A NEW FUZZY APPROACH FOR SEGMENTATION OF CHROMOSOMES

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Abstract

Image segmentation has become one of the important tools to be used in the field of medicine. Segmentation is typically used to identify objects or other relevant information in digital images. Banding pattern is one of the unique parameter in karyotyping chromosome to detect chromosomal abnormalities which are the causes for birth defects. One of the main problems in computer vision system is analysing images having high uncertainty degree. Fuzzy set theory is ideally suited for dealing with the treatment of such uncertainty problem in the segmentation process. The segmentation simplifies and changes the representation of an image into something that is more meaningful, easier to analyse and easy to understand. This paper presents the concept of fuzzy algorithm for segmentation of dark bands in chromosome.

Keywords: Image processing, Segmentation, Chromosome image, Fuzzy logic, Membership function

1. Introduction

In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes.The ends of the chromosome are called telomeres. Each chromosome arm is divided into regions, or cytogenetic bands, that can be seen using a microscope and special stains. The cytogenetic bands are labelled p1, p2, p3, q1, q2, q3, etc., counting from the centromere out toward the telomeres. The study of whole set of chromosomes is known as karyology. Centromere position, length, banding pattern and polarity are the four parameters which are used for segmentation and identification of karyotype.

In humans, each cell normally contains 23 pairs of chromosomes, for a total of 46. Twenty-two of these pairs, called autosomes, look the same in both males and females. The 23rd pair, the sex chromosomes, differs between males and females. Females have two copies of the X chromosome, while males have one X and one Y chromosome. Chromosomes in metaphase can be identified using special staining techniques called banding. Metaphase chromosomes make the classical picture of chromosomes (karyotype). A band is defined as a part of chromosome which is clearly distinguishable from its adjacent segments by appearing darker or brighter with more banding techniques. The chromosomes are visualized as consisting of a continuous series of bright and dark bands.

The development of fuzzy set theory and fuzzy logic provided an opportunity for the human science to incorporate a mathematical framework with attractive properties. Image segmentation is a vital part of image processing. Segmentation has its application widespread in the field of medical images, traffic image, pattern recognition etc. Medical image segmentation is difficult in image processing. The application of fuzzy technology in information processing is already important and it will certainly increase the importance in the future. Nowadays some of the most commonly used segmentation techniques are thresholding, clustering methods, histogram-based methods, edge detection and region growing. Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp

adjustment in intensity at the region boundaries. Edge detection techniques have therefore been used as the base of another segmentation technique. In recent years, many authors apply different methods for image processing based fuzzy technique. The performance of fuzzy rule based segmentation in many applications however, is sensitive to both the structure of the membership functions and associated parameters used in each membership function.

Gayathri and Kuppusamy [7] approached medical image segmentation for fuzzy clustering with bias field estimation clustering method in such corrupted by salt and paper noise. AmanPreet [3] discussed region based method, edge based technique, fuzzy set theory based segmentation, threshold technique, and artificial neural network based image segmentation techniques. It gives explanation about how the segmentation is done using each technique separately. Montseny and Sobrevilla [20] introduced histogram based image segmentation for applying fuzzy rule based algorithms to very noisy images having a very high degree of variability, accurate brightness membership degrees. Sandeep and Shikhachawla [21] discussed object based image segmentation using a fuzzy based modified mean shift and minimum spanning tree based clustering method of remotely sensed satellite images using image processing toolbox.NameirakpamDhenachandra*et al.*[4] used K clustering algorithm to improve the quality of original image and median filter is used to improve segmentation of image.TarunMahashwari and AmitAsthana [1] applied fuzzy image enhancement to improve the quality of image by enhancing the minute details of the degraded image.

Manpreet Singh [6] presented different edge detection operators and what will materialize when they are combined with fuzzy logic which can be used to detect and locate edges in efficient manner.Orlando Tobias [9] proposed image segmentation by histogram thresholding using fuzzy sets obtained by minimizing threshold dependent criterion function. Reshmalakshmi and Sasikumar [10] proposed fuzzy based method based on simple fuzzy rules in which helps in designing efficient orientation estimation frame work.GiuseppeAiroFarulla*et al.* [11] proposed fuzzy logic that combines three different techniques to segment touching characters and provide a better accuracy to segment characters even with noisy touching characters. Santiago Aja *et al.*[12] discussed a method based on fuzzy thresholding for multiregion image segmentation to overcome the common drawbacks of thresholding methods when images are corrupted with artifacts and noise. ThiThao Tran *et al.*[13] proposed fuzzy energy based active contour model with images for background clutter and object occlusion. This model improves the computational speed and avoids difficulties associated with time step selection issue in gradient descent based approaches.

AgustinaBouchet*et al.*[14] proposed fuzzy mathematical morphology operators(erosion and dilation) to color images from a new vector ordering scheme based on a fuzzy order in the red green bluecolor space. The proposed color operators can be efficiently used for color image processing. Danshmand*et al.*[16] developed adaptive fuzzy model based on multi scale and multi directional simulation of the human visual system delineate the bubbles in the flotation froth images. Nanayakkara and Samarabandu [17] applied fuzzy logic based image segmentation algorithm to detect the organ boundary in ultra sound images of prostates. SriramakrishnaChinasamy [18] presented an algorithm for medical image retrieval system to examine the particular image processing algorithms. It is used for image retrieval based on the transformation domain, segmentation and fuzzy logic to achieve better classification accuracy for retrieving medical images.PatriciaMelin*et al.* [19] applied edge detection fuzzy logic method for benchmark images and synthetic images the merit of pratt measure to illustrate the advantages of using generalized type 2 fuzzy logic. Davesh Nawgaje [25] presented a Fuzzy Inference System (FIS) approach to detect the edges of the microscopic images within colour, which is robust and has stability degrees. They proposed the logic based technique which is a set of three pixels and also used the smallest mask of 2*2 window image consists of a set of fuzzy rules which highlight all the edges that are correlated with an image.

The main aim of this paper is to determine the darkbands in chromosome images, effectively using fuzzy algorithm and to show

the accuracy by applying it to some images and chromosomes. The present paper has been organized as follows: section 2 explains basic concepts of fuzzy logic method for easily understanding, section 3 discusses the fuzzy image processing and fuzzy algorithm,section 4 presents experimental results and brief comparison of images.

2. Basic Concepts of Fuzzy Logic :

In 1965, an Electrical and Electronics Engineer Prof. L. A. Zadeh[2] introduced the many valued logic by defining the fuzzy sets. This concept is being used and is also found to be more appropriate in solving problems of all disciplines. To represent / manipulate data and information possessing non-statistical uncertainties the concept of fuzzy sets is used. It was specifically designed to mathematically represent uncertainty and vagueness and to provide formalized tools for dealing with the imprecision intrinsic to many problems.

In classical set theory, a subset A of a set X can be defined by its characteristic function $\chi_A : X \rightarrow \{0, 1\}$ where

$$\chi_A(x) = \begin{cases} 1 \ if \ \ x \in A, \\ 0 \ if \ \ x \notin A. \end{cases}$$

The mapping is represented by a set of ordered pairs $(x, \chi_A(x))$. The first component of the ordered pair is an element of the set X and the second component is its value in $\{0, 1\}$. The value '0' is used to represent non-membership and the value '1' is used to represent membership of the element of A. The truth or falsity of the statement "x is in A" is determined by the ordered pair. The statement is true, if the second component of the ordered pair is '1', and the statement is false, if it is '0'. Fuzzy set of X is an arbitrary mapping $f: X \rightarrow [0,1]$, the unit segment of the real line. If the set X bears some structure, one may distinguish some fuzzy sets of X in terms of that additional structure. The value '0' is used to represent complete non-membership, the value '1' is used to represent complete membership and values in between are used to represent intermediate degrees of membership.

The set X is referred to as the Universe of discourse for the fuzzy set A. Frequently, the mapping μ_A is described as a function, the membership function of A, the degree to which the statement ''x in A'' is true, is determined by finding the ordered pair $<x, \mu_A(x)>$. The degree of truth of the statement is the second element of the ordered pair. Since the introduction of the concept of fuzzy sets by Zadeh, many papers appeared showing the importance of the concept and its applications to logic, set theory, group theory, groupoids, real analysis, measure theory, topology etc.

2.1 Definition: Let X be a nonempty set.A Fuzzy set A in X is characterized by its membership function $\mu_A : X \rightarrow [0,1]$ and $\mu_A(x)$ is interpreted as the degree of membership of element x in Fuzzy set A for each $x \in X$. It is clear that A is completely determined by the set of tuples $A = \{(x, \mu_A(x)) / x \in X\}$.

3. Fuzzy Image

3.1 Fuzzy Image Processing

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets.The representation and processing depend on the selected fuzzy technique and on the problem to be solved.Fuzzy image processing is divided into three main stages: image fuzzification,modification of membership values, and image defuzzification. Figure 1 shows the block diagram of the fuzzy imge processing process

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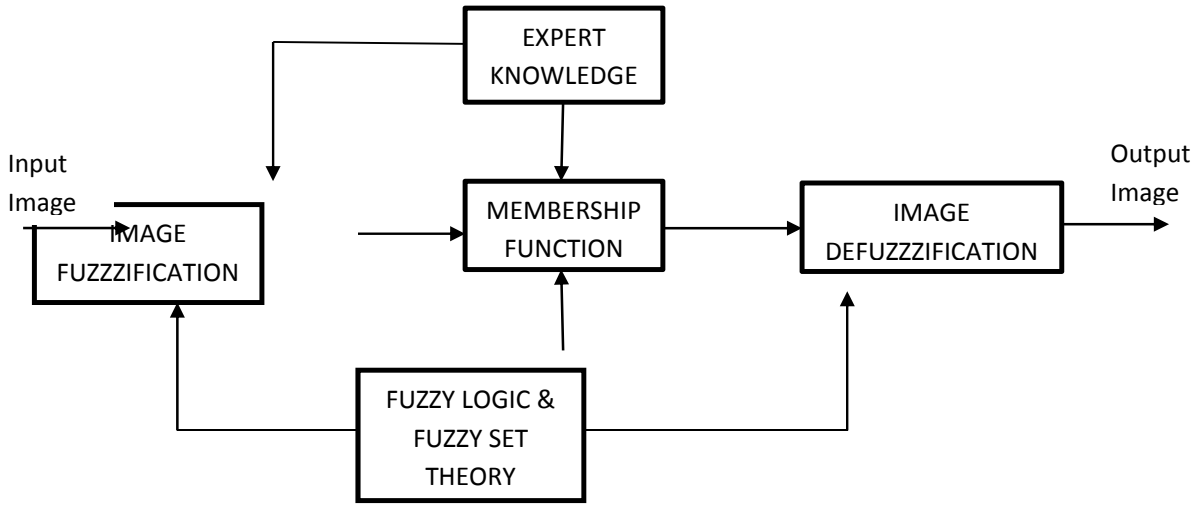

Figure 1: Block diagram of fuzzy image processing[25]

3.2Fuzzy set theory based segmentation

Fuzzy set theory based segmentation is used in analyzing images, and provide accurate information from any image. Fuzzification function can be used to remove noise from image. A gray- scale image can be easily transformed in to a fuzzy image by using fuzzification function. Fuzzy logic provides a way to handle the blurring, noise and background variations in a more robust way and also helps in preserving the information.Fuzzy logic has been used in numerous applications such as facial pattern recognition, air conditioners, washing machines, vacuum cleaners, antiskid braking systems, transmission systems, control of subway systems and unmanned helicopters, knowledge-based systems for multiobjective optimization of power systems.

3.3 Fuzzy Algorithm

The proposed image segmentation algorithm contain following steps:

1. Take an input image and set membership function for each gray level as:

$$\mu(x,y)=e^{-\left[\frac{\left(S-\frac{f(x,y)}{L}\right)^2}{2}\right]}$$

Where L, f(x, y), S denote level, any max graygray level, variance between gray values respectively.

2. Get new membership values by putting:

$$v(x,y)=\begin{cases} 2(\mu(x,y))^2 & if\ \mu(x,y)\le 0.5 \\ 1-2(1-\mu(x,y))^3 & if\ 0.5<\mu(x,y)\le 1 \end{cases}$$

3. Get final segmented image $g(x,y)$ by setting the method as:

$$g(x,y)=LS-\sqrt{L^2\log\left(1/(v(x,y))^3\right)}$$

4. Experimental Results and Discussions

Individual chromosome images are taken as input image for the proposed method.Matlab software is used to implement the proposed algorithm.In order to evaluate the effectiveness of the proposed method, algorithm is tested with the help of a number of images. In this paper, Fig 2(a) and Fig 3 (a) represents the original chromosome images taken as test image for the experimental process and analysis of results.

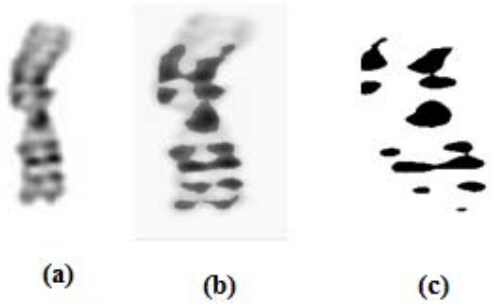

Figure 2: (a) Original image (chromosome 1) (b) Membership output(c) defuzzified output

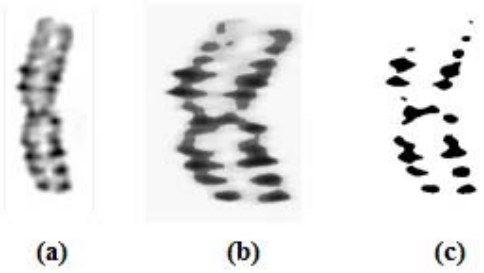

Figure 3: (a) Original image (chromosome 2) (b) Membership output(c) defuzzified output

The membership function in fuzzy logic helps in grouping the similar pixel intensity values together for the image. The output mainly depends on the membership values that is used in the segmentation of darkbands in chromosomes. This membership function improves the performance of fuzzy logic and helps in solving the problem related with intensity inhomogeneity. It enhances the intensity of dark region in chromosomes. Then defuzzification is applied to the output of membership function for extracting the darkbands in chromosomes. The output of membership function for chromosome 1 and chromosome 2 is shown in fig 2(b) and 3(b) respectively. The output of defuzzification process for chromosome 1 and chromosome 2 is shown in figure 2(c) and 3(c) respectively. When the value of S lies between 1.5 and 2, the segmentation of darkbands is achieved effectively.

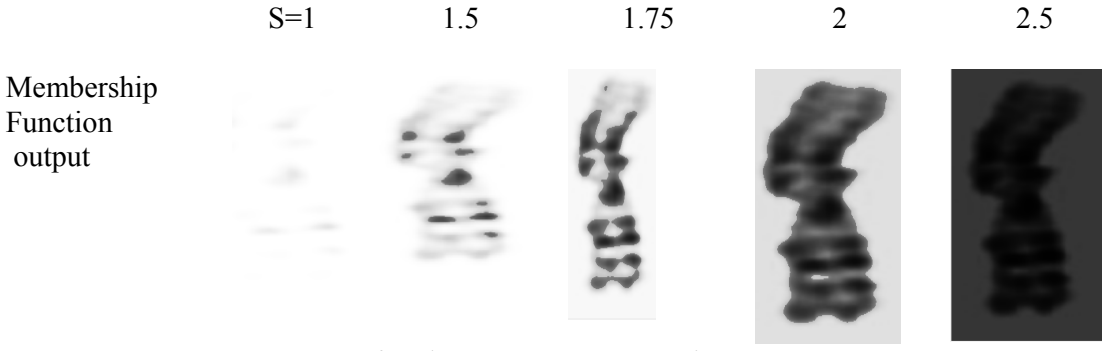

Figure 4: Output for chromosome 1 on varying parameter S

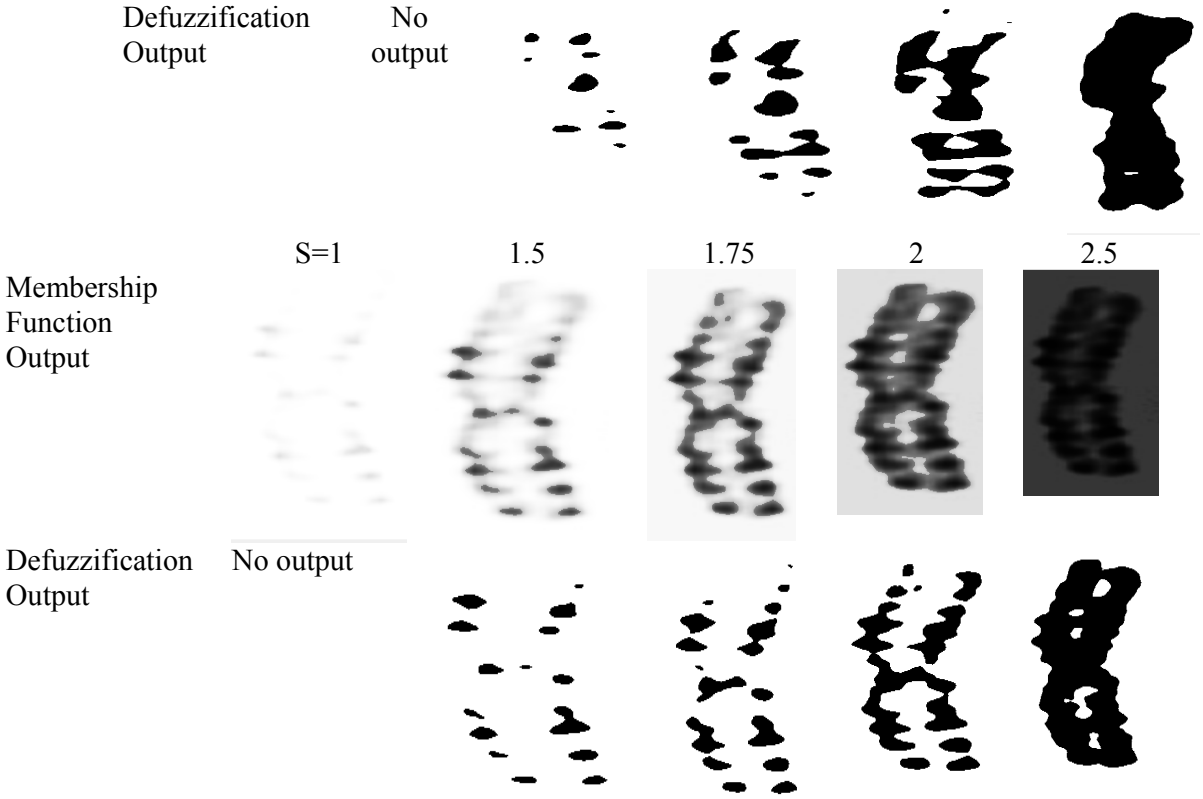

Figure 5: Output for chromosome 2 on varying parameter S

When S > 2 and S < 1.5, then segmentation process gets distorted. The output for membership function and defuzzification process on varying S for chromosome 1 and chromosome 2 is shown in fig. 4 and fig.5. The value of S also depends on the image that has been given as input.

5. Conclusion

In this paper, fuzzy algorithm has been used for segmentation of darkbands in chromosome and it provides more potential for effectively segmenting chromosome data and computational time**.** Simulation results shows the performance of the fuzzy logic in extracting the darkbands in chromosome.By varying thevalue of S, changes occur in the segmented output.However when S goes beyond some value, all the darkbands merges and the image gets deteriorated. The proposed model is successfully implemented using chromosome image to improve the analysis in medical field**.** In future, the proposed fuzzy algorithm can be extended to all types of images.

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