value of surrounding pixels in ascending order.

C. *Adaptive Filter*

Adaptive filters are those filters which changes their based on the image characteristics for the selected filter region. The performance of noise is calculated using mean and variance. During the process, it preserves the details of the image.

D. *Wavelet Transform*

In wavelet transform filtering, energy of signal is concentrated in small number of co-efficient. This can be done to identify the coefficients with high signal to noise ratio (SNR). After this, coefficients with low SNR can be remove and image is reconstructed using inverse wavelet transform [7].

E. *Partial Differential Equation*

Partial differential equation (PDE)-based method is another efficient method to remove the noise from an image. This method employs numerical calculative approach. The most important technique in this method is curve propagation. It can be used in various applications like object abstraction in an image, object tracking in an image, stereo reconstruction, etc.

IV. STATISTICAL PERFORMANCE OF DE-NOISING FILTERS

The inherent noise present in the images also complicates the diagnosis. In order to improve the diagnosis, noise is removed from the image by applying de-noising filters. After noise removal, segmentation is applied on the images.In order to evaluate the performance of various filters with respect to different types of noises, experimental calculation is performed on brain tumor images from dataset. The main objective of this comparative analysis is to identify the most optimum filtering technique and the parameters selected for performance evaluation are Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR) [2]. The values of RMSE and PSNR are calculated using the formulae given below,

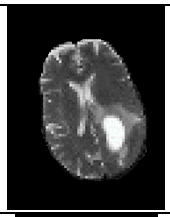
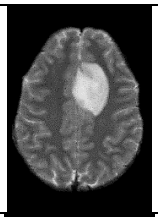
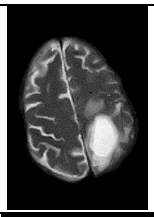
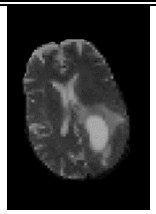
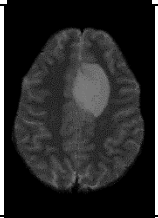
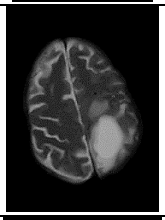
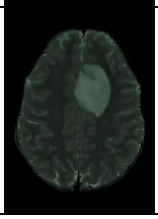
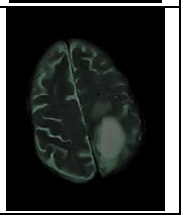
$$RMSE = \frac{\sqrt{\sum(f(a,b)-g(a,b)^2}}{pq} \quad \text{.....} (1)$$

$$PSNR = 20log\frac{255}{RMSE} \quad \text{.....} (2)$$

Here, function f (a, b) is the original brain image pixel with noise and g (a, b) is the new enhanced image pixel and p and q are the calculated number of pixels in the 2D Cartesian coordinates system of the image. Lower value of RMSE depicts the improved and enhanced of image without significant alteration in it and the high PSNR value indicates the better filtering technique.

V. RESULTS

It is clearly interpreted that Root Mean Square Error (RMSE) values provide quantitative interpretation of filter performance. Peak Signal to Noise Ratio (PSNR) values provide qualitative interpretation of filter performance.Dataset of three images is used here for the process of filtering by different filtering techniques and it is clearly evident that adaptive filter is giving best results and RMSE, PSNR values validates the results.In fig.1.images are from three datasets. Image1 is Di-Com image.Image2 is from brainweb dataset.Image3 is from MRI Laboratory.These images are analysed step by step wise to remove the noise in the best possible way.

	Image1	Image2	Image3
Pre-processed Image			
Mean Filtered Image			
Median Filtered Image			

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

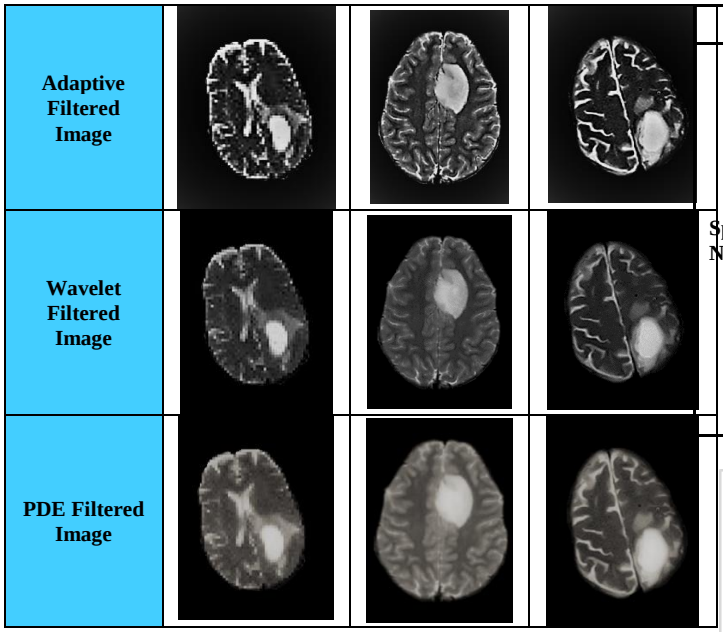


Fig.1. Step wise description of image for best filtering technique.

The results of comparative study for RMSE and PSNR values are tabulated in table 1 and graphically represented RMSE values in figure 2 to 5 and PSNR values are graphically represented in figure 6 to 9.The dataset used here considers images with variation of noise .In applications , where data is being collected from remote areas, due to fluctuation sin electric power disturbances in the form of attenuation gets added in diagnostic machines. These disturbances reforms the characteristic features of an image. To avoid this, filtering techniques are discussed and analyzd.

TABLE I

REPRESENTATION OF FILTER PERFORMANCES IN DIFFERENT RANGE OF FREQUENCIES

Type of Noise	Type of Filter	Noise Level	10%	30%	50%	70%
Gaussian Noise	Mean Filter	RMSE	27.95	73.93	111.37	148.43
		PSNR	19.20	10.75	7.20	4.70
	Median Filter	RMSE	27.84	75.77	111.51	145.44
		PSNR	19.24	10.54	7.18	4.88
	Adaptive Filter	RMSE	21.27	62.74	91.26	118.07
		PSNR	21.58	12.18	8.93	6.69
	WT Filter	RMSE	27.65	74.04	107.46	139.44
		PSNR	19.30	10.74	7.51	5.24
	PDE Filter	RMSE	27.24	73.86	107.48	139.64
		PSNR	19.43	10.76	7.50	5.23
Impulse Noise	Mean Filter	RMSE	21.19	67.33	96.43	124.21
		PSNR	21.61	11.57	8.45	6.25
	Median Filter	RMSE	20.79	64.64	94.02	121.68
		PSNR	21.77	11.92	8.67	6.43
	Adaptive Filter	RMSE	14.65	52.12	77.54	100.87
		PSNR	24.81	13.79	10.34	8.06
	WT Filter	RMSE	20.33	63.89	93.19	120.85
		PSNR	21.97	12.02	8.74	6.49
	PDE Filter	RMSE	20.49	64.50	93.90	121.70
		PSNR	21.90	11.94	8.68	6.43
Speckle Noise	Mean Filter	RMSE	26.43	70.61	98.49	125.56
		PSNR	19.69	11.15	8.26	6.15
	Median Filter	RMSE	24.57	68.23	97.61	125.91
		PSNR	20.32	11.45	8.34	6.13
	Adaptive Filter	RMSE	18.48	59.17	81.10	103.39
		PSNR	22.80	12.69	9.95	7.84
	WT Filter	RMSE	22.31	66.97	95.82	123.56
		PSNR	21.16	11.61	8.50	6.29
	PDE Filter	RMSE	24.61	69.19	97.52	124.92
		PSNR	20.31	11.33	8.35	6.20

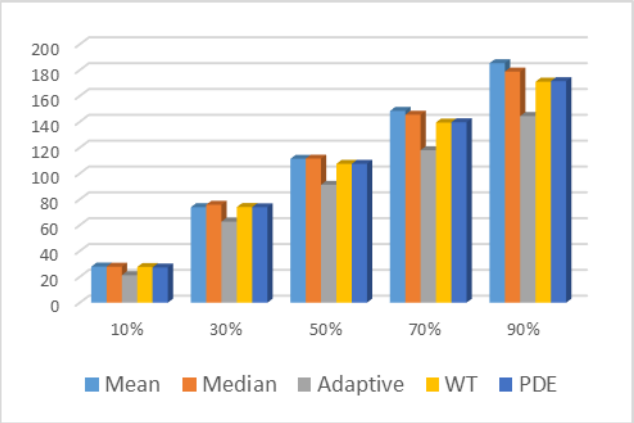


Fig. 2. Comparison of RMSE values for Gaussian noise, de-noised by Mean, Median, Adaptive, WT and PDE filters

Figure 1 above shows that RMSE values of Gaussian noise with different filters. It is noted that with low noise images, results of all filters are similar. However, for images with high noise, Adaptive filter works better as compared to other de-noising filters.

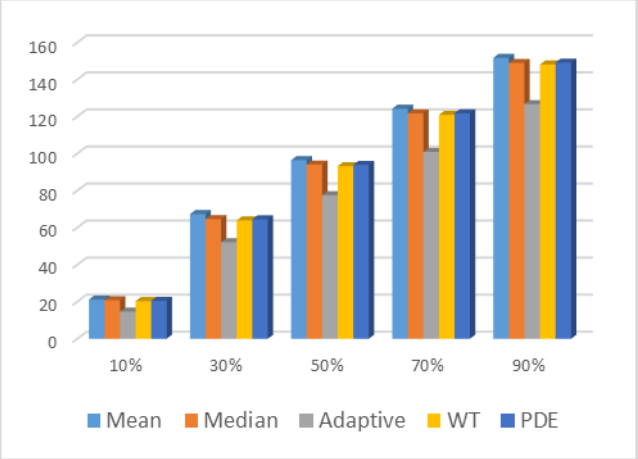


Fig. 3.Comparison of RMSE values for Impulse noise, de-noised by Mean, Median, Adaptive, WT and PDE filters

Figure 3 indicates that RMSE values of Impulse noise with different filters. Adaptive filter is found as most efficient filter among all other filters for noise varying from 10% to 90% in MR Images.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

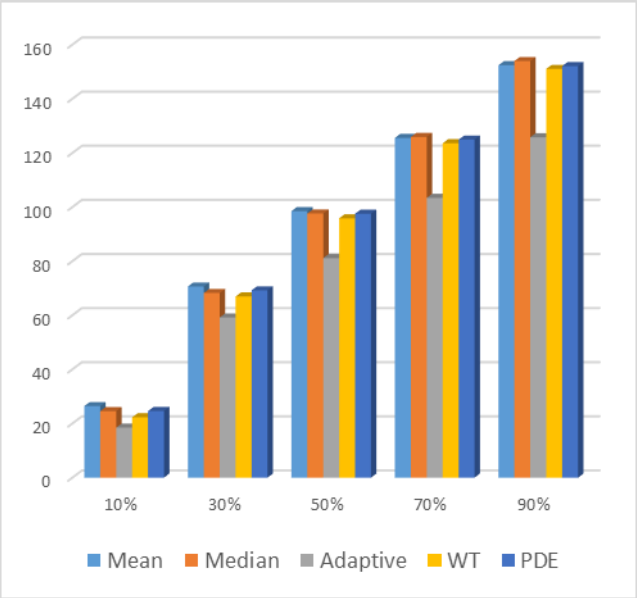


Fig. 4. Comparison of RMSE values for Speckle noise, de-noised by Mean, Median, adaptive, WT and PDE filters

Figure 4 represents the performance of various filters for Speckle noise with noise level varying from 10% to 90% in MR Images. It is noted that at 90% noise level, RMSE values for all noise filters, except Adaptive filter, is above 150, whereas the same for Adaptive filter is below 140, which indicates that Adaptive filter performs better with Speckle Noise.

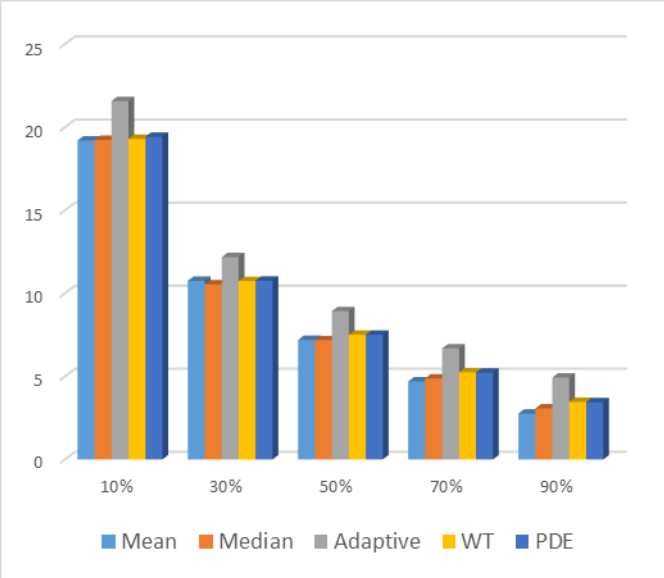


Figure 5: Comparison of PSNR values for Gaussian noise de-noised by Mean, Median, Adaptive, WT and PDE filters

Figure 5 above shows that Peak Signal to Noise Ratio values for Gaussian noise with Adaptive filter are highest among all the filters, which indicates that Adaptive filter performs better than Mean, Median, Wavelet & PDE filters for different intensity of noises.

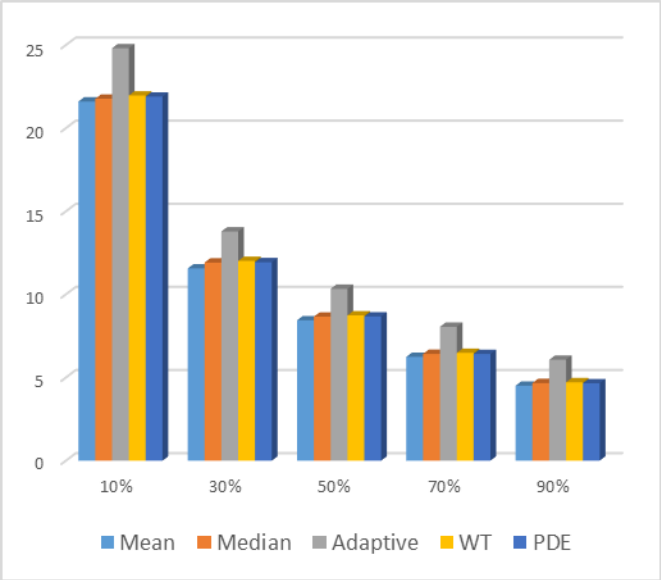


Figure 6: Comparison of PSNR values for Impulse noise de-noised by Mean, Median, Adaptive, WT and PDE filters

Figure 6 indicates that for Impulse noise levels ranging from 10% to 90%, Peak Signal to Noise Ratio values for Adaptive filter are found to be better than that of other filters.

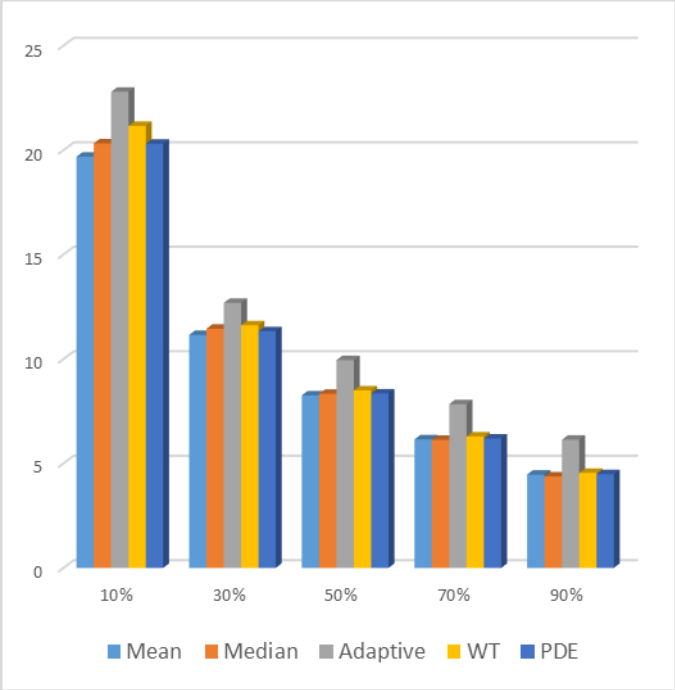


Figure 7: Comparison of PSNR values for Speckle noise de-noised by Mean, Median, Adaptive, WT and PDE filters

Figure 7 presents the performance of various filters over Speckle Noise. It is noted that the PSNR values of Adaptive filter over entire range of Noise spectrum are highest indicating that Adaptive filter performs better than other filters.

VI. CONCLUSION

Based on the above, tables and graphs, it is observed that each filter perform differently on different type and on different level of noise like 10 % , 70%. However, Adaptive filter, by modifying slightly the filtering method in Kernel sides of the image components, are able to adjust themselves to local attributes and structures of the image and hence performs better than other de-noising filters for Gaussian Noise, Impulse Noise as well as Speckle Noise. Such de-noised image will be further used for segmentation purpose and for the extraction of tumor.

REFERENCES AND FOOTNOTES

1. S. Vaishali, K. Krishan Rao,“ A review on noise reduction methods for brain MRI images”, International Conference on Signal Processing and Communication Engineering Systems, IEEE xplore, (2015).
2. Verma Kimmi, Rituvijay ,Shabana urooj, , “Extraction of Brain tumor attributes using Contourlet Transform with geometric transform Invariant technique”, International Journal of Pure and Applied Mathematics, Volume 114 No. 12, 119-125, (2017).
3. Verma Kimmi, Rituvijay ,Shabana urooj, , “Comparative statistical parametric analysis of braintumor images using contourlet transform and Fuzzy C-means clustering algorithm”, International Journal of Engineering Trends and Technology (IJETT) , Volume 49 Number 7, July,(2017).
4. Thiago Vallin Spina ; Paulo A. V. de Miranda; Alexandre Xavier Falcão,” Hybrid Approaches for Interactive Image Segmentation Using the Live Markers Paradigm” , IEEE transactions on image processing, Volume 23, Issue 1,(2014)
5. Verma Kimmi, Shabana urooj, Rituvijay, “Qualitative Analysis of Brain Imaging and Mapping Techniques”, International Journal of Scientific research, (2016).
6. M. Gudmundsson, E. A. El-Kwae, M. R. Kabuki. “Edge detection in medical images using a genetic algorithm”. IEEE transactions on medical imaging. Vol 17, pp: 64-72, (2012).
7. Pham, D. , Xu, C. and Prince, J. L. “A survey of current methods in medical image segmentation”, Annual Review of Biomedical Engineering, vol. 2, pp. 315–337,(2000).
8. S. Thilagamani and N. Shanthi; “A Survey on Image Segmentation through Clustering” International Journal of Research and Reviews in Information Sciences Vol. 1, No. 1, March (2011).
9. Zhubin SunXiaodong, Lizhu Wang,” A hybrid segmentation method for multivariate time series based on the dynamic factor model”, springer link, vol 31, Issue 6, pp 1291-1304 Aug 17.

ABOUT AUTHORS:

Ms. Kimmi Verma is working as faculty in department of Electronics & Communication Engineering. She has submitted her Ph. D Thesis in Electronics Engineering and has done her M. Tech in Microelectronics & B. Tech in Electronics and Instrumentation Engineering. She is a Class A certified Professional in Robotics under MHRD project ‘E-yantra’ from IIT Mumbai. She has teaching experience of more than 14 years in engineering academics. She has published several research papers in reputed international journals and is an author of book titled “Analog and Digital Electronics” with University Science press.

Dr. Shabana Urooj is presently a faculty member of Electrical Engineering Department, School of Engineering, Gautam Buddha University Greater Noida UP, India. She has received her Ph. D degree from Jamia Millia Islamia (A Central University) and M. Tech. and B. E from Aligarh Muslim University. She has more than 14 years of teaching and 03 years of industrial experience. She has published more than 70 papers in international and national journals and conferences. She is presently servicing academics since last 15 years by editing and reviewing reputed journals. She has been Associate Editor of IEEE Sensors Journal, reviewing IEEE Transactions of Instrumentation & Measurement, Elsevier’s reputed journals, ACTA Press journals etc. Dr. Shabana is recipient of Young Associate Professional Membership Award from American Ceramic Society, U S A. Biomedical Instrumentation, Computer Aided diagnosis of life threatening diseases is major area of her interest and Optimization & Control. She is actively involved in IEEE activities for professional and technical development of students and faculty members. She is life member of ISTE and member of CSI.