

**Sarah J. Mohammed**Mechanical Engineering  
Department, University of  
Technology, Baghdad, Iraq

Email:

[sarah\\_jasimm@yahoo.com](mailto:sarah_jasimm@yahoo.com)

Received on: 13/12/2017

Accepted on: 9/8/2018

Published online: 25/12/2018

## A Proposed Alzheimer's Disease Diagnosing System Based on Clustering and Segmentation Techniques

**Abstract-** Alzheimer's-disease (AD) is one of the prevalent diseases that afflict the elderly. The medical field defines Alzheimer is the destruction of brain cells so that the person loses knowledge and perception, afflict both sexes and is called dementia. The medical field often suffers from accurate diagnosis and detection of the disease in the early stages. This paper presents a diagnostic approach of Alzheimer based on K-mean clustering algorithm with Markov random field segmentation on Magnetic Reasoning Images (MRI) to build software able to help the medical staff identifying and diagnosis the disease. The experimental result shows that 91% accuracy is achieved, which demonstrate the system's reliability in the medical diagnostic environment.

**Keywords:** Alzheimer's disease, K-mean clustering algorithm, Markov random field.

**How to cite this article:** S.J.Mohammed, "A Proposed Alzheimer's Disease Diagnosing System Based on Clustering and Segmentation Techniques" *Engineering and Technology Journal*, Vol.36, Part B, No. 2, pp. 160-165, 2018.

### 1.Introduction

Alzheimer's a disease that causes brain cell death and tissue damage, when the disease is suspected, individual behavior and cognition can be registered and then brain scans for the diagnosis of disease [1].

A German psychiatrist and neurologist Alois Alzheimer, was discover Alzheimer's disease in 1906, he was found to cause a dramatic shrinkage of the cerebral cortex, emaciated brain cells, neurofibrillary tangles and senile plaques. Alzheimer's a disease classified into three stages: early, moderate, advanced relied on diagnosis time and symptoms [2].

Usually, there is a relation between aging and Alzheimer's disease, and can be distinguished as aging is associated with general healthy deterioration, such as vision, hearing, Skin health, slow memory retrieval and low in metabolic rate[3].

The aim of build a new approach is to diagnose in early stages of disease to find solutions to eliminate it before causing dementia.

MRI play an important role in the detection of Alzheimer because it shows the most accurate information with high resolution in the brain image such as cerebrospinal fluid.

### 2. Theoretical Background

There are many approaches that have been proposed for diagnose AD. Sandhya Joshi and his team proposed a new algorithm for the

classification of AD and Parkinson's disease (PD) based on selection of the most influencing features such as diabetes, age and smoking generate a set of vectors utilized within data mining and six different methods of Machine Learning (ML) for the classification. The system was tested 180 patient's records and achieved accuracy rate of 99.33% [4].

Another researcher presented a computer \_assisted\_diagnosis (CAD) implement for the early-diagnosis of the AD, utilized the Kernel\_Principal\_Component\_Analysis (PCA) aspect to feature space reduction related with Linear Discriminant Analysis (LDA). Then used Support-Vector-Machine (SVM) classifier to feature extraction training. This approach achieved up to 92.31% and 96.67% accuracy values for Single Photon Emission Computed Tomography (SPECT) in addition to Positron Emission Tomography (PET) images respectively [5].

Some researchers presented an unsupervised 3-D change detection model relied on Change\_Vector\_Analysis. The threshold of the Generalized Likelihood Ratio map is automatically calculated to gain a binary change map. Then, find clustering histogram to classify the change vectors. Gain a Kappa Index of 0.82 utilizing different kinds of simulated lesions and 2% classification error. [6].

Moreover, some researchers presented a new computer aided diagnosis (CAD) model for the early AD diagnosis relied on support-vector-

machines (SVM) and nonnegative-matrix-factorization (NMF). They utilized two various brain image databases: (SPECT) database and (PET) images containing AD patients and healthy for discrimination purpose. The useful feature extracted and selected by Fisher-discriminant-ratio (FDR) and nonnegative-matrix-factorization (NMF). They got a good feature reduction and they classified by a SVM-based. The model achieved accuracy up to 91%. [7]

Other researchers presented a novel approach utilized brain rhythms extraction from magnetoencephalogram (MEG). This approach depend on the empirical approach decomposition ability to separate local signal oscillations and constrained blind basis secession to gain the efficacy that conjointly characterizes a subclass of channels. Then analysed MEG connectivity for 36 AD, 18 Mild Cognitive Impairment (MCI) and 26 control subjects in ( $\delta$ ,  $\theta$ ,  $\alpha$  and  $\beta$ ) bands for both sides of central, lateral, the areas (anterior and posterior ) with magnitude squared coherence-c(f) calculated from the original MEG channels and from the adaptively extracted rhythms, c(f) distinguished AD and MCI subjects from controls with 69.4% and 77.3% accuracies, respectively, in a full leave-one-out cross-validation evaluation.[8] Scientists and researchers utilized new terms and approaches to employee and enhance the images a powerful tool in many different science domain such us medical felid. Image segmentation is generally apportioning the image into segments. Usually used to determine objects in the image that is interested and meaningful. There are many types of segmentation technique each one has a specific use depending on the application type and the aim of the segment. [9].

Many image segmentation algorithms used in medical imaging applications for diagnosing region of interest. Segmentation algorithms vary widely depending on the nature of application, imaging modality and other features.

Image segmentation is the classification of an image into different groups. Many researches have been done in the area of image segmentation using clustering. There are different methods and one of the most popular methods is k-means clustering algorithm. K -means clustering algorithm is an unsupervised algorithm and it is used to segment the interest area from the background. The K-means algorithm was first discussed by J. MacQueen in 1967 and then by J. A. Hartigan and M. A. Wong around 1975[10]. The K-means clustering is an algorithm to classify or to group the objects relied on features/ attributes into K groups, where K is an integer number, for each group the algorithm minimize the distances

between data  $A_k$  and the corresponding cluster centroid belongs to its closest cluster [11]:

$$L_K A_K = \operatorname{argmin}_i D(A_K - C_i) = \operatorname{argmin}_i \|A_K - C_i\|^2 \quad (1)$$

Where C is cluster,  $L_K$  is label for  $A_K$  and  $\operatorname{argmin}$  is minimize the dataset within cluster. The K-Means algorithm attempts to obtain a cluster centers sets to minimize totals distortion. Hence, can define the distortion is the summationn of the ddistances of data\_points fromi its cluster centers[11]:

$$\theta(A, C) = \sum_i \in c \sum_j \in \text{ith cluster} \|A_j - C_i\|^2 \quad (2)$$

To minimize  $\theta$  value, K-Mean algorithm alternate between ttwo steps: Labelingg and Update\_centering.

Labeling: Suppose the p-th iterations ends up by asset of clusterr centers  $C_i^{(p)}$ ,  $i=1,2,\dots,K$ . Every data\_point labeled based on such a set of clusterr centers, i.e.,  $\forall A_i$ , compute[11]:

$$C_i^{(p+1)} = \frac{\sum_{A_k \in \Omega_i} A_k}{|\Omega_i|} \quad \dots(3)$$

$$L_k^{(p+1)}(A_k) = \operatorname{min}_i \|A_k - C_i^p\|^2 \quad \dots (4)$$

The set data\_points belong to the same cluster:

$$\Omega_j = \{A_k : L_k(A_k) = C_j\} \quad \dots(5)$$

Markov random field (MRF) modeling itself is not a segmentation method but a statistical model which can be used within segmentation methods. MRFs model spatial interactions between neighboring or nearby pixels. These local correlations provide a mechanism for modeling a variety of image properties [12]. In medical imaging, they are typically used to take into account the fact that most pixels belong to the same class as their neighboring pixels. In physical terms, this implies that any anatomical structure that consists of only one pixel has a very low probability of occurring under a MRF assumption. MRFs are often integrated into segmentation algorithms. For each pixel  $p(i,j)$  in a cluster S, the area-type that the pixels belongs to is definite by a classes label,  $W_s$ , that can identified as a discretess\_random\_variables has values in  $\Lambda = \{1, 2, \dots, L\}$ . The labels sets  $w = \{W_s, s \in S\}$  is a random fieldd and called labell process. The denoted image features such as grayscale and ttexture are assumed to be a realizationn  $R = \{R_s, s \in S\}$  from anothers randoms field, represent the labell process function W. the iimage process Fi signifies the aberration from the essential llabell proces. The main aim is to gain an eoptimal llabelling  $\hat{w}$  whichs maximize a posteriorii probabillity  $P_i(R|W)$ , that is the maximumi a posteriorii (MAP) calculate[13]:

$$arg - max_{W \in \Omega} \prod_{s \in S} P(R_s | W_s) P(w) \quad (6)$$

Where  $\Omega$  represent the set off all potential llabelings. Here, the model of iimage pprocess is done by an additives whitee noise. Hence, assume thatt  $P_i(R_s | W_s)$  follows a Gaussians\_distributionn and pixell classes  $\lambda \in \Lambda = \{1, 2, \dots, L\}$  are denoted by the meann vectors  $\mu_\lambda$  and  $\Sigma_\lambda$  denoted the covariancesmatrices. Also  $w$  is assumed to bee a MRFi with assessment to the firsts orders neighborhood system. Hence,  $P(w_i)$  follows a Gibbsddistribution based on the Hammersley-Clifford theorem[13]:

$$P(w) = \frac{\exp(-u(w))}{z(\beta)} = \frac{\prod_{c \in C} \exp(-V_c(w_c))}{z(\beta)} \quad (7)$$

Where  $Z(\beta) = \sum_{w \in \Omega} \exp(-U(w))$  represent the partition functions or (normalizing constant),  $U(w)$  represent the energy function and  $V_c$  represent the cliquec potentiall of clique  $c_i \in C$  having  $w_c$  the labell cconfiguration.  $C$  represents the set of spatial second orders cliques (i.e. doubletonsi). See the energies off singletons (i.e. Pixels sites  $s_i \in S$ ) immediately reflects the probabilisticc\_modeling off labels wwwithout contexts, while ddoubleton clique ppotentials represent the relation among neighboring pixell labels. In the approach, thesee potentials ffavor alike classes' in nneighboring pixels. Hence, in MRFi images segmenitaton model can define the energy function  $U_i(w, R)$  as following form [13]

$$U(w, R) = \sum_{s \in S} (\ln(\sqrt{(2\pi)^3} |\Sigma_{W_s}|) + \frac{1}{2} (R_s - \mu_{W_s})^T \Sigma_{W_s}^{-1} (R_s - \mu_{W_s})) + \beta \sum_{\{s, r\} \in C} \delta(w_s, w_r) \quad (8)$$

$$\delta(w_s, w_r) = \begin{cases} 1 & \text{if } w_s, w_r \text{ are dissimilar} \\ 0 & \text{otherwise.} \end{cases}$$

$\beta$  represent the constraint controlling the homogeneity of the areas. Generally  $\beta$  value larger than 0 and when increase the resulting areas become more homogeneous. In this paper, will combine the K-means algorithm with Markov-random-field models for AD diagnosing.

### 3. Methodology

The proposed approach of AD diagnosing is shown in the block diagram figure (1).

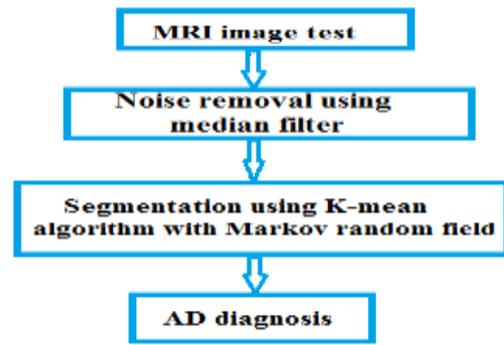


Figure 1: Block Diagram of the proposed system The proposed algorithm of AD segmentation is shown below:

#### The proposed MRI brain segmentation algorithm

**Input:** MRI(x,y) image

**Output:** image segmented Z(x,y)

**Process:**

**Step1:** for i=1 to N do // read all MRI(x,y) in DB, N is no. of images in DB

M(x,y)= call:: Median(MRI(x,y))

**Step2:** For i=1 to n do // read MRI(x,y)

For j=1 to m do

Begin

Initial Sc //initial cluster seed based on gray-scale information

End

For i=1 to No. of Sc do

D(i)= sqrt((xi-xi+1)+( yi-yi+1)) //

compute distance cluster

argmini || A(x,y)-C(x,y) ||<sup>2</sup> // compute

cluster data set

**Step3:** For i=1 to k do // compute the MRF for each cluster

Begin

For all pixel P(i,j) of S // S is cluster

Set label w = {W<sub>s</sub>, s ∈ S} // W is label process

For each W calculate max-probability

P(W|R)

F(MRFi)= set U (w,R) // compute

energy function of MRF

End

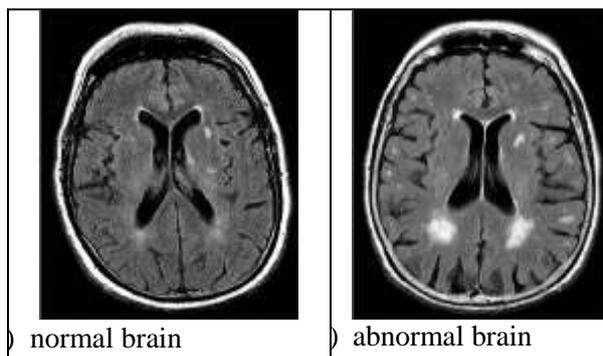
End

The first step is open file and read the MRI image of the AD. Then the input MRI image pass through median filter for Noise removal and improve image quality. The next step is AD segmentation process, the proposed approach combine two segmentation methods (K-mean Clustering algorithm and Markov random field) Works sequentially. The aim of using the MRF method model is to quantify each cluster of K-mean algorithm to ensure accurate results to diagnosis and segment Alzheimer's disease. First, applied K-

mean algorithm, based on gray-level-information, initiates by assigning a threshold utilizing histogram information, for separate the objects from the background and initializing seeds of clusters. Then assign center and calculate distance measure of each cluster and compares all points in a cluster so it merges the similar and different deletions based on gray-level-information of pixel. The distance between the center and the point will be ignored, as this point does not belong to the same object. After this process, the algorithm update-centering: Each clusters center will be recalculated. The algorithm stay iterates between labeling and Update -centering steps (iteration) until the most similarity pixel extraction will be done within each cluster (stable status). The proposed algorithm selects each cluster in an image (each cluster represent object in an image) and applies the Markov random field to obtain accurate segmentation results, then will gain the AD from the cluster that it contains. Usually, neighboring pixels have similar properties (intensity, grayscale, texture), the proposed MRF relied on these properties to construct a feature vector for each pixel  $p(i,j)$  in the cluster and assigned a label  $W_s$  utilizing 2nd order neighbors. Then define a probability measure on the set of all possible labelings and select the most likely one (optimal labeling) which maximize a posteriori  $P_i(R|W)$ . The proposed MRF compute the energy function only for the area that is more homogeneity basing on the label process and highest probability. The final result of this algorithm is the segments of the tested image, one of these segments representing the suspect segment (infected), the properties of this segment (intensity, grayscale, texture) transferred to feature vectors that depend on the AD diagnosis.

**4. Results and Discussion**

The results of this approach rely on the MRI brain image which is characterized by strong intensity in the affected area. The system test MRI images contains normal and abnormal brain image such as show in figure (2).

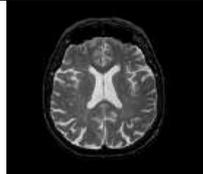
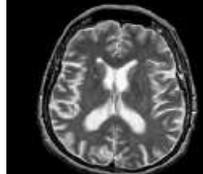
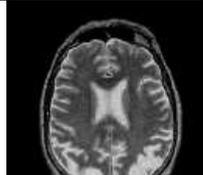
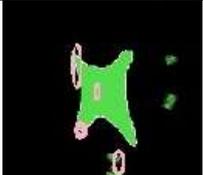


**Figure 2: the normal brain image and abnormal.**

The input MRI brain image browsed to the system and pass through the median filter for noise removal.

The MRI brain image segmented utilizing two segmentation methods the first is a K-mean algorithm that results image separated into numbers of clusters, then applied the second method that is MRF for each these clusters. The proposed approach tested conducted on MRI brain database consists of 60 images and the results indicated that proposed approach has 91% accuracy rate, table (1) shows some infected samples and the accuracy rate of the system. The result is diagnosis Alzheimer’s disease on an original MRI brain image as show in the figure (3).

**Table 1: the proposed system accuracy.**

Samples	AD Diagnosis	Accuracy Rate
		8 9.4
		93.6
		86.1
		94.1

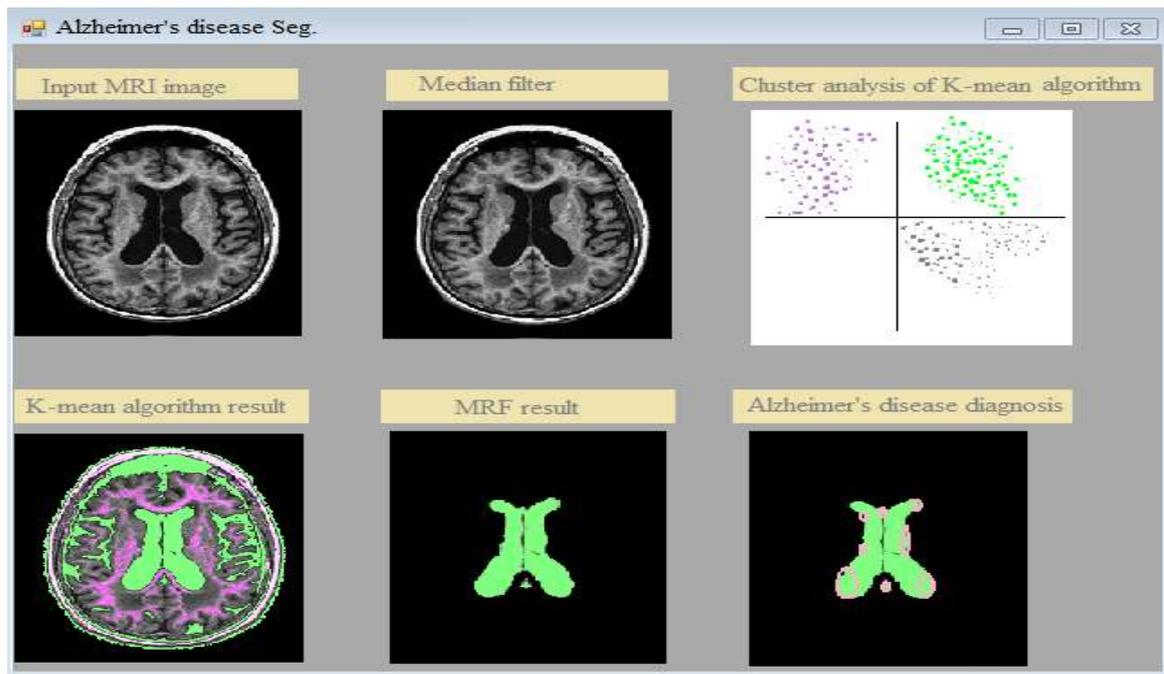


Figure 3: Segmentation and diagnosis Alzheimer's disease

### Conclusion

In this paper, Segmentation and Diagnosing Alzheimer's disease approach is presented, which aimed to Alzheimer's segmentation and Diagnosing from MRI brain image relied on image processing methods utilizing enhancement filters that serve in medical image processing such as median filter and segmentation methods. Experimental results show that the segmentation for medical images processing is very sensitive stage. The system utilize two methods of Segmentation (k-mean algorithm and MRF) works sequentially, because of the results that emerged was not accurate when we utilize k-mean algorithm only although the K-mean algorithm is fast and able to segment images into objects, therefore, we utilize the MRF on K-mean clusters to obtain robust and accurate diagnosis of the disease. The proposed approach achieved 91% accuracy rate.

### References

[1] A. Association, "2012 Alzheimer's disease facts and figures," *Alzheimer's and Dementia: The Journal of the Alzheimer's Association*, vol. 8, no. 2, pp. 131–168, 2012.

[2] N. Zilka, M. Novak, "[The tangled story of Alois Alzheimer](#)", AD center of excellence, Slovakia, pp343-345, 2006.

[3] NS. Wellman, BJ. Kamp, "[Nutrition](#) in aging", *Krause's Food and the Nutrition Care Process*, pp. 442-459, 2012.

[4] S. Joshi, D. Shenoy, V. simha G G,P L Rrashmi, K R Venugopal,and L M Patnaik, "Classification of Alzheimer's Disease and Parkinson's Disease by Using Machine Learning and Neural Network Methods" *IEEE*, 2010.

[5] M. Lo pez, J. Ram ırez, J. M. Go rriz, D. Salas-Gonzalez, L. A Ivarez, F. Segovia and R. Chaves." *Neurological Image Classification for the Alzheimer's Disease Diagnosis Using Kernel PCA and Support Vector Machines*", *IEEE*, 2009.

[6] R. Simões, and C. Slump." *Change detection and classification in brain MRI images using Change Vector Analysis*". *IEEE*, 2011.

[7] P. Padill, M. López, J. M. Górriz, J. Ramirez, D. Salas-González, and I. Alvarez, "NMF-SVM Based CAD Tool Applied to Functional Brain Images for the Diagnosis of Alzheimer's 's Disease". *IEEE*, 2012.

[8] J. Escudero, S. Sanei, D. Jarchi, D. Abásolo, and R. Hornero," *Regional Coherence Evaluation in Mild Cognitive Impairment and Alzheimer 's Disease Based on Adaptively Extracted Magnetoencephalogram Rhythms*" *Physiol. Meas.*, May 2011.

[9] G. Linda, C. Stockman, Shapiro and George, "Computer Vision", New Jersey, Prentice-Hall, pp279-324, 2001.

[10] B. Hans-Hermann, "Origins and extensions of the *k*-means algorithm in cluster analysis", *Electronic Journal for History of Probability and Statistics*, Vol 4, No. 2, 2008.

[11] [MacKay, David](#) , "[An Example Inference Task: Clustering](#)", [Inference and Learning Algorithms](#), Cambridge University Press, pp. 284–292, 2003.

[12] S.Z. Li., "Markov random field modeling in computer vision", Springer, 1995.

[13] Li, Z. Stan, "Markov Random Field Modeling in Image Analysis", Springer [Advances in Computer Vision and Pattern Recognition](#), 2009.



**Sarah j. Mohammed** received the M.S. degrees in computer science from University of Technology, Baghdad, Iraq in 2015. She is working as assistant Lecturer, in Mechanical Engineering Department, University of Technology, Baghdad, Iraq. She has many publications in image processing filed.