

# A Novel Methodology Based on Statistical Mixture Models for Identifying Lesions

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## Abstract

Lesions, also called as convolution is a part of the disturbance caused by the electrical signals in the brain. Several models have been introduced in the literature, however this article makes an attempt to highlight the presence of the symptoms by considering bivariate features. The data is collected from the American medical association data set and the results derived are exhibiting good recognition accuracy.

**Keywords:** Lesions, electrical signals, brain activity, performance evaluation, filters, noise.

## INTRODUCTION

In spite of the technological up gradations in the area of medical field, there are still some problems which are recurrent in nature and which are still challenging. There are many models and articles, in particular having done a rigorous study about the brain activities. Amid these studies, the rate at which the diseases are surmounting is still a challenging task which needs further evaluation and insights. Among the various diseases that impact the brain include lesions, syndrome, tumors, Sclerosis, inhomogenities. Among these diseases, this article focuses in particular about the lesion disease. Lesion is a cause that is generated due to the variation of the electrical signals that are generated within the brain cells. In most of the cases, children are more sufferers and there exist no concurrent previous symptoms which help to diagnose the abnormality and which helps to overcome the diseases. Lot of literature is available and most of these surveys [1][2][3][4] are based on the studies focused towards minimizing or suggesting preventive measures that can help recurrent occurrences. Enormous reviews and architectures are presented in this area, and the conclusions are mostly focused on the EEG graph signals. The symptoms which signify this disease highlight those children suffered/suffering with high fever may be the potential candidates/subjects to get attacked by this disease. However, significant studies in the

literature showcase that even though without temperature being a factor majority are the sufferers of this disease. Therefore further strategies are to be designed to diagnose the disease effectively such that the tendency of the disease or even tending towards the disease can be minimized. In general, according to the medical history, Lesions are classified into Partial Lesions and General Lesions. The symptoms prevailing with regard to the above two types of Lesions are mostly common. However, the only differentiating factor between the two types is that, the electrical signals generated in case of partial lesions are marginally insignificant. Where as in general Lesions, the loss of electrical signals or variations in electrical signals may be at a higher range and may be witnessed at multiple places along the brain. The review literature highlights the various models presented in this direction by using many models, which in general can be classified as generative and degenerative models[5][6][7][8]. Among the degenerative models, the literature is driven mostly using the techniques of machine learning together with feature extraction.

However, as the symptoms that prevail in both the cases i.e. partial and general lesions are mostly similar, to classify these diseases one needs to have a clear distinction among the features for accurate classification. Hence, effective feature extraction models are to be developed for better analysis of the disease. Also it is necessary to underline the plausible changes of getting a disease by understanding the inherent MRI scan. In order to classify the disease more accurately, we have considered more than one feature in this proposed article, the electric signal and the symptom. Therefore, in this article a model based on Beta Mixture Models is considered, which guarantees effective identification of the disease. Fuzzy logic is considered for extracting the patterns. The results derived are compared with benchmark metrics like Average Difference, Maximum Distance, Image Fidelity. The rest of the paper highlights the Beta Mixture Model along with the updated equations generated using Expectation Maximization algorithm, the dataset considered, the methodology for fuzzy

logic for extracting the features is proposed, the experimental results together with performance evaluation metrics and the Conclusion .

### BETA MIXTURE MODEL AND EXPECTATION-MAXIMIZATION ALGORITHM

Tissues in any brain image are considered to be a collection of dense correlation coefficients. In order to accurately identify the underlying cause of the brain disease, it is necessary to compute these coefficients at different levels. Hence, in this article Beta Mixture Models is used to accurately identify the relationship among tissues. The probability distribution function of the beta mixture model is given by:

$$B(x_i, \alpha_i, \beta_i) = \sum_{i=1}^L \prod_i f_i(\mu_i | \alpha_i, \beta_i)$$

K-means algorithm is used to obtain the initial parameters of the mixture model. In order to update the initial parameters Expectation-Maximization (EM) algorithm is used. The EM algorithm works in two steps: E-Step and M-Step. The updated equations generated using EM-algorithm are given below:

$$\alpha_k^{l+1} = \frac{1}{N} \sum_{s=1}^N \frac{\alpha_k^{(l)} g_i(x_i, \theta^{(l)})}{h(x_s, \theta^{(l)})}$$

$$\beta = \frac{1}{\alpha_k} \sum_{s=1}^N [t_k(x_i, \theta^{(l)})]$$

$$\mu_i^{k+1} = [x^{\alpha_{ix-1}} (1-x)^{\beta_{ix-1}}] \cdot e^{-\left(\frac{x-\mu}{\sigma}\right)^2} [B(x_{i\mu}, x_{\mu i})^{-1}]$$

### DATASET CONSIDERED

The dataset for the proposed methodology is taken from American medical association which contains the various brain disease related images. For the training purpose 2000 samples images are taken and for testing purpose around 100 samples images are taken.

### FUZZY C-MEANS ALGORITHM FOR EXTRACTING THE FEATURES

In this article Fuzzy c-means algorithm along with beta mixture model is used for effective classification of the brain disease. Fuzzy c-means clustering algorithm is detailed below:

1. A Fuzzy pseudo-partition is initially selected.
2. Reiterate the cluster membership function.
3. Using the Fuzzy Pseudo-partition estimate the centroid such that the centroid minimizes Fuzzy SSE (Sum of Squared Error).
4. Recalculate Fuzzy Pseudo-partition until the centroids do not change.


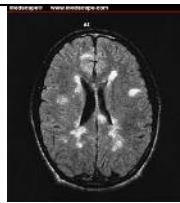
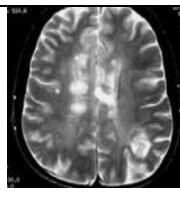
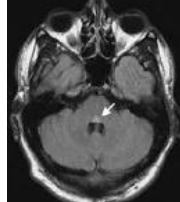

### METHODOLOGY

1. Initially the brain images are preprocessed using histogram based Gaussian elimination method.
2. Normalize the brain images.
3. Cluster the specific homogeneous groups using Fuzzy c-means algorithm.
4. Using k-means algorithm estimate the initial parameters of the model.
5. For each segment apply the finite mixture model distribution.
6. Identify the clusters exactly based on log likelihood estimate.
7. Component likelihood function is used for regrouping.
8. Metrics such as Probabilistic Rand Index (PRI), Global Consistency Error (GCE), and Variation of Information (VOF) are used to evaluate the performance of clustering algorithm.
9. Image quality metrics such as Maximum Distance (MD), Average Difference (AD), and Image Fidelity (IF) is evaluated on reconstructed images.

### EXPERIMENTAL RESULTS

The proposed model is tested using subjective and objective measures on different brain images namely B0 and B1 with sub regions named as B0S1, B1S1, B0S2, B1S2, B0S3, B1S3, B0S4, B1S4. Segmentation quality metrics such as PRI, GCE, and VOI are used to evaluate the quality of segmentation outputs. The medical images are reconstructed by obtaining the histogram of the images. The reconstructed images are evaluated using image quality metrics such as MD, AD, IF which are tabulated below:

**Table 5.1:** Quality Metrics showing the performance of GMM, BGMM-FCM

Image	Quality Metric	GMM	Finite Beta GMM with Fuzzy C-Means	Standard Limits	Standard Criteria
	Average Difference	0.82	0.82	-1 to 1	Closer to 1
	Maximum Distance	0.49	0.89	-1 to 1	Closer to 1
	Image Fidelity	0.38	0.87	0 to 1	Closer to 1
	Average Difference	0.49	0.91	-1 to 1	Closer to 1
	Maximum Distance	0.18	0.83	-1 to 1	Closer to 1
	Image Fidelity	0.36	0.89	0 to 1	Closer to 1
	Average Difference	0.68	0.832	-1 to 1	Closer to 1
	Maximum Distance	0.48	0.863	-1 to 1	Closer to 1
	Image Fidelity	0.63	0.878	0 to 1	Closer to 1
	Average Difference	0.38	0.60	-1 to 1	Closer to 1
	Maximum Distance	0.33	0.94	-1 to 1	Closer to 1
	Image Fidelity	0.37	0.811	0 to 1	Closer to 1
	Average Difference	0.33	0.829	-1 to 1	Closer to 1
	Maximum Distance	0.28	0.891	-1 to 1	Closer to 1
	Image Fidelity	0.48	0.878	0 to 1	Closer to 1

## CONCLUSION

In this article, a methodology is presented using Beta Gaussian mixture model and fuzzy c-means algorithm. The results derived are compared with existing model based on finite Gaussian mixture model. Experimentation of the proposed method is carried out in Mat lab environment and the results are compared using bench mark image quality metrics like Image fidelity, average difference, and maximum distance. The results show superior performance with respect to Image Quality metrics. In the proposed method, the edges of the images are very clearly visible as the Image Fidelity is close to 1. The developed methodology is an ideal way to analyze the details of brain images more clearly in a better way as compared to the existing models. Therefore, this model helps towards better classification of the diseases and

since for each and every image, a PDF is generated, hence basing on this PDF value also one can arrive at a conclusion about the presence or absence of the disease.

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