Application of Image Segmentation Technique in Tongue Diagnosis

ZHAI Xue-ming1, LU Hang-dong1, ZHANG Li-zhong2

1 School of Computer Science and Technology, North China Electric Power University, Baoding 071003, China
2 Hebei Medical University, Shijiazhuang 100024, China
hangdonglu@yahoo.cn

ABSTRACT: Tongue diagnosis is an important diagnostic method of traditional Chinese medicine. The accuracy of tongue diagnosis can be improved by tongue characterization. Tongue area segmentation are important contents of preprocess of tongue image. The use of computer vision technology to achieve the objective of tongue diagnosis of Chinese medicine is of great significance. The first task of objective analysis of tongue images is to extract tongue area out. The first step is to use median filter to remove noise image. The second step is to transform the image color space to HIS color space, Then the utilization dual Snakes algorithms obtain the accurate and complete tongue image. Through testing, the method has proved to be satisfactory for tongue image segmentation.

KEYWORDS: Tongue image; The objective of tongue diagnosis; Image segmentation; Snake

I. INTRODUCTION

Tongue diagnosis is one of Chinese medicine gain diagnostic message important origins, and it is one of important way that gains the patient state of health. However, traditional Chinese medicine relies on experience transmission mode, by means of the diagnose of doctor's clinic experiences and short of the objective basis. Therefore it is very important to use of computer technology to achieve the quantification of tongue diagnosis and objective. In recent years, the tongue of objective research received universal attention. The existing research and the results have proved tongue image analysis technology for objective is feasible. Although tongue characterization has been made some progress, but there are some defects, also need for new methods of exploration in order to achieve better diagnostic results.

After obtains Tongue image by means of image acquisition equipment, The first step of machine diagnosis is extracted the tongue area from the tongue images. Despite the biggest tongue original image can be acquired, but an inevitable part of the non-tongue (such as the cheeks, lips and teeth) still exists. The non-tongue on the part of the original image affects the identification of tongue color and texture characteristics. So it is a important step of automatic analysis indicators to extract the tongue from background area. The quality of segmentation is directly related to the follow-up to the accuracy of the analysis.

At present, there are many methods of tongue segmentation have been proposed, such as threshold segmentation, Region growing, watershed, Snake and so on. But the former several ways less adaptive, can not be better to segment Tongue. While The later, Snake method is a effective extraction method of the objectives outline based on the high-level information. The advantage of it is that the goal outline of the role of the process and the final outcome is a complete curve. The defects of traditional dynamic contour is: (1) Smaller convergence domain. Only dynamic contour of the initial outline of the goal line from the edge of division within a small area can be very good convergence; (2) Exist re-entrant corner in the target can not be convergence. Therefore this method is less automatically, can not be completely out of people's participation, not suitable for large sample and clinical applications. Although the references on its improved, but still less than satisfactory.

This paper presents a new segmentation method. First of all, through the color space conversion image preprocessing, and then the application of double Snakes of the algorithm, namely the use of two Snakes on both sides from inside and outside the body to locate the outline of the tongue, and then the exact division of the tongue part.

II. IMAGE PRE-PROCESSING

The adoption of images tongue body RGB by means of digital cameras. As a result of many factors, there are many noise, need to eliminate these noises, so the first thing is image median filter. Median filter is the typical based on the sort of nonlinear filtering, it retains the edge sharpness and image detail while eliminating noise. Images using RGB color model, Specific algorithm is as follows:

\[
R_{ij} = MED\{r_1, r_2, \cdots, r_n\}
\]
\[
G_{ij} = MED\{g_1, g_2, \cdots, g_n\}
\]
\[
B_{ij} = MED\{b_1, b_2, \cdots, b_n\}
\]

Respectively, \(R_{ij}, G_{ij}, B_{ij}\) on behalf of (ij) department of R, G, B components of the output value, \(r_x, g_x, b_x\) \(x \in 1 \sim n\) representative of the pixel filtering window of the color component values, so that put the the central value of pixel in a local area as output value, place the noise points.

Then, the image color space conversion will be done after eliminating noise. As the element of RGB color space is sensitive to changes in the test environment, RGB color model of the tongue has been difficult to correct the results of standardization. So chose the HSI model which conformed to person's vision induced. Since the HSI model in light of the weight (I) and color of the weight (H + S) are separated, with the light of the weight not relevant to the color image information. People of color feel is mainly
determined by H color, so it can give full play to the description of the role of color in the HSI space.

Through the following formula to calculate the image in the HSI model of H, S, J:

$$H = \arccos \left( \frac{1}{2} \frac{[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}} \right) \quad \text{R} \neq \text{G or R} \neq \text{B}$$

$$S = \frac{1}{3} \min \{ R, G, B \}$$

$$I = \frac{2}{3} (R+G+B)$$

But there is a singular point in the HSI model, if color point on I axis, then its S value is zero, but H has not defined, moreover nearby the singular point, R, G, B value's small change can cause H, I, S value obvious change. In order to solve this problem, carries on the transformation to H, I, S component, introduces other 2 feature vector.

$$X = (X_1, X_2)$$

$$X_1 = S \cdot I \cdot \cos(H)$$

$$X_2 = S \cdot I \cdot \sin(H)$$

III. OUTLINE INITIALIZATION

Based on the Snakes of the segmentation, first of all, the outline of the initialization must be carried out. Tongue segmentation used as a gray projection based with the rigid template of tongue-profile approach to initialize. This approach defines a rectangular area outside the boundary of the tongue-profile template, the template used snake spline model to describe. It composed by the number of control points, and sub-spline curve its rigid deformation can be expressed as, in which for the curve section of the law to the vector, to scale deformation.

IV. SNAKE MODEL

A. The original Snake model

Proposed most early what Snakes model is Kasseta\cite{4}. The basic idea is to find a continuous closed curves $\mathbf{v}(s)=(x(s), y(s))$, then, we will make the follow value is the minimum,

$$E_s = \int_0^{\ell} \left( \| \mathbf{a}(s) \| V_s^2(s) + \beta(s) \| V_{ss}(s) \| ^2 \right)/2 + E_{ext}(V(s)) \| ds$$

In this Formula:

$$E_{ext} = \gamma(s)E_{image}(V(s)) + E_{con}(V(s))$$

$$E_{image} = W_{line}E_{line} + W_{edge}E_{edge} + W_{term}E_{term}$$

$E_{image}$ is image power which is the image in the V(s) point of the gradient generally. $E_{con}$ representative of the image on a fixed point on the contour of the role of exclusion or to attract. $E_{image}$ and $E_{con}$, collectively referred to as external energy.

Double snakes algorithm is to use two snakes to locate on both sides from inside and outside the contours of tongue. One of a snakes locate the initial positioning of tongue contour, and converge from the lateral to the medial; another location on the tongue initial outline of the medial to lateral expansion. The inside of the initial outline by means of adaptive change, and point to the outer contours of the role of external driving forces, to the lateral contour approximation, until its own snakes energy to minimize. Due to internal and external contours were initialized in the tongue on both sides of the outline of the internal and external, so the inside of the outline usually pass outward expansion of the outline during the inside outline approaching to the outside outline, drive the evolution of the inner contours of the role of external forces reduced. The role of external forces drive inside the outline of the evolution gradually decreases, When the inside and outside contours coincide, the external force to zero, to ensure that the inside of the outline will not cross the lateral contour continue expanding outward and into the lip area and its outer region. As the medial outline of the region from the tongue outward expansion, and the lip area and the shadow in the lateral of the tongue outline, so the inside of the outline is the first to come to the brink of tongue. This can weaken the impact on the segmentation results, which caused by lips and mouth area of the shadow, and also can reduce the accuracy of the outline of the requirements of initialization.

Because of the inner and outer sides of the outline of the evolution of the status and functions are different, so their energy function is not the same.

B. the double Snakes energy function

Double snakes algorithm is to use two snakes to locate on both sides from inside and outside the contours of tongue. One of a snakes locate the initial positioning of tongue contour, and converge from the lateral to the medial; another location on the tongue initial outline of the medial to lateral expansion. The inside of the initial outline by means of adaptive change, and point to the outer contours of the role of external driving forces, to the lateral contour approximation, until its own snakes energy to minimize. Due to internal and external contours were initialized in the tongue on both sides of the outline of the internal and external, so the inside of the outline usually pass outward expansion of the outline, during the inside outline approaching to the outside outline, drive the evolution of the inner contours of the role of external forces reduced. The role of external forces drive inside the outline of the evolution gradually decreases, When the inside and outside contours coincide, the external force to zero, to ensure that the inside of the outline will not cross the lateral contour.
continue expanding outward and into the lip area and its outer region. As the medial outline of the region from the tongue outward expansion, and the lip area and the shadow in the lateral of the tongue outline, so the inside of the outline is the first to come to the brink of tongue, this can weaken the impact on the segmentation results, which caused by lips and mouth area of the shadow, and also can reduce the accuracy of the outline of the requirements of initialization.

Because of the inner and outer sides of the outline of the evolution of the status and functions are different, so their energy function is not the same.

1) Lateral contour of the energy function

\[
E_{\text{snake}} = \sum_{i=1}^{n} \alpha_i \left[ \frac{\partial Q_i(\tau)}{\partial \tau} \right]^2 d\tau + \beta_i \left[ \frac{\partial^2 Q_i(\tau)}{\partial \tau^2} \right]^2 d\tau + \lambda_i \left[ \frac{\partial Q_i(\tau)}{\partial \epsilon} \right]^2 d\epsilon
\]

Lateral contour of the energy function using a single Snake algorithm energy function, including continuity of the contour, smoothness constraints and gradient constraint. The contractile force generated by Internal energy has make the outline of the characteristics of contraction, gradient bound converge to the gradient of its response to the larger regional.

2) Inside of the energy function

- a) Internal energy function: The inside contour’s internal energy function used traditional Snake General form, but because the inside outline usually needs to inflate outward, while the outline continuous’ characteristic restraint actually requests the outline the length to be as far as possible short, therefore in order to resist the outline of this kind of shrinkage character, it has removed the continuous restraint in the internal energy function, only retained smoothness to restrain one item.

\[
E_{\text{int}}(Q_i) = \beta_i \int_{\tau_i}^{\tau} \left[ \frac{\partial^2 Q_i(\tau)}{\partial \tau^2} \right]^2 d\tau
\]

In this formula, \(Q_i(\tau)\) is sub-spline curve, weight parameter \(\beta_i\) controls the restraint degree of smooth.

- b) External energy function: The movement of contour medial to lateral expansion can be seen as the spring which connected by a team of inside and outside contours, which contraction produced the force and effect on the inside of the outline. This force can be introduced by a binding energy of \(E_{\text{modal}}\) which add in the external energy function. So the inside outline of the external energy function including two items: the gradient constraint item which can Enhance the changes of the image gray and Restraint energy item \(E_{\text{modal}}\). Among them, the gradient of constraint controls the inside outline and makes it contract to the brink of Tongue. \(E_{\text{modal}}\) create a external force which works on inside outline and makes the inside outline approach to the inside outline gradually.

In this, set up the inside outline and outside outline are inner(s), outer(s) respectively. The definition of \(E_{\text{modal}}(\text{inner}(s)) = \lambda(\text{inner}(s) - \text{outer}(s))^2\).

In this formula, the parameters of weight controls the constraint degree of external force.

Therefore, the external energy function can be expressed as:

\[
E_{\text{ext}}(Q) = \gamma_i \int_{\tau_i}^{\tau} \left[ \frac{\partial Q(\tau)}{\partial \epsilon} \right]^2 d\epsilon + \lambda \int_{\tau_i}^{\tau} \left[ Q(\tau) - Q(\tau) \right]^2 d\epsilon
\]

In this formula, \(Q(\tau)\) is sub-spline curve of inside outline, \(Q(\tau)\) is sub-spline curve of outside outline, the parameters of weight \(\gamma_i\) controls the gradient of constraint degree in the area where the contour lies on. In sum, the total energy function of inside contour is:

\[
E_{\text{snake}} = \sum_{i=1}^{n} \beta_i \left[ \frac{\partial^2 Q_i(\tau)}{\partial \tau^2} \right]^2 d\tau + \gamma_i \left[ \frac{\partial Q_i(\tau)}{\partial \epsilon} \right]^2 d\epsilon + \lambda \left[ Q(\tau) - Q(\tau) \right]^2
\]

V. EXPERIMENT AND DISCUSS

We adopted the double Snakes algorithm on 462 tongue images of the actual division of experiments, and compared with the single-Snake algorithm. The adoption of parameters of the double Snakes algorithm shows in the follow:

<table>
<thead>
<tr>
<th>TABLE I. PARAMETERS CHOICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>parameters (\alpha) (\beta) (\gamma) (\beta_1) (\gamma_1) (\lambda)</td>
</tr>
<tr>
<td>values (0.1) (0.6) (-1) (0.7) (-0.4) (50)</td>
</tr>
</tbody>
</table>

During the experiment, by adjusting the initialization parameters of the internal and lateral contour to improve the accuracy of the segmentation. Experiments show that the accuracy of the single-Snake is 81.63%, and the accuracy of the double Snake is 92.89%. This shows that the double Snakes on the tongue segmentation have the high accuracy. The following photos show the process of tongue segmentation using double Snakes.

Figure 1. the process of tongue segmentation using double Snakes.
CONCLUSIONS

Snakes, as a general outline of the two-dimensional model has been successfully applied to solve many of the issues in the field of computer vision and image analysis. It be used to image segmentation, through the energy function of the special design, can extract the outline of the features what we want, as well as the integration of knowledge-based constraints in the extraction process, the robustness, precision, relevance, etc. Were better than traditional methods.

In this paper, a double Snakes model is proposed which based on the traditional model of Snake and in the use of the tongue segmentation. Compared with the old segmentation, double Snakes have a lower request on the initialization of outline, and more accurate results of the segmentation. Through the experiments show that the algorithm is effective and practical.

REFERENCES


