Comparing Intuitionistic Fuzzy Set Theory Method and Canny Algorithm for Edge Detection to Tongue Diagnosis in Traditional Chinese Medicine

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***Abstract*—The tongue diagnosis is an important diagnostic method in Traditional Chinese Medicine (TCM). Human tongue is one of the important organs which contain the information of health status. Image segmentation has always been a fundamental problem and complex task in the field of image processing and computer vision. Its goal is to change the representation of an image into something that is more meaningful and easier to analyze. In other words, it is used to partition a given image into several parts in each of which the intensity is homogeneous. In order to achieve an automatic tongue diagnostic system, an effective segmentation method for detecting the edge of tongue is very important. We mainly compare the Chan Vese Method and Canny algorithm for edge segmentation. The segmentation using Canny algorithm may produce many false edges after cutting; thus, it is not suitable for use. But, for our two steps Chan Vese method can automatically select the best edge information. Therefore, it may be useful in clinical automated tongue diagnosis system. Experiments show the results of these techniques.**

Keywords- tongue diagnosis; traditional chinese medicine; intuitionistic fuzzy set theory; canny algorithm; image edge detection

I. INTRODUCTION

Tongue diagnosis [1] is a very valuable and widely used diagnostic method in TCM, which mainly relied on the observation of tongue of patients. This method is also important in clinical applications and self-diagnosis [2]. It is simple, nonpainful, noninvasive, immediate and inexpensive. It is like a mirror of the bowels, and the pathological changes of the bowels can reflect from the change of the tongue features. So it becomes the important evidence for the diagnosis. But the current practice in TCM is mainly experience based, and the quality of the visual inspection varies between medical professionals. Most experience of tongue diagnosis depends on the subjective analysis of the examiners [3], so that the diagnostic results may be uncertain. Furthermore, the skills of a small number of good experts are not easily transferable to other less experienced professionals. Thus, it is beneficial to devise more objective approaches and quantitative models to evaluate the tongue and correlate some features to patients' health conditions. To achieve the demand for automation of pathological analysis, the automatically segmenting the tongue is very important. Recently, there have been a number of attempts to develop automated digital tongue diagnostic systems using image analysis. The goal of providing an automated system for tongue analysis is not to replace conventional diagnostic methods, but to assist doctors with their decision-making by giving an early alert signal that can lead to further diagnosis by other techniques such as MRI, CT and X-Ray etc.. The computerized diagnostic approach, which provides quantitative models to evaluate different features of the tongues and deduce the patients' illness, is still at an early stage of development. Many of the developed systems are only dedicated to the recognition of pathological features in tongue diagnosis, and the mapping from images of the tongue to diseases is not considered. Therefore, how to make the scientific representation of a tongue, which is obtained via image processing techniques, considered here is our current work. And then, establishing a database for mapping from images of the tongue to disease immediately is our ultimate purpose in the future.

Imaging is an essential part in medical science to visualize different anatomical structures in human body. Popular edge detection techniques [4] (Laplacian of Gaussian, Sobel detector, Prewitt detector, Canny edge detector) can extract boundaries but due to abrupt change in brightness levels of image in medical images, correct and smooth edges are not obtained. Recently, intuitionistic fuzzy set (IFS) theory was used to improve accuracy in detection. Chaira & Ray [5] detected edges of medical image using IFS technique. Couto et al [6] suggested image thresholding methods using IFS. Chaira [7,8] introduced intuitionistic fuzzy entropy in objective function of conventional clustering algorithm and applied to medical images.

The rest of this paper is organized as follows: Section II discuss the preparation of tongue medical image for edge segmentation. Section III is the description of Canny algorithm. Section IV discuss the intuitionistic fuzzy set theory and their implementation steps. One example of discussion the result of each method is shown here. Finally, a conclusion is drawn in Section V.

II. EDGE SEGMENTATION METHODS TO TONGUE DIAGNOSIS

Tongue images can be captured using a specific set of image acquisition devices, including advanced camera and other corresponding lighting system. In the classification process, tongue range must be extracted from the image region. However, the tongue image includes lips, skin or teeth. Therefore, when using a variety of edge segmentation

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methods, most common errors are to generate during edge segmentation. The main reason is the similarity of color between tongue and skin. The coupled light source is not stable; hence, making segmentation becomes more difficult. Here, we compare two methods to explain the above reasons.

Edges in a digital image provide important information about the objects contained within the image since they constitute the boundaries between the objects in the image. Edge detection is a frequently performed operation in many image processing applications because it is usually the first operation that is performed before other image processing tasks such as image segmentation, boundary detection, object recognition and classification, image registration, and so on.

III. EDGE DETECTION BY CANNY ALGORITHM

In 1986, Canny edge detection operator was proposed on optimization algorithms for edge detection. Relatively simple algorithm to make the whole process effectively is executed and has been widely used, but Canny operator has the defect that being vulnerable to various noise disturbances. Thus, there are certain limitations of its concrete application [9].

The detecting process of the Canny algorithm consists of the following steps[10]:

- Use the Gaussian filter smoothing image to restrain noise.
- Calculating the gradient magnitude M(x,y) and the gradient direction H(x,y) of the image M(x,y) is defined as follows,

$$M(x,y) = \sqrt{E_x(x,y)^2 + E_y(x,y)^2} \quad (\ )$$

The H(x,y) is defined as follow,

$$H(x,y) = \arctan\left(E_x(x,y) \Big/ E_y(x,y) \right) \quad (\ )$$

E_x and E_y are the result what the image being affected by the filter along the row-column direction.

- Do non-maximum suppression for the gradient magnitude.
- Dual-Threshold algorithm is adopted to detect and connect edges.

The main defects of the traditional Canny algorithm are the usage of Gaussian filter. When smooth the noise, some edge is also smoothed. Besides, the detection results have some isolated edges and some false edges.

IV. EDGE DETECTION BY INTUITIONISTIC FUZZY SET THEORY METHOD

This study implements intuitionistic fuzzy set theory method to detect edges that clusters, thresholds, and then detects edges of tongue region using intuitionistic fuzzy set theory. Clustering segments image into several clusters and histogram thresholding eliminates unwanted clusters that are not related to tongue region. Finally, image is edge detected, where a clear boundary is obtained. Proposed method performs better than existing edge detection methods.

A. *Intuitionistic Fuzzy set (IFS)*

Attanassov's [11] IFS theory emerges from simultaneous consideration of membership values μ and non-membership values ν of elements of a set. An IFS A in X is given as , where and for . $\mu_A(x)$ and $\nu_A(x)$ are membership and non-membership values of an element x to set A in X. When $\nu_A(x) = 1 \mid \mu_A(x)$ for every x in set A, then set A becomes a fuzzy set. For all IFSs, Atanassov also indicated an intuitionistic degree, $\pi_A(x)$, which arises due to lack of knowledge in defining membership degree, for each element x in A and is given as

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x),\ 0 \le \pi_A(x) \le 1 \quad (3)$$

Due to hesitation degree, membership values $\mu_A(x)$ lie in an interval range

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B. *Construction of Intuitionistic Fuzzy Set (IFS)*

Intuitionistic fuzzy image is constructed from intuitionistic fuzzy generator (IFG). In this study, Sugeno's IFG is used. Sugeno's intuitionistic fuzzy complement

, $\lambda > 0$, N(1)=0, N(0)=1. (4)

Non-membership values are calculated using Sugeno type intuitionistic fuzzy complement $N(\mu(x))$. Thus, using Sugeno type intuitionistic fuzzy complement, IFS becomes

with hesitation degree as

(5)

This Sugeno IFG is used to create an intuitionistic fuzzy image. Intuitionistic divergence measure idiv_measure (i,j) at each pixel position (i,j) in image is calculated between image window (same size as that of template) and template using max-min relationship as

$$idiv - measure\ (i,j) = \max_N [\ \min_r (Idiv(A,B)].$$ (6)

Idiv(A,B) is intuitionistic fuzzy divergence measure between each element in image window (a_{ij}) and template (b_{ij}). An edge-detected image is obtained and then superimposed on original image to show that tongue region is exactly demarcated by boundary.

V. Comparison of These Methods to Tongue Diagnosis

In Fig. 1, it is the original input tongue image. The result in Fig. 2, using Canny algorithm can produce more noise, and more false edges. It is not easy to select one edge of the tongue, so is not suitable for use in the tongue image. The result of nonlinear derivative method is shown in Fig. 3. It can be achieved automatically select the best edge information.

VI. Conclusion

In this paper, Canny algorithm and intuitionistic fuzzy set theory method for image edge detection approach have been successfully applied. By Canny algorithm, some false edges occur. While using intuitionistic fuzzy set theory approach for image edge detection, we can effectively segment the tongue without affecting the integrity of the further tongue diagnosis. Experimental results show that the implemented intuitionistic edge detector exhibits much better performance than the competing operators and may efficiently be used for the detection of edges in digital images.

This is the first step to establish a automated tongue diagnosis system, and will improve the scientific representation of tongue diagnosis in Traditional Chinese Medicine. In the future, we hope to continue to use this effective method for the separation between tongue and tongue coating, which is useful in the realization of physiological and pathological status within human body from the viewpoint of Traditional Chinese Medicine. Furthermore, more efficient codes can be exploited to further reduce the computational load of the proposed algorithm for future research work.

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Figure 1. The original input image.

Figure 2. Edge segmentation by Canny method

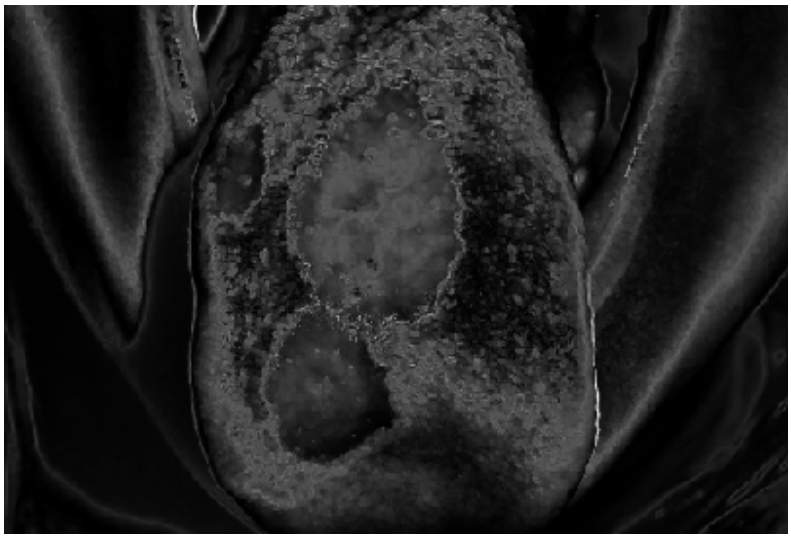

Figure 3. Edge segmentation by intuitionistic fuzzy set theory method which Edge without thresholding

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