Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 132 (2018) 534–540

Procedia Computer Science

www.elsevier.com/locate/procedia

International Conference on Computational Intelligence and Data Science (ICCIDS 2018)

An Improved Method for Image Segmentation Using K-Means Clustering with Neutrosophic Logic

Mohammad Naved Qureshi[a], Mohd Vasim Ahamad[b,*]

[a]Electrical Engineering Section, University Polytechnic (Boys), Aligarh Muslim University, India
[b]Computer Engineering Section, University Women's Polytechnic, Aligarh Muslim University, India

Abstract

Images are one of the primary media for sharing information. The image segmentation is an important image processing approach, which analyzes what is inside the image. Image segmentation can be used in content-based image retrieval, image feature extraction, pattern recognition, etc. In this work, clustering based image segmentation method used and modified by introducing neutrosophic logic. The clustering technique with neutrosophy is used to deal with indeterminacy factor of image pixels. The approach is to transform the image into the neutrosophic set by calculating truth, falsity and indeterminacy values of pixels and then, the clustering technique based on neutrosophic set is used for image segmentation. The clusters are then refined iteratively to make the image more suitable for the segmentation. This iterative process converges when required number of clusters areformed. Finally, the image in the neutrosophic domain is segmented. The proposed algorithm provides better results than existing K-means clustering approach.

Keywords: Image Segmentation; Neutrosophic Logic; K – Means Clustering; Image Processing; Image Cluster

1. Introduction

An image is a2-D array of very small square regions called as pixels. The intensity of pixels in a grayscale image are represented by numeric values that can easily be stored in a 2-D array. Image segmentation is the process of partitioning an image into various regions, each having similar attributes (luminance value for grayscale images and

* Corresponding author. *E-mail address:* vasim.iu@gmail.com

1877-0509
10.1016/j.procs.2018.05.006

color components for color images). The image segmentation can be used in content based image retrieval, image feature extraction, etc [5]. There are many algorithms for image segmentation based on clustering, which try to partition an image into a number of regions [6]. Clustering is an approach that tries to group a set of data objects in to the same cluster that are similar to each other, and dissimilar data objects are associated into different clusters [7] [12].

The K-Means clustering algorithm tries to group a set of data objects into k clusters based on the distance between the data object and the k centroids selected beforehand [1] [3]. Data objects are associated with the centroid closest to them. The k-means clustering algorithm starts with selecting value of k (number of clusters) and random initial centroids for each cluster. In each iteration, data objects are associated with the closest centroids. Then, centroids are updated based on the distance values of data objects associated with it. After centroid calculation (mean value of all data objects in a cluster), data objects are again compared with new centroids and associated with the closest one. This process continues until termination criteria is met [1] [2]. In the case of image segmentation, a set of image pixels are grouped in a manner such that, pixels within a cluster have more similarity in comparison with pixels in another cluster.

The fuzzy logic is proposed to deal with the vagueness and uncertainty. It has two values associated with each variable, the degree of truthiness and degree of falsehood. It can be represented as FS= {T, F}, where T and F are the degree of truthiness and degree of falsehood of the variable towards the set FS respectively. Neutrosophic logic introduces a new parameter to fuzzy sets, called as indeterminacy. Neutrosophic logic theory considers every possible outcome for a variable X like X, Anti-X and Neut-X which is neither X nor Anti-X [1] [4]. The neutrosophic notation for an element x be x (T, I, F), where T is the degree of membership of x with S, I is the indeterminacy of x with S and F is the degree of non-membership of x with S [4] [11].

In this work, firstly k-means clustering algorithm is appliedon the input image. The output of this step isprovided as an input to neutrosophic set by defining a neutrosophic domain. Then, truth, falsity and indeterminacy values for each pixel are calculated to find the presence of the pixel in any cluster. A pixel p can be represented in the neutrosophic domain as netrosophic component P (T, I, F). Neutrosophy on boundary pixels of the clusters is also calculated, as the chances of error for boundary pixels are maximum, due to the assignment of that pixel in wrong cluster. The truth-value for every boundary pixel is calculated by placing it in every other cluster and associated with the cluster for which the truth-value is maximum [10].The values for T, I and F can be calculated as follows:

$$\overline{Z} = \frac{1}{x^2} \sum_{a=k-\frac{x}{2}}^{k+\frac{x}{2}} \sum_{b=1-\frac{x}{2}}^{1+\frac{x}{2}} z(a,b) \quad (1)$$

$$\delta(k,l) = \text{abs}[\text{z(k,l)} - \bar{z}\ \text{(k,l)}] \quad (2)$$

$$\text{T(k,l)} = \bar{z}\ \text{(k,l)/ Zmax} \quad (3)$$

$$\text{I(k,l)} = \delta(k,l)/\delta\text{max} \quad (4)$$

$$\text{F(k,l)} = 1 - \text{T(k,l)} \quad (5)$$

Where z(k, l) is the intensity value of the pixel (k,l), $\bar{z}$(k,l) is the mean value of z(k,l). δ(k, l) is the difference between intensity z (k, l) and its local mean value $\bar{z}$(k, l). This is implemented only for boundary pixels. Therefore, in our proposed methodology we have enhanced this algorithm to include all pixels in segmentation. The experimental results shows that the modified approach has resulted in better-segmented regions in the image compared to K-means and K-means with neutrosophic logic.

2. Proposed Method

For the large number of clusters, the K-Means clustering algorithm can make several empty clusters. If no points have been allocated to a cluster in the assignment step that can result in noisy image. Therefore, we need a criteria through which we can remove the problem of empty cluster generation. To remove the empty clusters consider each pixel as the data point and then apply clustering algorithm to generate the large number of clusters. Finally merge the similar looking clusters and remove the empty clusters. The approach is to transform an image into neutrosophic set by calculating truth, falsity and indeterminacy values of pixels. Then, a clustering technique based on neutrosophic set is used to segment the image.

So, the proposed methodology finds a way to calculate all these values and provides better results than existing K-mean approach discussed so far. The new Image segmentation method using neutrosophic logic consists of following phases as in the fig. 1.

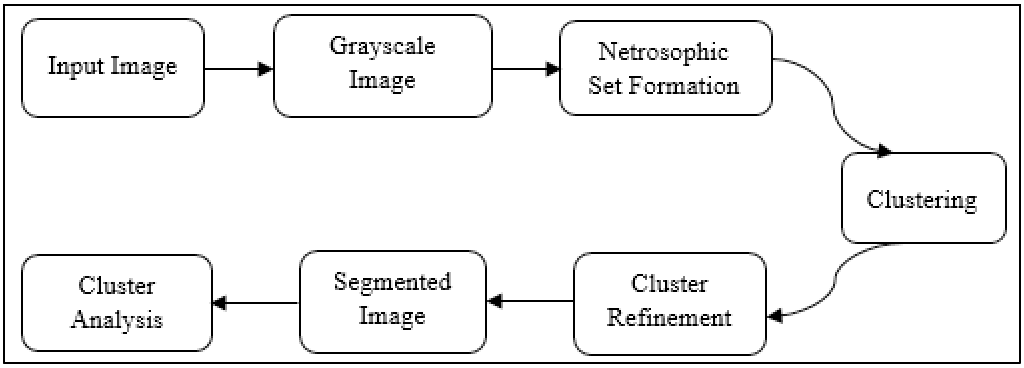

Fig. 1. Flowchart of proposed method

2.1. Converting the input image into grayscale image

A grayscale image is a simple kind of image that contains one domain, and each pixel in the image can be represented by an integer [0,255] i.e. it carries only intensity information. We have used MATLAB built in function to calculate the intensity value of each pixel.

2.2. Neutrosophic Set Formation

In this phase, the image is transformed into neutrosophic domain. A pixel $P_{(i,\,j)}$ of an image is represented in neutrosophic domain using its three components i.e. $T_{(i,j)}$, $F_{(i,j)}$, and $I_{(i,j)}$. This approach considered a pixel in 3*3 window and calculated the mean of the window based on intensity value. The mean value is assigned each pixel in order to calculate truth value.

$$\mathrm{Mean}_{(i,j)} = \frac{1}{(2w+1)^2} \sum_{\substack{i=x-w \\ j=y-w}}^{\substack{i=x+w \\ j=y+w}} \mathrm{In}(i,j) \tag{6}$$

Where w= √ (ws)-2. ws is the size of window and in this case it is considered to be 3*3. In(i,j) is the intensity of pixel (i,j). (x,y) is the center of window in which the mean is calculated w= √ ws-2. For a window size 3*3, w=1.

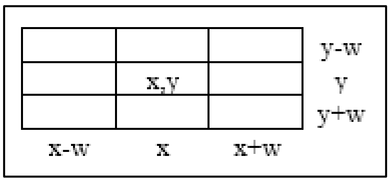

Fig.2: Window Size

Indeterminacy of the pixel means how different the pixel is from its neighboring pixels inside the window. The best way to calculate that is to use standard deviation and difference map of the pixels.Standard deviation calculates the dispersion of a set of pixels from its mean. Mathematically, standard deviation is calculated as the square root of variance.

$$\text{std} = \frac{1}{(2w+1)^2} \sum_{\substack{i=x-w \\ j=y-w}}^{\substack{i=x+w \\ j=y+w}} [In(i,j) - Mean(i,j)]^2 \quad (7)$$

We compute the maximum difference of pixel intensity from its surroundings pixels as follows:

$Diff_{(i,j)}$=max ($In_{(i,j)}$ -$In_{(x,y)}$) (8)

Where $In_{(x,y)}$ is the intensity of each pixel inside the window. Then we calculate the indeterminacy as

$$I_{(i,j)} = \frac{Std * Diff}{\max(Std * Diff)} \quad (9)$$

The falsity value of each pixel can be calculated as:

$$F_{(i,j)} = 1 - T_{(i,j)} \quad (10)$$

2.3. Neutrosophic Cluster Formation

Clustering is the machine learning approach to group pixels into different clusters so that the pixels residing in same cluster share some common characteristics. The process of clustering used in this work can be described as follows:

- Pick a pixel P which has the smallest indeterminacy value i.e. (the nearest pixel to the local mean) and has not been assigned to any cluster.
- Assign a same cluster to a pixel (P) and to its neighbor (N) whose truth difference from it is less than or equal to predefined /same threshold value i.e. $|T(P) - T(N)| \leqslant Th$
- The above two steps are repeated until each pixel is assigned to a cluster C.

Pseudo Code

1. For each pixel $P_{(i,j)}$ with $I_{(i,j)}$ is minimum
2. If $P_{(i,j)} \notin C_k$, where k is cluster label then $p_{(i,j)} \in C_k$
   a. Check $P_{(i,j)}$ neighbours(N)
      i. if $|T(P) - T(N)| \leq Th$
      ii. Then $N \in C_k$
   b. End
3. Else
   a. i=i+1
   b. J=j+1
4. Go to 2
5. End

Fig. 3. Pseudo Code for Neutrosophic Cluster Formation

2.4. Cluster Refinement

In the refinement stage, the clusters with small number of pixels are merged or grouped with its surrounding or neighboring clusters. Moreover, if cluster C_i has number of pixels less than or equal to minimum cluster size (CZ) then cluster C_i is merged to its surrounding cluster C_j. In this work, minimum cluster size is considered as equals to w*h*0.001, Where w is the width of the image and h is the height of the image. For example if the size of image is 400 × 400 then the minimum cluster size can be calculated as CZ= 400*400/1000=160. Therefore, a minimum of 160 pixels will be grouped in a single cluster.

Pseudo Code

1. For each cluster C_i where having $CZ_i <$ min CZ then
   Merge (C_i, C_j) where C_j is the neighboring cluster.
2. Step 1 is repeated until each cluster size $CZ_i >=$min CZ

Fig. 4. Pseudo Code for Cluster Refinement

2.5. Clusters analysis for Segmentation

Once all clusters have been refined, they can be analyzed based on neutrosophic logic to generate segments for the image. In this stage, each cluster pair is merged into one cluster based on their size and difference in truth value. This work made sure that small cluster is merged into bigger one and not vice versa. However, the cluster pairs with the minimum difference in their size and truth-values cannot be merged.

Pseudo Code

1. For each cluster pair (C_i, C_j)
   If $Min[CZ_i, CZ_j]*|T_{Ci} - T_{Cj}|$ is minimum.
   Then
   Merge C_i and C_j into C_k
   $CZ_k = CZ_i + CZ_j$
   $T_{(Ck)} = CZ_i * T_{(Ci)} + CZ_j * T_{(Cj)} / (CZ_i + CZ_j)$
2. The above step is repeated until the number of cluster equals to three

Fig. 5. Pseudo Code for Cluster Analysis for Segmentation

3. Result Evaluation and Discussion

The input image for the execution of the proposed method is taken from [13].

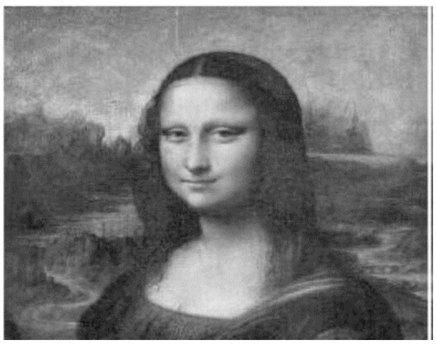

Fig. 6. Input Image

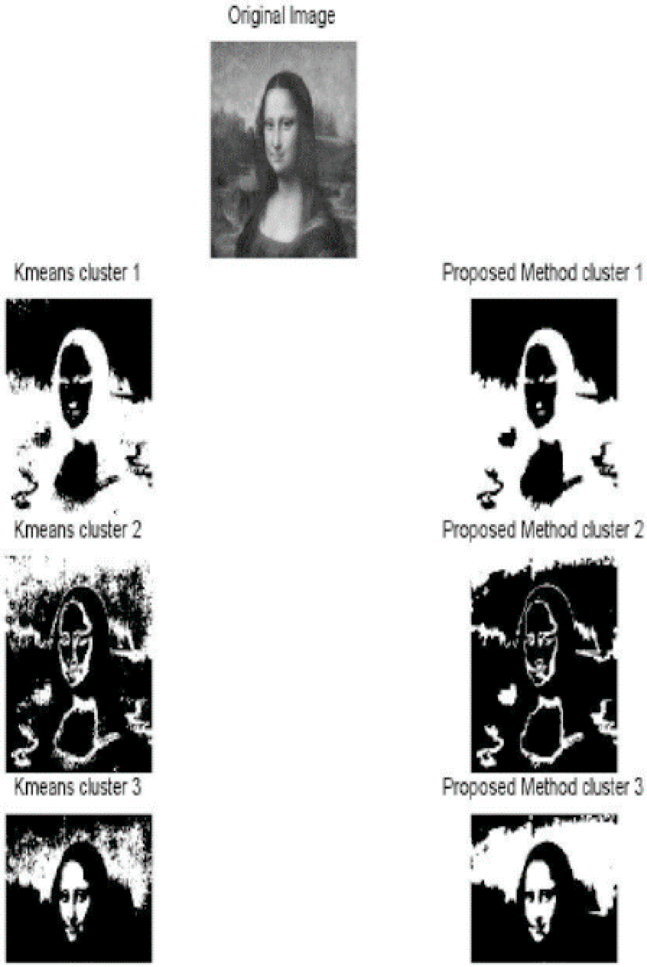

Fig. 7. Segmentation of image by K-means neutrosophy and proposed methodology

From the figure 7, it is clear that in the case of K-means using Neutrosophy in cluster 1, lots of pixels has been segmented in wrong cluster. However, in cluster 1 of proposed method, every cluster is clearly defined and segments can be identified easily. It is so, because this approach used clustering in such a way that the threshold value used to decide that a pixel is assigned to a particular cluster is very small. Accordingly, this work obtained a large number of clusters at the earlier stage and these clusters are refined to clearly segment the image. In cluster 2 using K-means, lot of area of black part of the image is considered as white. But using the proposed method, it is clearly identified that these area are separated. Similarly, in a cluster many white dots are seen in black area which are not a part of the cluster. But, after executing the proposed method, clusters are easily identified.

4. Conclusion and Future Work

An image can be considered as a 2-D array of very small square regions called as pixels. Images are one of the primary method of information sharing.The image segmentation is an important image processing approach, which analyzes what is inside the image. Image segmentation can be used in content-based image retrieval, image feature extraction, pattern recognition, etc. Neutrosophy is an enhancement to the fuzzy logic and appends the uncertainty factor in addition to truth and falsity components. The K-Means clustering algorithm tries to group a set of data objects into k clusters based on the distance between the data object and the k centroids selected beforehand. In the case of image segmentation, a set of image pixels are grouped in a manner such that, pixels within a cluster have more similarity in comparison with pixels in another cluster.

To start with the proposed method, firstly k-means clustering algorithm is applied on the input image. The output of this step is provided as an input to neutrosophic set by defining a neutrosophic domain. Then,the neutrorosophy isintroduced to image segmentation bycalculating the T, I, F values of each pixel in the image. The K-Means clustering algorithm using neutrosophic logic is implemented to minimize the indeterminacy of the pixels. The resulting clusters are then refined iteratively to make the images suitable for segmentation. The results of the proposed method describes that it can be used to get better results on synthesis image as well as real images with/without noise. The proposed method for image segmentation provides improved results for color images. The future works are described as follows.

- Neutrosophy can be applied to other image processing problems like feature extraction and classification.
- Apply neutrosophy to different research area like control theory, artificial intelligence.

References

[1] Nadeem Akhtar, and Mohd Vasim Ahamad (2015) “A Modified Fuzzy C Means Clustering Using Neutrosophic Logic.” In IEEE fifth International Conference on Communication Systems and Network Technologies,DOI 10.1109/CSNT.2015.164: 1124–1128.

[2] Nadeem Akhtar, Mohd Vasim Ahamad, and Shahbaz Khan (2015) “Clustering on Big Data Using Hadoop MapReduce.” In IEEE International Conference on Computational Intelligence and Communication Networks, DOI 10.1109/CICN.2015.161: 789–795.

[3] Nadeem Akhtar, Mohd Vasim Ahamad, and Shahbaz Khan (2016) “MapReduce Model of Improved K-Means Clustering Algorithm Using Hadoop MapReduce.” In Second International Conference on Computational Intelligence & Communication Technology, DOI 10.1109/CICT.2016.46: 192–198.

[4] Smarandache F (1998) “Neutrosophy / neutrosophic probability, set, and logic.”American Research Press, Rehoboth, NM.

[5] W. K. Pratt (2008) “Image Segmentation.”, Digital image processing. 4nd ed. Wiley: 579-622.

[6] C. Pantofaru, and M. Hebert (2005) “A comparison of image segmentation algorithms.” Tech. Rep. CMU-RI-TR-05-40: 2-14.

[7] J.A. Hartigan (1975) “Clustering algorithms.” John Wiley & Sons, Inc.

[8] Deng Y., and Manjunath B.S. (2001) “Unsupervised segmentation of color texture regions in images and video.” IEEE Trans. Pattern Analysis Machine Intell, **23(8)**: 800-810.

[9] J.T. Tou, and R.C. Gonzalez (1974) “Pattern Recognition Principles.”Massachusetts: Addison – Wesley.

[10] Nadeem Akhtar, Nishi Agarwal, and Armita Burjwal (2014) “K-Mean Algorithm for Image Segmentation Using Neutrosophy.” In Proceedings of ICACCI 2014, DOI: 10.1109/ICACCI.2014.6968286:2417-2421.

[11] Yanhui Guo, and H.D.Cheng (2009) “New neutrosophic approach to image segmentation.” Pattern Recognition, **42(5)**:587-595.

[12] Mohd Vasim Ahamad, Misbah Urrahman Siddiqui, Tariq Ahmed, and Asia Mashkoor (2017) “Clustering and Classification Algorithms in Data Mining.”International Journal of Advance Research in Science and Engineering, **6(7)**:1110-1117.

[13] Schwartz, L.F.F. (1988) “The Visual Computer.” International Journal of Computer Graphics, **34(276)**:4-40.