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An Ingenious Segmentation Application for Brain Lesion Detection in Multimodal MR Images

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Abstract— Automatic segmentation and detection of brain disease is a disreputably complicated issue in Magnetic Resonance Image (MRI). The similar state-of-art segmentation methods and techniques are limited for the detection of brain disease in multimodal brain MRI. Thus this research work deals with the accurate segmentation and detection of brain diseases in multimodal brain MRI and this research work is focused on improve automatic segmentation results. This work analyses the segmentation performance of existing state-of-art method improved Fuzzy C-Means Clustering (FCMC) method and marker controlled Watershed method .In our research work the proposed method is to compound segmentation results of improved Fuzzy C-Means Clustering (FCMC) method and marker controlled Watershed method to carry out accurate brain tumor detection and improved the segmentation results. The performance of proposed method is evaluated with the assorted performance metric, viz., Segmentation accuracy, Sensitivity and Specificity. The comparative performance of our Proposed Method, FCMC Method and Watershed method is demonstrated on real and benchmark multimodal brain MRI datasets, viz. FLAIR (Fluid Attenuated Inversion Recovery) MRI, T1 MRI, MRI and T2 MRI and the experimental results of the proposed method exhibits better results for segmentation and detection of brain diseases in multimodal brain MR images.

Keywords— Brain diseases, FCMC Method, Watershed Method, Proposed Method, Bilateral Filter, Brain MRI, Multimodal

I. INTRODUCTION

The Magnetic Resonance Image (MRI) presents the high soft tissue delineation compared to other medical imaging modalities and it's typically used to analyze a variety of diseases in a brain and the image segmentation is majorly used in health care system for analysis and diagnoses of various diseases in various medical applications. Segmentation and detection of brain disease from several multimodal brain MR image is a challenging task due to various factors such as brain MR image generated from diverse scanners with diverse configurations and also the brain disease like Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea varies from intensity varies to healthy tissues and with their shape, size and location is specific to patient.
With the considerable advance in the brain MRI methods have exposed the wide possibilities of brain anatomy analysis based on multimodal Brain MR Images.

The MRI imaging is typically used in the various biomedical applications to diagnose a variety of diseases, to visualize the inner formation of the brain and to detect brain diseases like Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea. MRI technique detects and presents the extreme variations in the soft tissues as compared to other medical imaging techniques. Multimodal Brain MR Images presents the noninvasive broad visualization of internal anatomical understanding of the brain. In order to improve the accuracy for detection of the tumor in multimodal Brain MR Images, the imaging techniques have extended the quality of the Brain MR images. Hence the exploration of this complex and high quality Brain MR Images became the major tedious task for the technicians[1]. Moreover, due to the human intervention the investigations are bound to be mistaken. Also these manual analyses are a lot of time-consuming and restricted in discovering of brain disease like Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea in multimodal Brain MR Images as compared with the computerized methods [1].

Fuzzy C-Means Clustering (FCMC) is most accepted method under unsupervised technique which has been effectively used in many applications and several areas like clustering, segmentation, etc. but a few limitations are present for traditional FCMC Method. Hence, over last few decades, some improvements have been proposed to FCMC method and only FCMC method is not enough to obtain a

better segmentation and detection of Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea diseases in multimodal brain MR images. The typically used method for analysis of MR images is segmentation based imaging in clinical analysis. Image segmentation is repeatedly used for measuring and visualizing the brain's anatomical structures, for analyzing brain changes, for picturing pathological regions, and for surgical planning and image-guided.

2. LITERATURE SURVEY

J.L.Marroquin et al.[2] emphasize the significance of 3D segmentation of brain MR scans. It uses separate parametric models for the strength of each class. The brain map is employed with a healthy registration procedure to find non-rigid transformation to map the standard brain to the specimen to be segmented. This transformation is further used to segment brain from non-brain tissues, computing prior probabilities and finding automatic initialization and finally applying MPM (Maximization of the Posterior Marginal) -MAP algorithm to find out optimal segmentation. Major findings from the study show that the MPM-MAP algorithm is comparatively robust than EM in terms of errors while estimating the posterior marginal. For optimal segmentation, the MPM-MAP algorithm involves only the solution of linear systems and is consequently computationally efficient.

M.G DiBono et al. [3] emphasized that a complete methodology is required to explore the feasibility of the SVR kernel-based approach for tremendously complex regression problem. The authors have addressed this problem by adopting a method modeled as a multiphase process, i.e., preprocessing phase and a prediction phase. The authors created a virtual environment to gain subjective feature and objective measures, and then FMRI(Functional Magnetic Resonance Image) data was collected for predicted separately. After applying SVM (Support Vector Machine) regression, it was tuned with the help of applying statistical measures to achieve enhanced performance and generalizability. Generalization makes an algorithm simple to use in real-world applications. However, other statistical techniques such as sorting, distributions (chi-square, binomial) can be used to achieve more accuracy. Moreover, the virtual environment has its own limitations and special considerations that sometimes lead to inaccuracy.

Shi et al.[5] employed neural networks for medical image processing, including the key features of medical image preprocessing, segmentation, and object detection and recognition. The study employed Hopfield and feed-forward Neural Networks. The feed-forward and Hopfield Neural Networks are simple to use and easy to implement. The added advantage of Hopfield Neural Networks is that it does not require pre-experimental knowledge. The time required to make your mind up image processing jam is considerably reduced by using trained neural network.

Padole and Chaudhari [6] proposed an efficient method for brain tumor detection. One of the most important steps in tumor detection is segmentation. A combination of two standard algorithms, like mean shift and the normalized cut is performed to detect the brain tumor surface area in MRI. Pre-processing step is first performed by using the mean shift algorithm in order to form segmented regions. In the next step region nodes clustering are processed by Ncut method. In the last step, the brain tumor is detected during component analysis. Segmentation results will not be accurate if the tumor edges are not sharp, and this case occurs during the initial stage of the tumor. The Texture-based method is proposed in this work. Beside with brain tumor recognition or deduction, segmentation is also done automatically using this method. The proposed texture analysis and seeded region method was implemented in MATLAB environment using 25 MRI images by kumar and mehta[2011]

Anandhakumar and Meenakshi and [8] emphasized that MRI is helpful for analyzing brain images since of its high-accuracy rate. Detection of the brain tumor has become a challenging task. Most of the existing techniques used machine learning techniques to detect brain tumor, but still they are suffered by the wrong diagnosis. The proposed technique combines the clustering and classification algorithm to minimize the error rate. Segmentation task is performed using ortho normal operators and classification using BPN. Images having the tumor are processed using K-means clustering and significant accuracy rate of 75% is attained.

3. Proposed Method

The primary objective behind this research work is the accurate segmentation and detection of tumor in multimodal Brain MR Images, viz., FLAIR MRI, T1 Weighted and T2 Weighted. To achieve the objective of MR image segmentation, this work is proposed a method that merges the results of most established improved Fuzzy C-Means Clustering(FCMC)Method and marker controlled watershed method. The FCMC and Watershed segmentation methods are applied on the given MR image and then acquired results are optimally unified using proposed method to achieve the higher automatic segmentation accuracy.

The visual representation of brain imaging results in multimodal images such as T1 Weighted, T2 Weighted and FLAIR MRI. Hence, this research work focused on improvement of automatic segmentation accuracy and detection of disease in multimodal brain MR Image's with proposed method. The block diagram for this research work

is shown in [Figure–1] and this work is equipped with the bilateral filter [12] for smooth edges and for the better segmentation of multimodal brain MR Images and detection of brain diseases. The core framework of presented approach has been demonstrated in [Figure–4].

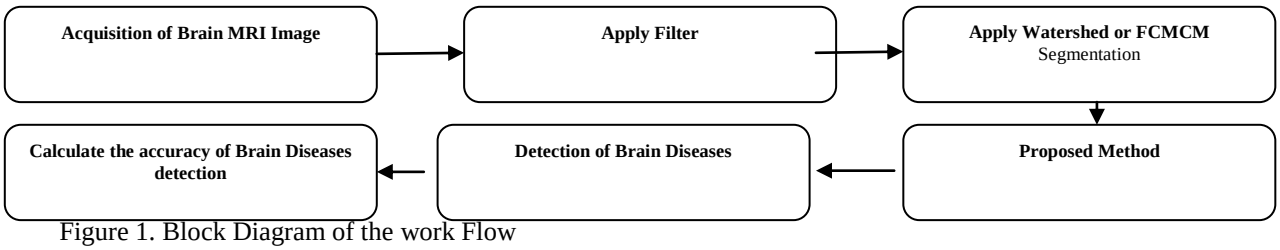

Figure 1. Block Diagram of the work Flow

Proposed Framework

Development of best possible incorporated framework to amalgamation of segmented regions of existing state-of-the-art brain disease segmentation methods Fuzzy C-Means Clustering (FCMC) method and Watershed method.

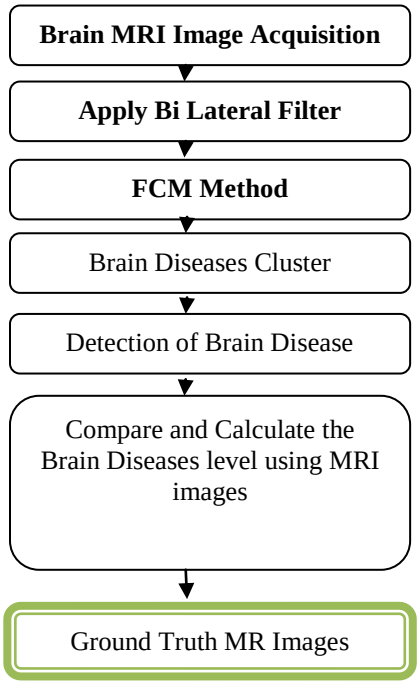

Figure :2 FCMC Method for automatic segmentation and detection of Brain Diseases in Multimodal MRI Images

FCMC method [8-10] [13] is unsupervised automatic segmentation methods and it plays vital role for segmentation and detection of anomalies in brain MR images and it accelerate the MRI segmentation process and FCMC method frame works is shown in[Figure-2]. The drawback of FCMC method is the less segmentation accuracy for the detection of anomalies in multimodal brain MR images. The watershed method [5-7][15] is described as morphological gradient based segmentation for this work and the minimal watershed method is illustrated in [Figure – 3].The objective of the watershed algorithm [1-2][4][13] is to improve the accuracy of the image segmentation, Watershed algorithm is depicted in [Figure-3].

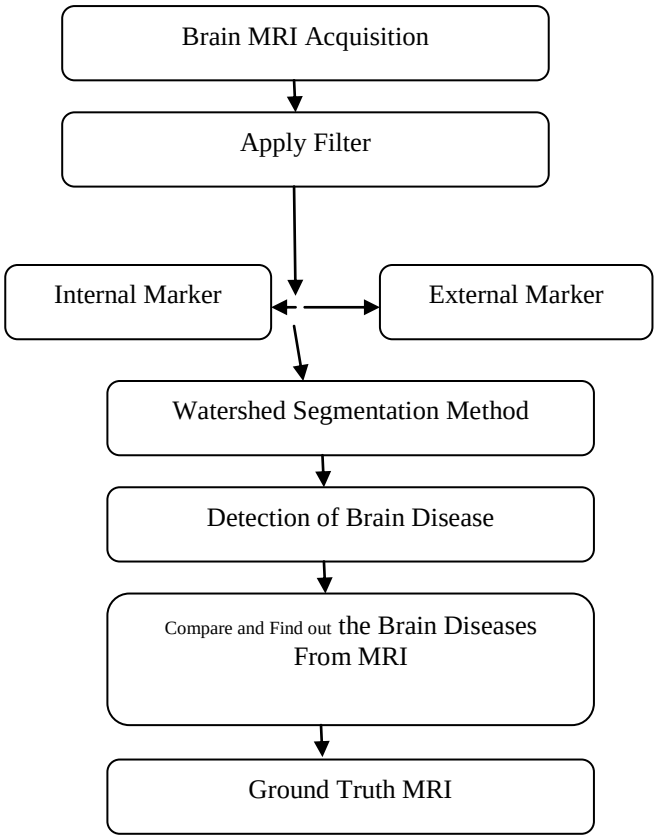

Figure 3: Watershed Segmentation method framework for automatic Segmentation and find out the Brain Diseases in Brain MRI.

The existing most accepted brain diseases segmentation methods Fuzzy C-Means Clustering (FCMC) method and Watershed Method (WM) exhibits the limited segmentation accuracy for the detection of diseases in multimodal brain MR images. The proposed framework [Figure–4] for automatic segmentation and detection of diseases in multimodal brain MR Image overcome the existing limitations of segmentation accuracy.

The major focus of the proposed method is to enhance the segmentation results of disease detection in multimodal brain MRI by finest merging [11] of segmented regions of Watershed method and FCMC methods. The Proposed method is equipped with the bilateral filter[12] to improve the MRI edges for better segmentation.

Algorithm for Proposed Method

In the proposed method, the finest sets of segments are uniquely divided and similar segmented regions results are merged and finally whole regions are identified and considered with the brain regions detected with brain diseases. The algorithm for proposed method is illustrated below.

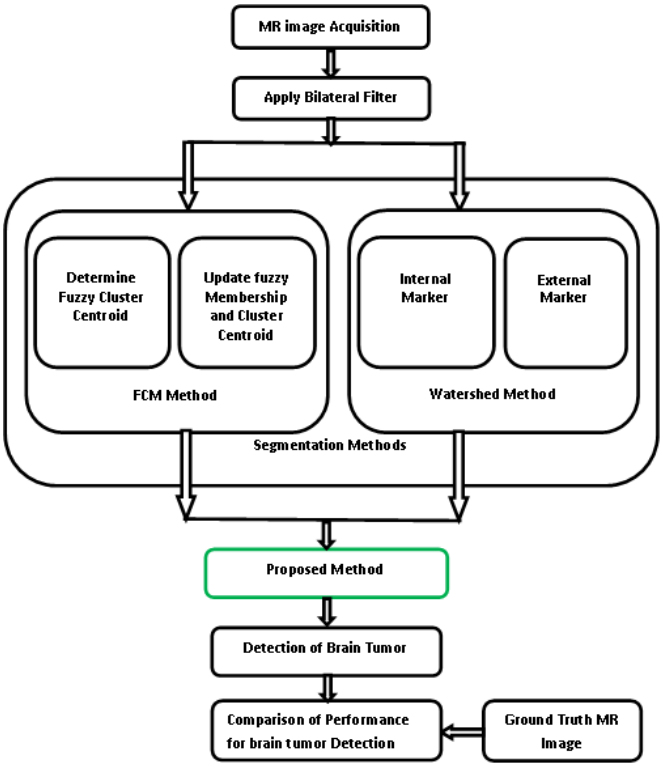

Figure.4. Proposed Method Framework for automatic segmentation and detection of Brain Image in multimodal Brain MR Images.

Input: water_seg and fc are the segmentation results from Water shed and FCMC segmentation methods respectively.

Step 1; Find out the number of region for water_seg and fc and store in a and b respectively.

water_seg →a,fc→b

Step 2: copy the image water_seg and fc into seglist1[a] and seglsit2[b]. Repeat the same process till a+b, where a+b mentioned the size of the seglist arrays.

Seglist1[a]← water_seg

Seglsit2[b]← fc

Step 3: Compare all the seglist1[a] and seglist2[b] to find the affected region.

[seglist1[a]] a,b , [seglist2[b]]a,b

Step 4: If seglist1[a] and segleist2[b] are same, then store the segmented region into the seglist1, seglist2 from water_seg and fc also.

[water_seg]ai,bi → seglist1;

[fc]ai,bi→ seglist2;

Step 5: Compare all the segment from seglist1 and seglist2 to find out the same type of regions using similarly index.

Steps 6: Determine the total regions from step4 and step5.

Flow of Proposed Method:-

The proposed method for detection of diseases in multimodal brain MRI procedure is described as follows:

1. Proposed method takes an input of segmented regions of FCMC method and Watershed method.
2. It determines and stores a total number of segmented brain MRI regions from FCMC method and Watershed method.
3. Identify and store the unique segmented regions from FCMC method and Watershed method.
4. Identify the similar segmented regions from FCMC method and Watershed method. If the regions are nearing neighbors and then merges the regions.
5. Determine the whole regions from similar and unique brain MRI regions and mark the regions with diseases.

4. RESULTS AND DISCUSSIONS

In order to demonstrate the results and theoretical construction presented in this work, we provide the MATLAB implementation of the framework to test the visual advantages of FCMC method, Watershed method and Proposed Method for the detection of diseases in multimodal brain MR images. In this research work, the performance of proposed method is evaluated with following metrics like Segmentation accuracy, Sensitivity and Specificity of real multimodal brain MRI and benchmark multimodal brain MRI datasets. The segmentation results of the real multimodal brain MRI is shown in [Figure-5] and the segmentation results of the benchmark datasets are shown in [Figure-6].

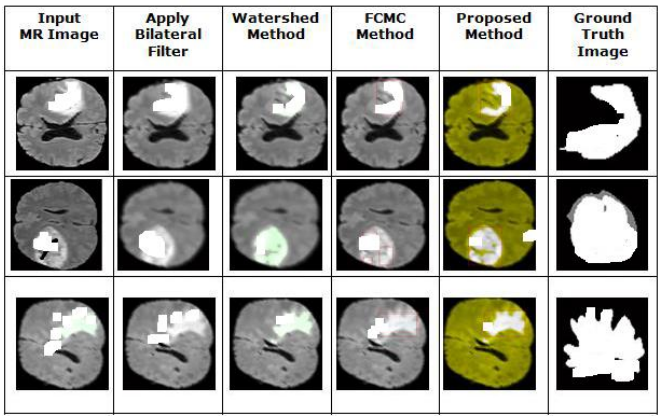

Figure.5. Automatic Segmentation and Detection of diseases in real brain MR Image.

The accuracy of FCMC Method, Watershed method and Proposed Method is measured by finding the comparison between the disease extracted from input multimodal Brain MR Images and the ground truth image of the parallel input image that is presented in the dataset. we have analyzed FLAIR MRI, T1 Weighted and T2 Weighted using performance metrics like the segmentation accuracy, sensitivity and Specificity with equation (5), (6) & (7) using FCMC method, Watershed method and Proposed method for the detection of diseases in multimodal brain MR Images. The multimodal brain MRI benchmark datasets contained the brain T1 Weighted, T2 Weighted and FLAIR MRI images along with their ground truth image. The comparative accuracy for FCMC, Watershed and Proposed Method is shown in [Table – 2] for three patient's multimodal brain MRI such as FLAIR, T1 Weighted and T2 Weighted.

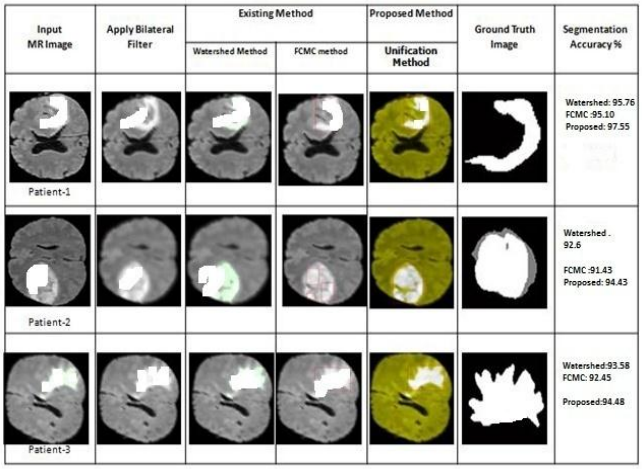

Figure.6. Automatic Segmentation and Detection of brain diseases using FCMC, Watershed and Proposed Method

The input multimodal Brain MRI dataset is segmented and performance evaluated with segmentation accuracy, sensitivity and Specificity for FCMC Method, Watershed method and Proposed Method and analysis results are depicted.

The performance analysis of segmentation results of FCMC Method, Watershed method and Proposed Method are evaluated with following metric segmentation accuracy, sensitivity and specificity on FLAIR Brain MRI dataset and experimental results are depicted in the previous paper.

Table :1 Analysis of T1 MRI

Input MRI	Performance Metrics	Watershed Method	FCMCM	Our Proposed Method
Patient-1	Accuracy in %	95.76	95.1	97.55
	Sensitivity in %	87.54	89.33	86.68
	Specificity in %	95.29	94.06	95.26
Patient-2	Accuracy in %	92.6	91.43	94.43
	Sensitivity in %	89.73	90.48	86.13
	Specificity in %	94.58	94.05	95.85
Patient-3	Accuracy in %	93.58	92.45	94.48
	Sensitivity in %	85.73	87.16	84.38
	Specificity in %	93.43	92.58	94.83
Patient -4	Accuracy in %	95.95	93.12	96.83
	Sensitivity in %	88.33	90.22	86.08
	Specificity in %	94.63	93.68	95.48
Patient -5	Accuracy in %	96.68	94.03	97.63
	Sensitivity in %	83.43	84.12	81.1
	Specificity in %	95.98	95.53	96.13
Patient -6	Accuracy in %	95.93	93.13	96.18
	Sensitivity in %	86.53	86.93	84.52
	Specificity in %	94.33	93.72	95.43
Patient -7	Accuracy in %	95.73	93.98	96.08
	Sensitivity in %	88.93	90.2	86.73
	Specificity in %	93.38	92.68	94.13

The performance analysis of segmentation results of FCMC Method, Watershed method and Proposed Method are evaluated with following metric segmentation accuracy, sensitivity and specificity on T1 Weighted Brain MRI dataset and experimental results are depicted in [Table-1].

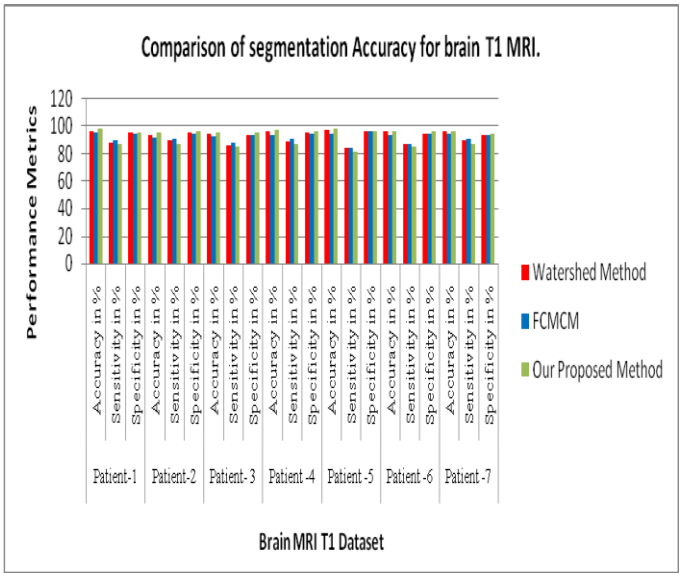

Figure 7: Performance metrics of different segmentation methods for 7 patients(T1 Dataset)

Table :2 Analysis of T2 MRI

Input MRI	Performance Metrics	Watershed Method	FCMCM	Our Proposed Method
Patient-1	Accuracy in %	94.68	94.52	96.57
	Sensitivity in %	86.46	88.75	85.70
	Specificity in %	94.21	93.48	94.28
Patient-2	Accuracy in %	91.52	90.85	93.45
	Sensitivity in %	88.65	89.90	85.15
	Specificity	93.50	93.47	94.87
	in %			
Patient-3	Accuracy in %	92.50	91.87	93.50
	Sensitivity in %	84.65	86.58	83.40
	Specificity in %	92.35	92.00	93.85
Patient -4	Accuracy in %	94.87	92.54	95.85
	Sensitivity in %	87.25	89.64	85.10
	Specificity in %	93.55	93.10	94.50
Patient -5	Accuracy in %	95.60	93.45	96.65
	Sensitivity in %	82.35	83.54	80.12
	Specificity in %	94.90	94.95	95.15
Patient -6	Accuracy in %	94.85	92.55	95.20
	Sensitivity in %	85.45	86.35	83.54
	Specificity in %	93.25	93.14	94.45
Patient -7	Accuracy in %	94.65	93.40	95.10

	Sensitivity in %	87.85	89.62	85.75
	Specificity in %	92.30	92.10	93.15

The performance analysis of segmentation results of FCMC Method, Watershed method and Proposed Method are evaluated with following metric segmentation accuracy, sensitivity and specificity on T2 Weighted Brain MRI dataset and experimental results are depicted in [Table-2].

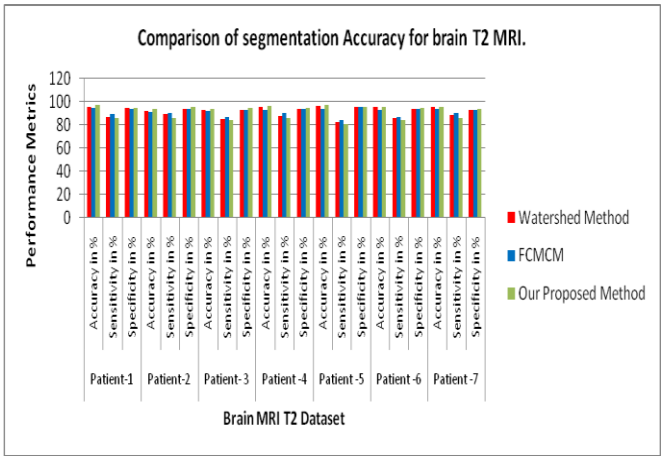

Figure 8: Performance metrics of different segmentation methods for 7 patients (T2 Dataset)

The comparative performance of the segmentation accuracy of FCMC Method, Watershed Method and Proposed Method on T2 MR Image is shown in [Figure-10].

This research work exhibits the comparative performance of the segmentation accuracy of FCMC Method, Watershed Method and Proposed Method on multimodal brain MR images, viz,. FLAIR MRI, T1 Weighted and T2 Weighted are shown in [Figure-7], [Figure-8] and [Figure-10]. The proposed method in the experimental results clearly demonstrated improved segmentation results for multimodal brain MR images.

5. **CONCLUSION**

The research work majorly focused on the performance improvement of automatic segmentation and accurate detection of brain diseases like Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea in multimodal Brain MR Images and also presented extensive analysis of the automatic segmentation methods for detection of the brain disease in multimodal Brain MR Images. The state-of-art methods for brain tissue segmentation are developed and demonstrated on multimodal brain MR images. The performance of proposed method has been evaluated on real and benchmark multimodal brain MRI datasets, viz. FLAIR MRI, T1 Weighted and T2 Weighted with following performance metric, viz., Segmentation accuracy, Sensitivity and Specificity. The proposed method in this research work demonstrated improved performance for detection of the brain diseases in multimodal Brain MR Images. The work also presented the relative analysis of Proposed Method, FCMC Method and Watershed method for segmentation of multimodal Brain MRI segmentation and detection of Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea. With the final outcome of performance development, the proposed method is efficient for automatic segmentation and detection of disease regions in Brain MR Images. This research work extends the possibilities of better segmentation and accurate detection of brain diseases like Parkinson's, Alzheimer's, Dementia, Creutzfeldt-Jakob, Tauopathies and Rosacea in multimodal MR Images.

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