**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 40-44

# Triangular Intuitionistic Fuzzy Set for Nuclei Segmentation in Digital Cancer Pathology

Dr. R. Uma Rani[1], P. Amsini[2]
[1]*Associate Professor, Dept. of Computer Science, Sri Sarada College for Women (Autonomous), Salem, Tamilnadu, India,*
[2]*Research Scholar, Sri Sarada College for Women (Autonomous), Salem, Tamilnadu, India*

***Abstract:*** *Advanced fuzzy set theoretic techniques play an important role in image processing mostly in medical field. Medical images are inadequately illuminated, where regions are vague or hardly visible, creating uncertainty. Intuitionistic fuzzy sets are more useful in processing the medical images in early days. Cancer is one of most common disease in women worldwide. The final prediction and prognosis of cancer is based on the examination of cells or tissues under the microscope by a pathologist. The digital slides are converted to images, which can be viewed and analyzed on a computer monitor. These are called digital pathology images. These images are then analyzed through various image processing algorithms. At the same time, histopathology images are very complicated to diagnosis the cancer cells from the hematoxylin and erosion stains. This kind of situation is handled by advanced intuitionistic fuzzy set theories. This paper presents triangular IFS applied for a segment of cancer nuclei from cancer histopathology images. Before segmentation, the contrast level is improved by using contrast stretching. This proposed method is evaluated by F1- Score, Dice metric and Jaccard index. TriIFS method produced better results when compared with the existing standard segmentation algorithms.*

***Keywords:*** *Image processing, digital pathology, TriIFS(Triangular Intuitionistic Fuzzy Set)*

## I. Introduction

Breast cancer is the most prevailing type of cancer in women worldwide. In India, cancer patients are increasing, particularly in urban areas. There are 25 to 32 patients around 100 patients have suffered from breast cancer compared to other types of cancers [1,2]. Diagnosis finds the state of the cancer whether it is benign or malignant. The biopsy samples are viewed under a microscope by a pathologist. Pathologists are spending more time to take medical decision for cancer diagnosis. Digital pathology has helped to decrease the manual work and error. The tissue samples are accumulating on glass slides and convert into digital images and analysis through digital image processing techniques. Automated nuclei detection and segmentation task is very difficult, particularly complicated on various pathology images [3]. Indeed, breast pathology images contain the absence of structure and unstructured nuclei. This type of problems handled by advanced fuzzy set theories. Fuzzy logic concepts have played significant role in image processing and it is handling various uncertainties. The fuzzy approaches in image processing that can understand, represented, process the images. This process called as fuzzy image processing. It has three main stages, namely image fuzzification, change of membership values, and if necessary image defuzzification[4]. The fuzzy image processing structure is shown in figure1.

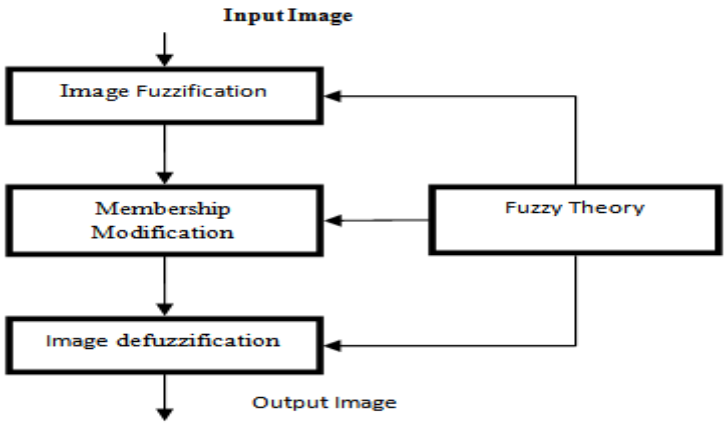



**FIGURE 1:** Structure of fuzzy image processing.

An intuitionistic fuzzy set contains membership and non membership, non-membership degree is not equal to complement of the membership degree, it is equal or less than to the complement of membership degree. This set has been most useful in real-time applications such as remotely sensed images and medical images[5]. Histopathology images are mostly poorly illuminated, and boundaries are vague and uncertainty. So, applied triangular intuitionistic fuzzy sets for detecting the cancer nuclei, and it is handled uncertainty.

## II. BACKGROUND AND RELATED WORK

In this section, review of digital histopathology images, nuclei cancer cells segmentation techniques and metrics.

### 2.1 Digital histopathology images

Digital pathology is the microscopic analysis of a surgical specimen or biopsy, which is processed by chemically and sections into the glass slides and then find out cancer expression. These sections are dyed with one or more stains for tissue components visualization under a microscopic. The pathologists are used hematoxylin and eosin stains over hundred years. Still, it is generally used in pathos labs. Eosin stains in pink color to represent stroma, cytoplasm and other structures and hematoxylin stains nuclei in dark blue color [6,7]. After staining, digital images are produced by using fast slide scanners.

### 2.2 Cancer nuclei cells segmentation techniques for H&E stained images

Fuzzy image processing methods are applied in many fields such as object recognition, robot vision, bio medical image processing, remotely sensed satellite images, and so on. In the following, fuzzy set and advanced fuzzy set theories are frequently suggested by many authors. Image preprocessing algorithms are used to upgrading of the image data. The aim of image segmentation is assisting to separate the object from image background. Segmentation techniques are such as contextual and non contextual. The contextual techniques are considered the proximity of the pixel in the object. The non contextual techniques are considered where grouped together of similar pixels[5]. The watershed, threshold, k-means, color k-means, fuzzy c-means and active contour segmentation methods are frequently applied for to detect the cancer nuclei [6].

### 2.3 Method for assessment of segmentation techniques

This proposed method is evaluated by F1- Score, Dice metric and Jaccard index. The F1-score and jaccard index both are region based metrics. These following details are given below,

#### 2.3.1. F1-score

F1 score also called as F-score or F-measure. It is used for evaluate a segmentation accuracy. It is considers both the precision (P) and the recall (R)[17,18].

$$F = \frac{2PR}{P+R} \qquad (1)$$

**Precision d**

#### 2.3.2. Dice metric

Dice metric is one of the quantitative evaluations of segmentation methods. This Sorenson dice similarity coefficient metrics is applied for segmentation performance evaluation[19]. Given Dice (F, G), F is a set of pixels annotated as a ground truth object and G a set of pixels segmented as a glandular object, Dice index is defined as follows,

$$\mathrm{Dice}(F,G) = \frac{2|F \cap G|}{|F|+|G|} \qquad (2)$$

Further, the dice coefficient represents the ratio of the overlapped region between the segmented and the truth region. The maximum value of Dice (F, G) is 1, when the segmented region is matching with truth region, and minimum value is 0 when the segmented region totally neglects the ground truth.

#### 2.3.3 Jaccard Index

For evaluating object segmentation as measuring the similarity between the ground truth and the segmentation. The segmentation result and corresponding ground truth are represented as S and G respectively [21]. Jaccard Index is defined as

$$JI = \frac{(G \cap S)}{(G \cup S)} \qquad (3)$$

Jaccard index is range between zero for the worst case and one for the best case for segmentation.

## III. METHODOLOGY

### 3.1 Statement of the Problem

One of the challenges for histopathology image segmentation such as variation in image colors due to Hematoxylin & Erosion reagents, staining process and sensor reaction. A lot of existing methods are used to detect the cancer nuclei [9,10,11]. It is very hard to find nuclei from uncertainty and vagueness situations. These conditions are handled by intuitionistic fuzzy sets.

### 3.2 Objectives of Study

Recently advanced fuzzy sets theory most important factor in image processing field, because of fuzzy techniques are knowledge and non-linear based. Fuzzy mostly used in image processing for biomedical image processing, object recognition and remotely sensed scene analysis. But in some cases, fuzzy set theory not segments the images obviously. Advanced intuitionistic and type II fuzzy set are provides better result. In fuzzy set theory consist basic three ways to define the membership function such as employing expert knowledge, clearly basis on statistical methods and analytically by suitable chosen function[4].

The fuzzy set theory initiated by L. A. Zadeh in 1965. In 1983, Atanassov was firstly introduced the concept of an Intuitionistic fuzzy set. The Intuitionistic fuzzy sets use two indexes such as membership and non-membership functions, which to described fuzziness. Intuitionistic fuzzy triangular function (TriIFS) is specified by three parameters a, b and c. the parameter of a, is lower limit, and c is upper limit and a value b [5]. Intuitionistic fuzzy triangular membership function of A consist of,

**Definition 3.1** A digital image is represent d(x, y), described with digitization. The 2D continuous image d(x, y) is divided into N number of rows and M number of columns. Images contain with a rows and a column is termed a pixel.

**Definition 3.2** let F be a nonempty set of the universe. If there are two mapping on the set F

$\mu_A: X \rightarrow [0,1] \quad x \rightarrow \mu_A(x)$ and $\square_A: X \rightarrow [0,1] \quad x \rightarrow \square_A(x)$

A denoted the Universal set X, $\mu_A$ and $\square_A$ are called the membership and non membership function of A, The set of the Intuitionistic fuzzy sets on the universal set X is denoted by F(X). The sum of membership and non membership degree is not superior than 1.

**Definition 3.3** For every ordinary fuzzy subset A on X, intuitionistic fuzzy index of x in A is distinct as $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$. It is called as degree of uncertainty degree or degree of hesitancy of the element x in A. Obviously for every $x \in X$, $0 \leq \pi A(x) \leq 1$[22].

**Definition 3.4** Intuitionistic fuzzy set (IFS). Let X be an universal set, an intuitionistic fuzzy set A in X is given by $A=\{\mu_A(x), \gamma_A(x)/x \in X\}$ where the functions, $\mu_A(x)$: X→ [0,1] along with $\gamma_A(x)$: X→ [0,1], determine the degree of membership and non membership of the element $x \in X$ correspondingly for every $x \in X, 0 \leq \mu_A(x)+\gamma_A(x) \leq 1$ [23].

**Definition 3.5** Triangular intuitionistic fuzzy number (TriIFN), A triangular fuzzy number consist of$\{\mu_A(x), \gamma_A(x)$ x ∈ F} where $\mu_A(x)$ and $\gamma_A(x)$ are considered triangular fuzzy number [23].

### 3.3 Proposed algorithm

Cancer histopathology images are containing H&E stains so it is very tough to segment the nuclei. The proposed algorithm is applied for separate the nuclei from breast cancer histopathology images. Breast cancer histopathology images are taken from breakhis database. This real time data is collected from 82 patients [13]. In proposed work, 40x magnification images are taken in the process. These images are blurred with noise and cells are unstructured. In the preprocessing, improve the contrast level by using contrast stretching.

TriIFS proposed algorithm:

i) Preprocessed image covert to fuzzy image. After that applied advanced intuitionistic fuzzy set theory. Initialize minimum and maximum values from the fuzzified image.

$M_{min}$ =(<a,b,c>),<a',b',c'>) $M_{max}$=(<e,f,g>),<e',f',g'>)

ii) Define the membership and non membership triangular intuitionistic fuzzy number

(a) Triangular Membership function

$$b = \begin{cases} b, & if\ b \leq e \\ \dfrac{bf - ae}{(b+f)-(a+e)} & if\ b > e \end{cases}$$

a=min(a,e)

c=min(c,f)

(b) Triangular Non membership function

$$b = \begin{cases} b, & if\ b \leq e \\ \dfrac{bf - ae}{(b+f)-(a+e)} & if\ b > e \end{cases}$$

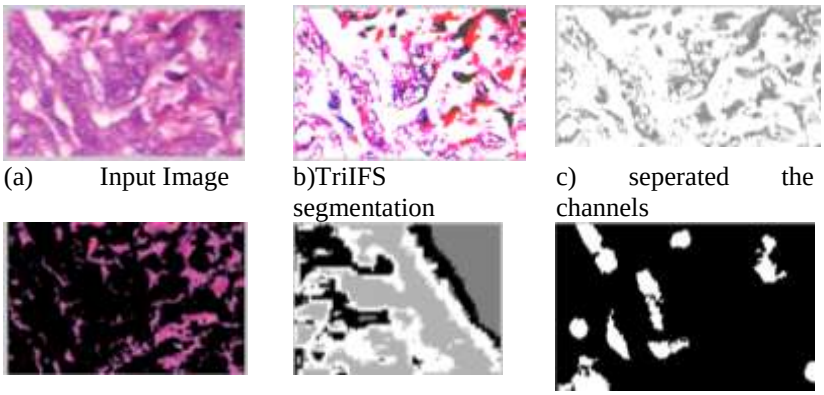
a=min(a,e)
c=min(c,f)

iii) Define maximum and minimum values between triangular intuitionistic fuzzy numbers by using $m^*_x$ fuzzy oscillation, infimum(inf) and supreum(sup) based [24].

iv) Fuzzy oscillation inf and sup defined as $max(A \cup B), min(A \cap B)$. Finally separated the red , green and blues channels from the defuzzified images.

## IV. Results And Discussion

Intuitionistic fuzzy set is one of the most powerful algorithms to deal with vagueness and uncertainty. Triangular intuitionistic fuzzy set algorithm compared to the existing methods through various evaluation methods shows in figure2. The existing methods are such as k-means, marker watershed and fuzzy c-means segmentation [9]. The proposed method is applied for various lobular carcinomas breast images. These images are contained unstructured nuclei and H&E stains cause uncertainty and vagueness. The existing methods also work well when applied for clear nuclei structured images. But, it is lack on uncertainty and vagueness when arise in image data.



(a) Input Image b)TriIFS segmentation c) seperated the channels

d) k-means segmentation e) Fuzzy c-menas f) Marker Watershed

**Figure 2: a)Labular__carcinoma images are taken for process, b) applied triangular intuitionistic fuzzy sets to detect the nuclei from image.c)separate rgb channels from segmented images.**

The triangular intuitionistic fuzzy proposed method is evaluated by F1- Score, Dice metric and Jaccard index. This proposed method was produced better results when compared to the existing standard segmentation algorithms are shown in Table1.

**Table 1: Evaluation metric for proposed and standard existing methods**

| S.NO | Methods | F1-score | Dice metric | Jaccard Index |
|---|---|---|---|---|
| 1 | k-means | 97.7 | 0.007 | 0.24 |
| 2 | Marker -Watershed | 94.4 | 0.0013 | 0.221 |
| 3 | Fuzzy c-means | 96.3 | 0.021 | 0.34 |
| 4 | Triangular intuitionistic fuzzy | 98.39 | 0.334 | 0.71 |

## V. Conclusion and Future Work

Digital pathology plays an important role in diagnosis state of the cancer. A new proposed method of triangular intuitionistic fuzzy set theory applied in image processing which is used to detect the cancer nuclei from various pathology images which contain vagueness and uncertainty. It is aid to reduce the manual work and errors. This proposed method is evaluated with F-measure, Dice metric and then Jaccard index. It gets better result compared to the existing standard methods. Different kind of existing techniques and continue to be

developed while detecting stage of cancerous in digital microscopy. In future work, improve the membership and non membership values by using operators in fuzzy set theory.

## References:


[1]. Australian Institute of Health and Welfare. Cancer. [homepage on the internet] Australia: AIHW; 2013 [cited 2014 May 29; updated 2013]. Available from: http://www.aihw.gov.au/cancer/

[2]. National Breast Cancer Centre. Clinical practice guidelines management of early breast cancer: Second edition. Canberra: National Health and Medical Research Clinic; 2001 Available from: http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/cp74_management_early_breast_cancer_131223.pdf.

[3]. Anant Madabhushi, "Digital pathology image analysis: opportunities and challenges".

[4]. Krassimir T.Atanassov,"Intuitionistic Fuzzy Sets", Theory and Applications, Springer- Verlag Berlin Heidelberg GmBH.

[5]. Tamalika Chaira, "Medical Image Processing", Advanced Fuzzy set Theoretic Techniques.

[6]. Sangita bhattacharjee, Jashojit, sanjay nag, indra kanta maitra, k. bandyopadhyay, " Review on histopathological slide analysis using digital microscopy".

[7]. H.Fox, "Is H&E morphology coming to an end?", J. Clin, Pathol, vol. 53, pp. 38-40, 2000.

[8]. A.D. Belsare, M. M. Mushirif, "Histopathological Image Analysis using Image Processing Techniques: An Overview", Signal & Image Processing: An International Journal vol.3, No.4, August 2012.

[9]. Humayun Irshad, Antoine Veillard, Daniel Racoceanu, " Methods for Nuclei Detection, Segmentation, and Classification in Digital Histopathology: A Review—Current status and Future Potential.

[10]. Rajesh kumar, "Detection and Classification of cancer from Microsccopic biopsy images using clinically significant and biologically interpretable features", Hindawi Vol 2015.

[11]. ArvydasLaurinavicius, Aida Laurinavicience, Darius Dasevicius, Nicolas Elie, Benoit Plancoulaine, Catherine Bor and Paulette Herlin, " Digital image analysis in Pathology: Benefits and obligation.

[12]. YukakoYagi, John R. Gilbertson, MD," Digital Imaging in Pathology: For Standrarization".

[13]. Fabio A. Spanhol, Luiz S.Oliveria, Caroline Petijean and Laurent Heutte," A Dataset for Breast Cancer Histopathologyical Image Classification", IEEE transaction on Biomedical Engineering vaol, 63 July 2016.

[14]. MaqlinParamanandam, Michael O'Byrne, BidishaGhosh , Joy John Mammen, Marie Therese Manipadam, Robinson Thamburaj,VikramPakrashi, "Automated Segmentation of Nuclei in Breast Cancer Histopathology Images" , Published: September 20, 2016.

[15]. MitkoVeta , Paul J. van Diest, Robert Kornegoor, André Huisman, Max A. Viergever, Josien P. W. Pluim," Automatic Nuclei Segmentation in H&E Stained Breast Cancer Histopathology Images", Published: July 29, 2013.

[16]. Krassimir T. Atanassov., Intuitionistic fuzzy set theorys and Applications

[17]. Sasaki, Y. (2007). "The truth of the F-measure"

[18]. Powers, David M W (2011). "Evaluation: From Precision, Recall and F-Measure to ROC, Informedness, Markedness & Correlation" . Journal of Machine Learning Technologies. 2(1): 37–63.

[19]. Nirmal Patel, Rajiv Kumar , "Image Segmentation & Performance Evaluation" (I JRAS ET).

[20]. Dennis Ali, " Nuclei segmentation of whole slide images in digital pathology".

[21]. Neeraj Kumar, Ruchika varma, sanuj Sharma, surabhi bhargava," A Dataset and a Technique for generalized nuclear segmentation for computatuional pathology", IEEE transactions on medical imaging, Jan 2017.

[22]. P.A.Ejegwa, A.J. Akubo, O.M. Joshua" Intuitionistic fuzzy set and its application in career determination via normalized euclidean distance method.

[23]. R.Sophia porchelvi, A.Banumathy, "Intuitionistic fuzzy shortest path algorithm for optimal boundary extraction in image processing", International journal of pure and applied mathematics, 2017.

[24]. Shramistha Bhattacharya, Srijita Barmam Roy, Sumantra saha," Application of fuzzy oscillation in the field of face recognition", 2105.