



Interval type 2 intuitionistic FCM cluster with spatial information algorithm applied for histopathology images

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Abstract

Image segmentation plays an important role for diagnosis, treatment of diseases and research studies. The objective of the segmentation is to investigate to separate the objects from the background image. The medical image contains uncertainty and vagueness where it is handled by advanced fuzzy set theories. Clustering is one of the ways to segment the image into different regions based upon similarity of pixels. The proposed algorithm of color based interval intuitionistic type 2 fuzzy c means with spatial information is firstly used for medical cancer histopathology images. this algorithm is extended for interval valued type 2 intuitionistic with spatial and lower computational complexity. It works well compared to the existing algorithm by the quality measurements. The image segmentation quality metrics are such as sensitivity, specificity and accuracy.

Keywords

Interval intuitionistic type 2 FCM, spatial, image clustering.

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1. Introduction

Clustering is one of the most powerful techniques used for image segmentation to partition an image into a number of disjoint clusters. The clustering methods such as k means, fuzzy c mean, improved fuzzy c mean, spatial fuzzy c mean algorithms [8, 9, 11]. Breast cancer is the most common invasive cancer affecting more than ten percentages in women worldwide. Early detection is the most important treatment of

breast cancer when perceived and treatable. The most important screening test for breast cancer is the mammogram, it is an X-ray of the breast. The cancer stage is analyzed through only biopsy testing. From this testing we collected the cancer biology samples as imaging format. Apart from manual detection, through histopathology images help to detect the cancer stages, it is taken for the second report of cancer analysis. The fuzzy set based clustering or segmentation methods are applied to reduce the uncertainty in the medical or remote sensing images[1, 9, 10].

2. Literature Survey

Digital Pathology is a continuously growing field in medical research based on tissue, education of biometrics, human pathology and then drug development. It is an enhanced productivity and improving treatment decisions and patient safety. Nowadays, image segmentation and classification methods are used to detect the cancer cells from histopathological samples in research medicine fields[9]. Developing new algorithms based on mathematics in image processing. K means and color based k means are used to segment the cancer nuclei, but k means algorithm produced the erroneous clusters along with discovering little cluster pixels only represented when the

cell overlapped. From k means determine the centroid coordinates and find distance among the object from the centroid. Finally grouping the objects based on the smallest amount distance. The fuzzy set was introduced by Zadeh in 1965, it is a mathematical way to represent vagueness. The fuzzy c means (fcm) segmentation used by researchers to segment the nuclei from digital microscopic images [1]. The spatial based FCM performs better compared to the fcm, because spatial based fcm clustering reduces the vagueness and uncertainty [1, 2, 4, 5]. This algorithm is the calculation of all the membership functions within the locality of the pixel in consideration. The fuzzy membership function and defuzzification included in the interval type 2 fuzzy c means algorithm [1].

3. Proposed Work

Motivated by Zadeh’s definition of fuzzy sets theory [1], different notions of higher-order fuzzy sets have been presented by various researchers. Among them, intuitionistic fuzzy sets (IFSs) proposed by Atanassov [2, 3] turned out to be a suitable tool for modelling the hesitancy arising from imprecise information.

IFS’s are defined using two characteristic functions, namely the membership and the non-membership, describing the belongings or non-belongingness of an element of the universe to the IFS respectively. This property advantages in determining whether a pixel belongs to the background or it belongs to the object. It is observed that in image processing the results using IFS are better than the fuzzy/non fuzzy set theory. Before segmentation or clustering applied the triangular intuitionistic fuzzy membership contrast limited adaptive histogram equalization (TIFM clahe) methods for improving the contrast level of the clahe. The benchmark breast cancer data set is taken for this process from break his P and D laboratory [11, 14]. The k means clustering is applied to segment the nuclei, portions of k clusters based on Euclidean distance [9]. The fuzzy c means(fcm) algorithms distance calculated based upon membership calculated in images [1, 2]. The FCM and Type 2 FCM were good for theoretical results, not good for practical results.

3.1 Type 1 Intuitionistic Fuzzy Set

The non empty set is defined as E, an intuitionistic fuzzy set E in E belong object in the form of $E = \{(e, \mu_E(e), \gamma_E(e)) : e \in E\}$, where the function of $\mu_E: E \rightarrow [0,1]$, it referred as a membership function and followed by non membership is defined as $\gamma_E: E \rightarrow [0,1]$, for every elements $e \in E$, $0 \leq \mu_E(e) + \gamma_E(e) \leq 1$. Atanassov specified the hesitation degree π , value defines one minus the sum degree of non membership and membership degree [7]. The hesitation degree or intuitionistic fuzzy index of e in E.

3.2 Type 2 Intuitionistic Fuzzy Set

A Type 2 Intuitionistic fuzzy set defines \bar{E} , E consist of membership and then non membership functions in type 2 grades

$e \in E$, the primary membership and non membership belongs to G_e^μ, G_e^γ .

$$G_e^\mu = \{(e, u) : u \in [\underline{\mu}_{\bar{E}}(e), \bar{\mu}_{\bar{E}}(e)]\} \tag{3.1}$$

$$G_e^\gamma = \{(e, u) : u \in [\underline{\gamma}_{\bar{E}}(e), \bar{\gamma}_{\bar{E}}(e)]\} \tag{3.2}$$

In fuzzy c means clusters can afford an unsupervised and non parametric approach and it was developed by J.C. Bezdek [2–5]. Divide the pixels in the image by using membership function with a value among zero to one.

$$FCM = \sum_{j=1}^N \sum_{i=1}^c \mu_{ij}^m ||x_j - \gamma_i||^2, \tag{3.3}$$

where N is the number of pixels partitioned with c1 clusters μ_{ij}^m is the membership value of pixels x_j in the i^{th} cluster. The m is the constant of the fuzziness degree. $||.||$, is considering the metric of the Euclidean distance. The membership value and cluster center as updated as [6, 7] follows

$$\mu_{ij} = \frac{1}{\sum_{n=1}^{c1} \left(\frac{||x_j - \gamma_i||}{||x_j - \gamma_k||} \right)^{\frac{2}{(m-1)}}} \tag{3.4}$$

$$\gamma_i = \frac{\sum_{j=1}^N \mu_{ij}^m x_j}{\sum_{j=1}^N \mu_{ij}^m} \tag{3.5}$$

The weakness of fuzzy c means clustering algorithm is awfully susceptible to noise because it is does not belong to spatial information. The k1 characterized by Euclidean distance among pixel samples, the speed of spatial information is calculated for each S_{ij} pixel as follows

$$\overline{S}_{ik} = \frac{\sum_{j=1}^N \overline{\mu}_{ij} (d_{k1j})^{-1}}{\sum_{j=1}^N (d_{k1j})^{-1}} \tag{3.6}$$

$$\underline{S}_{ik} = \frac{\sum_{j=1}^N \underline{\mu}_{ij} (d_{k1j})^{-1}}{\sum_{j=1}^N (d_{k1j})^{-1}} \tag{3.7}$$

The value of the spatial information to defuzzified as

$$S_{ik} = (\overline{S}_{ik1} + \underline{S}_{ik1})/2. \tag{3.8}$$

Computed the matrix of membership grades U_{ik1} by using the distance calculation [11, 13].

$$NewDis_{ik} = ||x_{k1} - \gamma_i||^2 [1 - (\alpha e^{-SP_{ik}})] \tag{3.9}$$

Modernized the centroid values of clusters

$$V^j = [\gamma_1^j, \gamma_2^j, \dots, \gamma_c^j]$$

at last verify to discontinue the condition, if $\max(|J^{(j+1)} - J^{(j)}|)$.



3.3 Proposed interval type 2 intuitionistic fuzzy c means with spatial clustering

These algorithm which help to reduce various uncertainties in histopathology images and the following steps are given below:

Step 1: Set the initial values for the centroids γ_i where $i = 1$ to c .

Step 2: The primary memberships of upper $\bar{\mu}_{ik}$ and $\underline{\mu}_{ik}$ lower membership for accordingly two fuzzifiers m_1 and m_2 . The m constant is satisfied by the condition of $m_1, m_2 \geq 1$. The two fuzzifiers help to construct a footprint of uncertainty (FOU) [7, 8, 10], the c denotes the number of clusters. Which is equal to 1 and it represents the difference between each pixel mean and value. The equation is given below:

$$(\mu_{jk})^{m_1} = \max \left\{ \left[\sum_{k=1}^c \left(\frac{DIF(x_i, \gamma_i)}{DIF(x_i, \gamma_k)} \right)^{\frac{2}{m_1-1}} \right]^{-1}, \left[\sum_{k=1}^c \left(\frac{DIF(x_i, \gamma_i)}{DIF(x_i, \gamma_k)} \right)^{\frac{2}{m_2-1}} \right]^{-1} \right\} \quad (3.10)$$

$$(\mu_{jk})^{m_2} = \max \left\{ \left[\sum_{k=1}^c \left(\frac{DIF(x_i, \gamma_i)}{DIF(x_i, \gamma_k)} \right)^{\frac{2}{m_2-1}} \right]^{-1}, \left[\sum_{k=1}^c \left(\frac{DIF(x_i, \gamma_i)}{DIF(x_i, \gamma_k)} \right)^{\frac{2}{m_1-1}} \right]^{-1} \right\} \quad (3.11)$$

Step 3: The value of the spatial information to defuzzified as

$$S_{ik} = (\mu_{jk} + \underline{\mu}_{jk})/2. \quad (3.12)$$

Step 4: computed the matrix of membership grades U_{ik} using the distance calculation [11].

$$NewDist_{ik} = \|x_k - \gamma_i\|^2 (1 - \alpha e^{-S_{ik}}). \quad (3.13)$$

Step 5: revise the new centroids of clusters

$$V^j = [\gamma_1^j, \gamma_2^j, \dots, \gamma_c^j]. \quad (3.14)$$

Step 6: To conclude verifying the end condition, if $\max(|J^{(j+1)} - J^{(j)}|)$, go to subsequently process or else go to step 2.

This proposed algorithm developed with type 2 intuitionistic so it was applied to segment the nuclei from various background uncertainties in the breast cancer histopathology images where measured up to existing methods. The type1 fuzzy c means algorithm most well known cluster analysis and it was based on membership grades being crisp. Type 2 fuzzy c means are characterized by membership themselves of fuzzy. The proposed algorithm is currently applied for histopathology images and it reduces the computational cost. Type 1 based fcm cannot handle the uncertainty but interval

type 2 fcm which is smoother and enables the uncertainty in the medical images.

The new proposed algorithm applied to the possibilistic c-means algorithm, which produced the better results. The fuzzy possibilistic c means algorithm (FPCM) was developed by N.R. Pal in 1975. Likewise spatial information based implemented the FPCM. the new novel SITY2PFCM implement and applied to the histopathology images. the novel algorithm applied for breast cancer nuclei segmentation. It contains the fuzzy partition matrix and then typicality partition matrix, the Objective function is given below,

This fuzzy possibility c means algorithm contains membership and possibility using weight as exponents m and η for the fuzziness and possibility respectively, which may be represented by a range rather than a precise value, $m = [m_1, m_2]$ where, m_1 and m_2 represent the lower and upper limit of weighting exponent for fuzziness and $\eta = [\eta_1, \eta_2]$ where η_1 and η_2 represent the lower and upper limit of weighting exponent for possibility[15].

$$U_{m_1, \eta_1} = \sum_{j=1}^N \sum_{i=1}^C \left(a \|\bar{\mu}_{ik} - \underline{\mu}_{ik}\|^{m_1} + b \|\bar{\tau}_{ik} + \underline{\tau}_{ik}\|^{\eta_1} \right) . d_{ik}^2$$

$$U_{m_2, \eta_2} = \sum_{j=1}^N \sum_{i=1}^C \left(a \|\bar{\mu}_{ik} - \underline{\mu}_{ik}\|^{m_2} + b \|\bar{\tau}_{ik} + \underline{\tau}_{ik}\|^{\eta_2} \right) . d_{ik}^2$$

Updating the positions of the centroids of clusters should take into account the degree of belonging interval of the fuzzy and possibilities metric in the clusters. The updating procedure for clustering the centroids for the upper and lower limit of the interval using fuzzy and possibilistic membership matrices, that centroids with spatial information with equation (3.12).

After image segmentation select the features based on type 2 intuitionistic fuzzy entropy based selection of the features. It helps to classification accuracy for predicting cancer stages from segmented image dataset. Select the intuitionistic fuzzy entropy features from the segmented images. The equation is given below,

$$InFE_n = \frac{\mu_a(T)}{\sum_{a=1}^k (T)} \quad (3.15)$$

T is a class and summation of intuitionistic feature calculated from this equation (3.15). Features selection from the after image segmentation, it is define whether cancer nuclei as malignant or benign stages. The features are nuclei area, perimeter, roundness, compactness, solidity and eccentricity from the segmented image and find the cancer stages.

4. Experimental Results and Discussion

Image segmentation results evaluated through quality measures such as sensitivity, specificity and accuracy. The sensitivity, specificity and accuracy are illustrated in terms of



true positive (TrP), true negative (TrN), false negative (FIN) and false positive (FIP). The true results measured by accuracy shown in table 1. The negative results handled by using sensitivity and specificity. The proposed algorithm interval intuitionistic fuzzy c means performed well assigned by accuracy measurement [7–10].

$$\text{Sensitivity} = \text{TrP} / (\text{TrP} + \text{FIN})$$

$$\text{Specificity} = \text{TrN} / (\text{TrN} + \text{FIP})$$

$$\text{Accuracy} = (\text{TrN} + \text{TrP}) / (\text{TrN} + \text{TrP} + \text{FIN} + \text{FIP}).$$

Table 1: The quality measurement for proposed and existing algorithm

Clustering performance measurements				
Methods	K means	FCM	IFCM	IT2SFCM
Sensitivity	45.60	43.3	55.0	60.4
Specificity	78.3	78.3	65.4	87.2
Accuracy	96.1	91.2	98.4	99.4

The quality measurement values obtained better than the existing algorithm, it is shown in table 1. The cluster method is compared to the interval type 2 based spatial PFCM with provides 99.5 percentage and reduces more uncertainties. Interval intuitionistic fuzzy c means algorithm with spatial method handled uncertainty and vagueness in histopathology color images. The data set is benchmark and taken from P and D laboratory, it contains benign and malignant breast tumors histopathology images. After segmentation, image features are extracted from the images to examine whether benign or malignant stages. The proposed algorithm was applied for breast cancer histopathology images for segment the nuclei, this result shown in figure 1. The proposed clustering algorithm segment the nuclei from the cancer histopathology images performed well. The breast cancer nuclei segmentation results are shown in Figure 1.

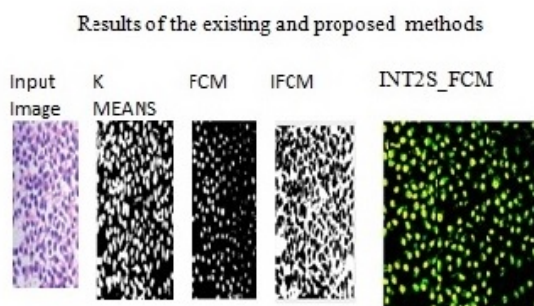


Figure 1. Results of cancer nuclei segmentation for existing and proposed methods

5. Conclusion

Digital histopathology images contain stains so hard to find the cancer nuclei. These kinds of problems are handled by

image processing algorithms to identify the nuclei from digital pathology cancer based images. The spatial function reduced the misclassified pixels in the medical images. Color based Interval type 2 intuitionistic fuzzy c means with spatial based clustering performed well in color based images and selected the nuclei from the stains where located in histopathology images. The proposed methods are evaluated by quality metrics methods such as accuracy, specificity and sensitivity followed by accuracy 99.4 percentage is highly acquired in proposed segmentation compared to the existing methods. The interval intuitionistic type 2 used to improve the performance of the spatial fuzzy c means algorithm and reduce errors. Our future direction will be the extension of interval type 2 PFCM spatial information based algorithm developing with high accuracy.

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