Image Segmentation using Fuzzy - Kohonen Algorithm

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***Abstract*— In this paper we propose a hybrid soft-computing technique for segmentation of an image. The algorithm used is a modified version of the Kohonen's algorithm found in neural networks. Our algorithm is formulated by modifying the objective function of the standard Fuzzy C-Means (FCM) algorithm. So this algorithm can also be called as a Fuzzy-Kohonen clustering algorithm.**

Keywords- Image Segmentation, Kohonen algorithm, Fuzzy C-Means algorithm, Supervised and Unsupervised Learning, Fuzzy-Kohonen Algorithm.

I. INTRODUCTION

Image segmentation plays an important role in many of the medical imaging applications, security and surveillance systems, space imaging, meteorological applications etc. Segmentation [1],[2] is a method in which the inputs are images, but the outputs are attributes extracted from those images. Segmentation [3] subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. That is, segmentation should stop when the objects of interest in an application have been isolated.

Image segmentation algorithms [3],[4] generally are based on one of the two basic properties of intensity values: discontinuity and similarity. In the first category, the approach is to partition an image based on abrupt changes in intensity, such as edges in image. The principal approaches in the second category are based on partitioning an image into regions that are similar according to a set of pre-defined criteria. Thresholding, region growing and region splitting and merging are examples of methods in this category.

The technique used in this paper is soft computing. Soft Computing [9] became a formal Computer Science area of study in the early 1990's. It [5] is a term applied to a field within computer science which is characterized by the use of inexact solutions to computationally-hard tasks such as the solution of NP-complete problems, for which an exact solution cannot be derived in Polynomial time. Earlier computational approaches could model and precisely analyze only relatively simple systems. More complex systems arising in biology, Medicine, the Humanities and similar fields often remained intractable to conventional mathematical and analytical methods. That said, it should be pointed out that simplicity and complexity of systems are relative, and many conventional mathematical models have been both challenging and very productive. Soft computing deals with imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness and low solution cost.

In supervised learning [9], the model defines the effect one set of observations, called inputs, has on another set of observations, called outputs. In other words, the inputs are assumed to be at the beginning and outputs at the end of the causal chain. The models can include mediating variables between the inputs and outputs. This type of learning consumes less time and gives accurate results, but require a presumed end result. Fuzzy C-Means employs this type of learning.

In unsupervised learning [9], all the observations are assumed to be caused by latent variables, that is, the observations are assumed to be at the end of the causal chain. In practice, models for supervised learning often leave the probability for inputs undefined. This model is not needed as long as the inputs are available, but if some of the input values are missing, it is not possible to infer anything about the outputs. If the inputs are also modelled, then missing inputs cause no problem since they can be considered latent variables as in unsupervised learning. This type of learning consumes more time as we cannot predict the number of iterations needed for a possible outcome and is less accurate. Kohonen, a self organising algorithm employs this type of learning.

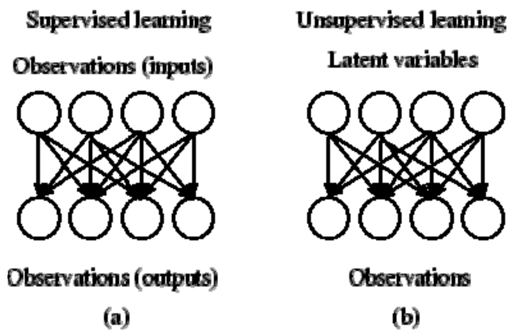

Figure 1: The causal structure of (a) supervised learning, (b) Unsupervised learning.

As observed above, the two algorithms have their own advantages and disadvantages. Hence we propose a hybrid of them which would give us a better and efficient result taking their limitations into consideration. In this method, we combine the supervised Fuzzy C-Means algorithm and the unsupervised Kohonen Self organizing algorithm to give a more efficient Fuzzy Kohonen algorithm [7],[8].

II. METHODOLOGY

The proposed soft-computing technique which uses the Fuzzy Kohonen algorithm is faster and efficient one compared to the existing technique which uses the conventional Kohonen algorithm. The block diagram of the proposed technique is shown below:

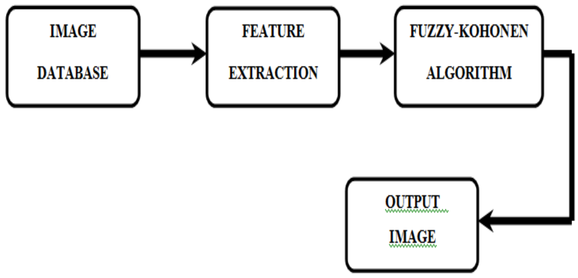

Figure 2: Block Diagram

A. Image Database

As shown in the figure 2, the first block is the image database. In specific cases like in medical imaging, image databases can be procured from hospitals. Image database is the set of images which are to be given as input to the algorithm. Here we have used sample retinal images from a hospital.

B. Feature Extraction

Feature analysis [10] refers to the methods for conditioning the raw data so that the information is most relevant for classification and interpretation (recognition) is enhanced and represented by the minimal number of features. Feature analysis consists of three components: nomination, selection and extraction. Feature nomination (FN) refers to the process of proposing the original p features; it is usually done by workers close to the physical process and may be heavily influenced by physical constraints, e.g., what can be measured by a particular sensor. For example, the nominated features can correspond to simple characteristics of various sensors that are represented by digitization of the sensor records. Feature selection (FS) refers to choosing the “best” subset of s features (s<p) from the original p features. Feature extraction (FE) [6] describes the process of transforming the original p-dimensional feature space into an s-dimensional space in some manner that “best” preserves or enhances the information available in the original p-space. This is usually accomplished mathematically by means of some linear combination of the initial measurements. In other words, when the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (much data, but not much information) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction.

The features of the images are needed for image recognition and image based shape analysis. The image can be studied in two levels namely statistical and structural. On the statistical level the texture of an image is defined by a set of statistics extracted from the entire texture region. On the structural level a texture is defined by sub patterns called primitives. The various features of the image could be extracted by using the parameters such as area, mean, standard deviation, entropy, energy etc.

C. Fuzzy-Kohonen Clustering Algorithm

The Fuzzy Kohonen Clustering Network (FKCN) clustering is closely related to the Fuzzy C-Means (FCM) algorithms. The integration of FCM and Kohonen Clustering Network (KCN) is one way to address several problems of KCN. Here we combine the ideas of fuzzy membership values for learning rates, and with the help of this learning rate we update the cluster center. This cluster center is taken as the weight in the KCN algorithm.

The fuzzy Kohonen clustering algorithm can be summarized as follows:

Step1: Given the sample space x={x1,x2,x3,…xn}, distance ||.||, number of clusters c and the error threshold ε >0.

Step 2: Set the fuzzy parameters m_0 iterations limit to t_{max}, initial iteration counter t=0 and initialize then weight vector v for t=0.

Step 3: Update all membership values $\{u_{ij}\}$ and calculate the learning rate $\{\alpha_{ij}\}$ where 0 < i < n and 0 < j < c.

$$u_{ij}=\frac{1}{\sum_{K=1}^{C}\left(\frac{||x_i-v_j||}{||x_i-v_k||}\right)^{\frac{1}{(m_t-1)}}} \quad (3.1)$$

$$\alpha_{ij}(t)=(u_{ij}(t))^{m_t} \quad (3.2)$$

$$\text{where } m_t=m_0-t\delta m, \quad (3.3)$$

$\delta m= m_0-1/t_{max}$, m_0 is the degree of fuzziness.

Step 4: Update all weight vectors using the learning rate.

$$v_i(t)=v_i(t-1)+\frac{\sum_{j=1}^{n}\alpha_{ij}(x_j-v_i)}{\sum_{j=1}^{n}\alpha_{ij}(t)} \quad (3.4)$$

Step 5: Compute the function

$$E(t)=\| v(t)-v(t-1)\| \quad (3.5)$$

Step 6: If $t+1>t_{max}$ or if $E(t)<\varepsilon$, terminate the iteration otherwise return to step 3.

Now, the updated weight values i.e., the cluster centers that are obtained after executing the algorithm are used as the weight vectors of the Kohonen self organizing algorithm.

III. RESULTS & DISCUSSION

The initial steps of the methodology were implemented and analyzed using MATLAB Software. Here we are taking two different images: Cameraman Image (figure 3)-a sample image from MATLAB and a retinal image (figure 4) as test images. Then these images are clustered into four clusters based on their intensities. The portion of each clustered image in white belongs to the cluster while the portion in black does not belong to the cluster.

The results observed are as follows:

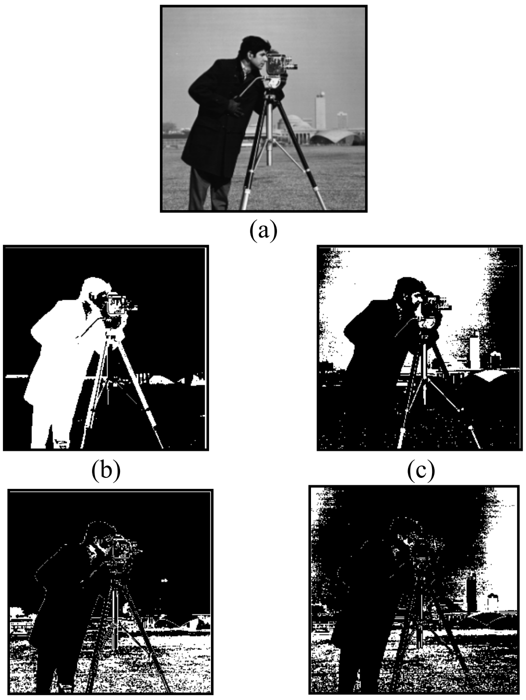

Figure 3. Clustering of Cameramen Image(a) Input Image. (b) Cluster I Image. (c) Cluster II Image. (d)Cluster III Image. (e)Cluster IV Image.

This technique can be implemented for any image application . The output for a retinal image sample is shown in Figure 4.

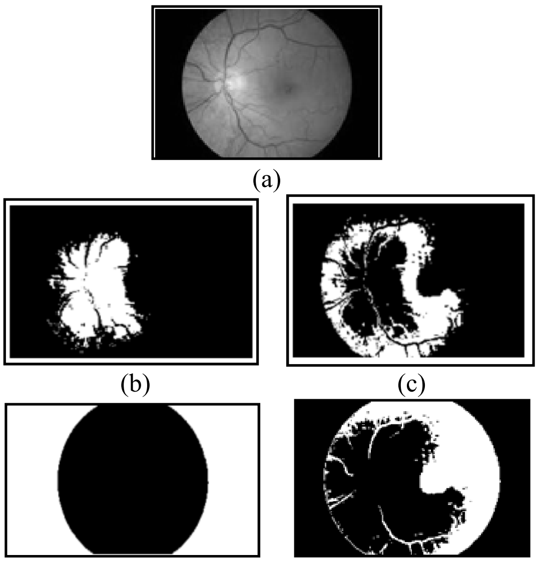

Figure 4.Clustering of Retinal image. (a) Retinal Input Image. (b) Cluster I Image. (c) Cluster II Image. (d)Cluster III Image. (e)Cluster IV Image.

IV. CONCLUSION

The algorithm of Fuzzy Kohonen Clustering Network (FKCN), based on the integration of Fuzzy C-Mean (FCM) and Kohonen Clustering Network (KCN), the FKCN is non-sequential, unsupervised and used fuzzy membership values from FCM as learning rate. The proposed algorithm will help us to reduce the time taken for training the neuron and it is also very efficient method. The algorithm detailed above has been implemented using the MATLAB software and the results are as shown. This algorithm can be improvised and implemented for applications including brain mapping, retinal image segmentation etc.

V. FUTURE WORK

The future work will include the use of the updated weights that are obtained after implementing the algorithm described above and then implementing it in the Kohonen algorithm and will be comparing the output that we obtained through this algorithm with the already existing algorithm. We will also be extracting various features of the image by using the various parameters such as area, mean, standard deviation, entropy, energy etc.

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