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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.*

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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

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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 (δ, θ, α and β) 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]:

$$L_K A_K = \mathrm{argmin}_i\, D(A_K - C_I) = \mathrm{argmin}_i \|A_K - C_I\|^2 \quad (1)$$

Where C is cluster, L_K is label for A_K and argmin is minimize the dataset within cluster. The K-Meanss 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]:

$$\theta(\mathrm{A},\mathrm{C}) = \sum_i \in \mathrm{c} \sum_j \in \text{ ith cluster} \parallel \mathrm{Aj} - \mathrm{Ci} \parallel^2 \quad (2)$$

To minimize θ 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,….,K. Every data_point labeled based on such a set of clusterr centers, i.e., ∀ A_i, compute[11]:

$$C_i^{(p+1)} = \frac{\sum A_{k\in}\,\Omega_i\, A_k}{|\Omega_i|} \quad \text{….(3)}$$

$$L_k^{(p+1)}(A_k) = min_i ||A_k - C_i^p||^2 \quad \text{… (4)}$$

The set data_points belong to the same cluster:

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

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 discretes_random_variables has values in ʌ = {1, 2, ….. , L}. The labels sets w= {W_s, s∈ 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∈ S} from anothers randoms field, represent the labell process function W. the iimage process Fi signifies the aberration from the essential llabel proces. The main aim is to gain an eoptimal llabeling ŵ whichs maximize a posteriorii probabilityy Pi(R|W), that is the maximumi a posteriorii (MAP) calculate[13]:

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

Wheres Ωi represent the set off all potential llabelings. Here, the model of iimage pprocess is done by an additives whitee noise. Hence, assume thatt Pi(R_s|W_s)follows a Gaussians_distributionn and pixell classes λ∈ʌ={1,2,…..,L}are denoted by the meann vectorss μ_λ and $\sum_\lambda$ denoted the covariancesmatrices. Also w is assumed to bee a MRFi with assessment to the firsts orders neighborhood system. Hence, P(wi) follows a Gibbsddistribution based on the Hammersley-Clifford theorem[13]:

$$P(w) = \frac{\exp(-u(w))}{z(\beta)} = \frac{II_{c\,\epsilon c} \exp(-Vc(wc))}{z(\beta)} \qquad (7)$$

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 $ci \in c$ having w_c the labell cconfiguration. C represents the set of spatiall second orders cliques (i.e. doubletonsi). See the energies off singletons (i.e. Pixels sites si ∈ S) immediately reflects the probabilisticc_modeling off labels wwithout 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 segmenitation model can define the energy function Ui(w,R) as following form [13]

$$U(w,R) = \sum_{s \ni S}(\ln(\sqrt{(2\pi)^3|\sum \quad Ws|}) + \frac{1}{2}(Rs - \mu_{Ws}) \sum_{Ws}^{-1}(Rs - \mu_{Ws})^T) + \beta \sum_{\{s,r\}\epsilon C} \delta(ws, wr) \qquad (8)$$

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

β represent the constraint controlling the homogeneity of the areas. Generally β 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).

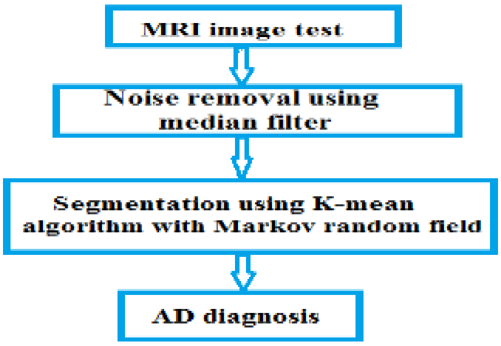


Figure 1: Block Diagram of the proposed system

The proposed algorithm of AD segmentation is shown below:

The proposed MRI brain segmentation algorithm

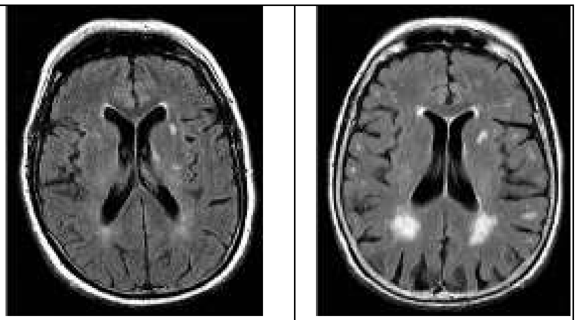
Input: MRI(x,y) image
Output: image segmented Z(x,y)
Process:
Step1: for i=1 to N do // read all MRI(x,y) in DB, N is no. of images in DB
M(x,y)= call:: Median(MRI(x,y))
Step2: For i=1 to n do // read MRI(x,y)
For j=1 to m do
Begin
Initial Sc //initial cluster seed based on gray-scale information
End
For i=1 to No. of Sc do
D(i)= sqrt((xi-xi+1)+ (yi-yi+1)) // compute distance cluster
$\text{argmin}_i \| A(x,y)-C(x,y) \|^2$ // 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_s, 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 Ws 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 Pi(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).



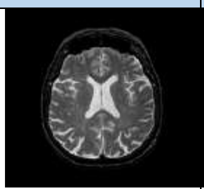
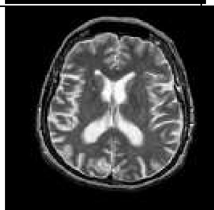
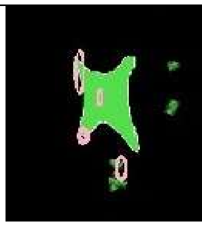
) normal brain) abnormal brain

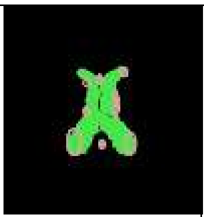
Figure 2: the normal brain image and abnormal.

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	Accurac y Rate
		8 9.4
		93.6
		86.1

		94.1

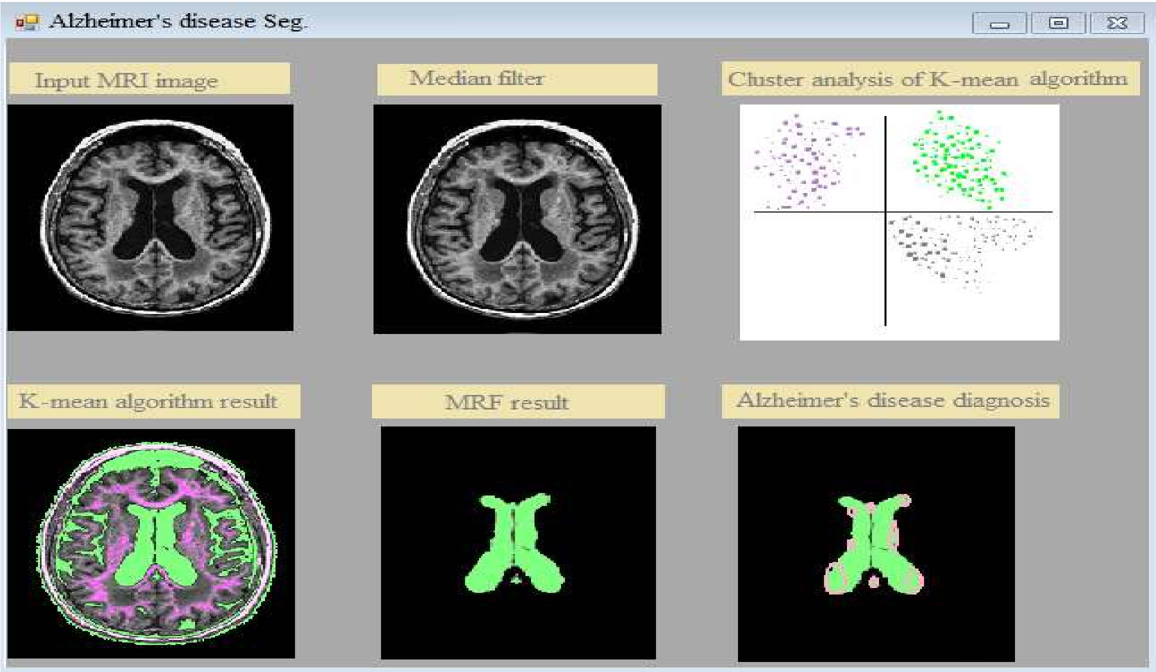


Figure 3: Segmentation and diagnosis Alzheimer's disease

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.

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